International PhD Thesis

CARDIORESPIRATORY FITNESS AND PLANT-BASED DIETARY PATTERNS AS MODIFIABLE FACTORS ASSOCIATED WITH MENTAL AND NEUROCOGNITIVE HEALTH

Doctorado en Investigación Sociosanitaria y de la Actividad Física
Departamento de Enfermería, Fisioterapia y Terapia Ocupacional
Universidad de Castilla-La Mancha

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CUENCA, 2026

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Centro de Estudios Socio-Sanitarios

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CERTIFY:

That the International PhD thesis entitled: "CARDIORESPIRATORY FITNESS AND PLANT-BASED DIETARY PATTERNS AS MODIFIABLE FACTORS ASSOCIATED WITH MENTAL AND NEUROCOGNITIVE HEALTH" presented by María Valentina Díaz Goñi has been carried out under our direction, being an expression of the technical and interpretative capacity of its author in conditions that he deserves the title of Doctor with International Mention, provided by the committee if it considered so.

Signed by
Arthur Eumann Mesas
Cuenca, 15 July 2026

Signed by
Bruno Bizzozero Peroni
Cuenca, 15 July 2026

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GRANT AND FUNDING



The research presented in this doctoral thesis was conducted within the Health and Social Research Center at the University of Castilla-La Mancha (Spain), an independent research center dedicated to the study of lifestyle behaviors and health.

Research Project

Some of the work included in this thesis was developed as part of the following research project:

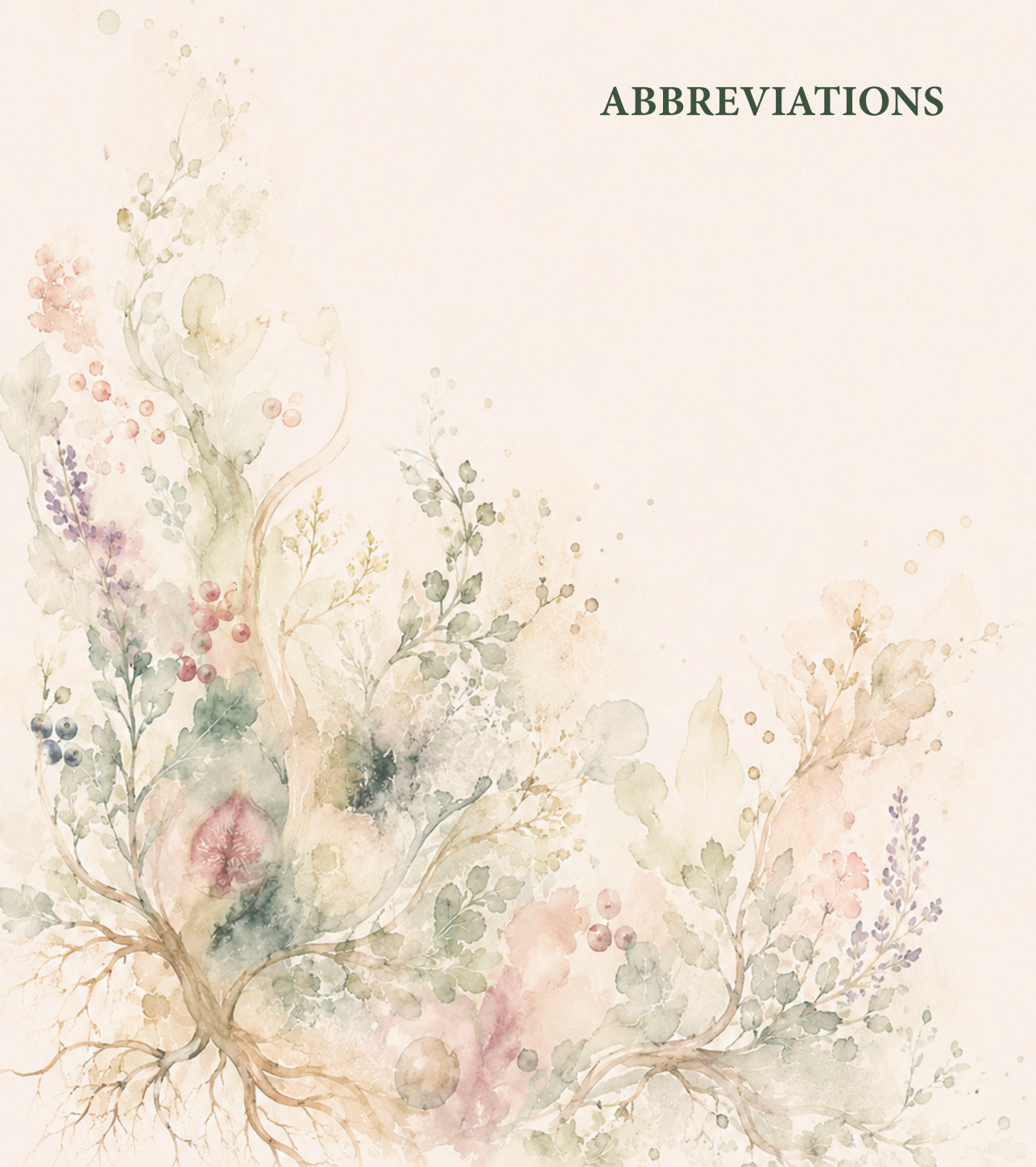
- Nuts4Brain Project: The relationship between nut consumption and mental health outcomes throughout adulthood. Under grant number PI21/01898, this project was funded by the Ministry of Science and Innovation of Spain, the European Union NextGenerationEU program, the *Instituto de Salud Carlos III* (Spain), and the European Regional Development Fund.

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ABBREVIATIONS



BDNF	Brain-derived neurotrophic factor
CRF	Cardiorespiratory fitness
DALYs	Disability-adjusted life years
DSM-5-TR	Diagnostic and Statistical Manual of Mental Disorders 5th edition – Text Revision
EDs	Eating disorders
hPDI	Healthy Plant-Based Diet Index
ON	Orthorexia nervosa
OSFED	Other specified feeding or eating disorder
PDI	Plant-Based Diet Index
uPDI	Unhealthy Plant-Based Diet Index
VO_2max	Maximum oxygen consumption
VO_2peak	Peak oxygen consumption
WHO	World Health Organization

These abbreviations were used specifically in the introduction of this doctoral thesis. Additional abbreviations can be found in each of the manuscripts comprising this dissertation. In other sections of the thesis (i.e., presentation, methods, aims, conclusions, future research lines, appendix, and other scientific contributions), abbreviations have been avoided to enhance readability.

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- Manuscript II. The Associations Between Vegetarian and Vegan Diets and Orthorexia Nervosa Symptoms in Adults: A Systematic Review and Meta-Analysis.

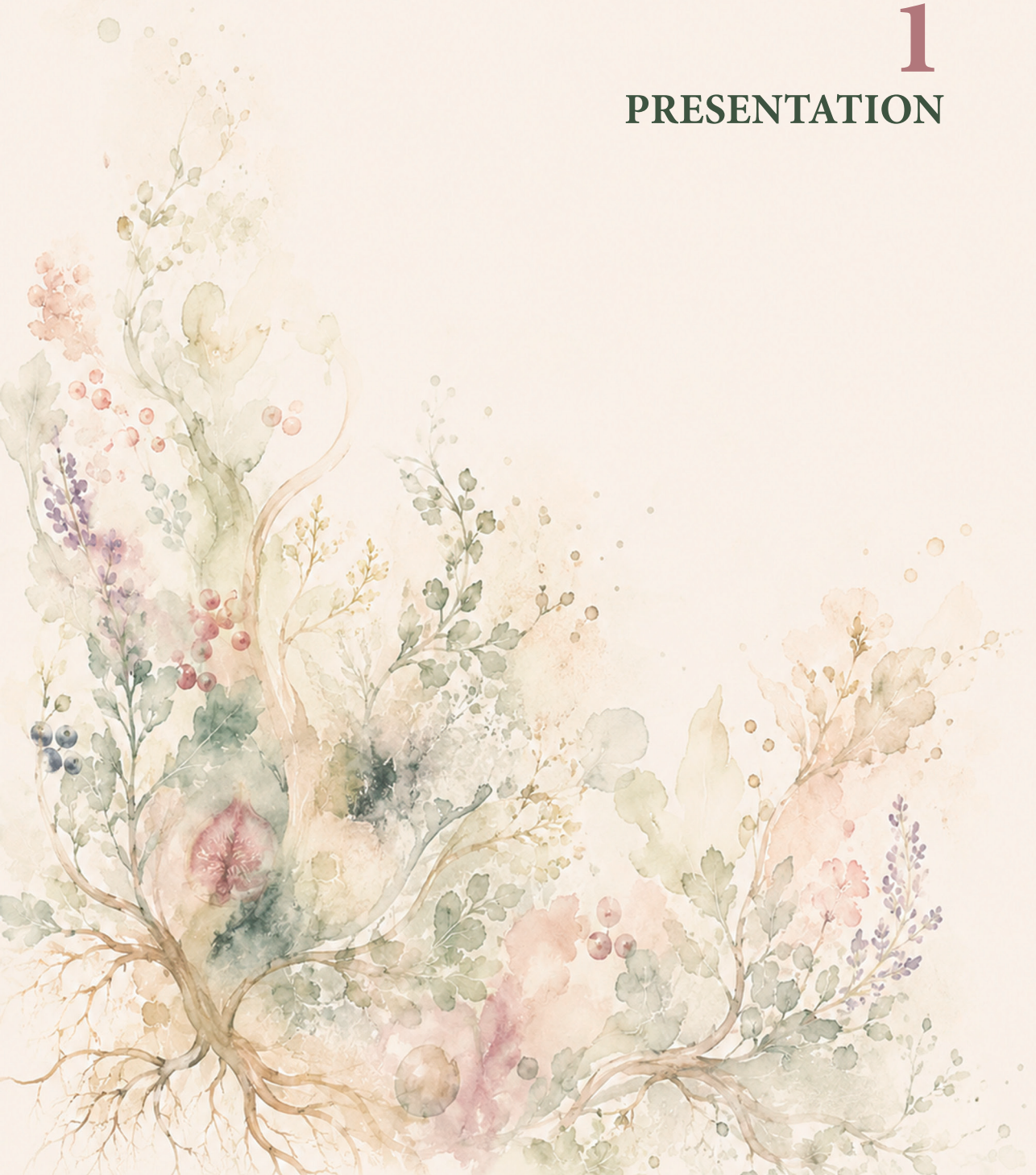
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1
PRESENTATION



Mental and neurocognitive disorders pose a growing challenge to global public health. According to the Global Burden of Disease study, mental disorders affected approximately 1.17 billion people worldwide in 2023 and contributed substantially to global disability, with a particularly high burden during adolescence and young adulthood. At older ages, neurocognitive disorders, particularly dementia, represent major causes of disability, dependency, and care needs, and their burden is expected to increase over the coming decades. Depression is among the most prevalent and disabling mental disorders, while the global burden of eating disorders is also projected to increase. Orthorexia nervosa, characterized by an excessive preoccupation with consuming foods perceived as healthy or pure, has additionally attracted increasing scientific attention, although its diagnostic status and conceptual boundaries remain insufficiently defined.

Despite their diagnostic and clinical heterogeneity, these conditions have multifactorial etiologies involving complex interactions among genetic, biological, behavioral, psychosocial, and environmental factors. Some of these factors are potentially modifiable and may therefore constitute relevant targets for prevention, risk reduction, and early intervention. In this context, the present doctoral dissertation focuses on two potentially modifiable factors: cardiorespiratory fitness and plant-based dietary patterns.

Cardiorespiratory fitness reflects the integrated ability of the cardiovascular, respiratory, and musculoskeletal systems to transport and utilize oxygen during sustained physical activity. Although partly determined by genetic and other individual characteristics, it is strongly influenced by regular physical activity. Higher cardiorespiratory fitness has been consistently associated with more favorable physical health outcomes, And increasing attention has recently been directed toward its potential role in mental and neurocognitive health. Existing evidence suggests that higher levels may be associated with a lower risk of depression and dementia. However, prospective evidence remains limited for several mental and neurocognitive disorders and is not fully consistent across age groups, populations, and assessment methods. A comprehensive synthesis is therefore needed to clarify the magnitude and consistency of these associations and to identify the main research gaps.

Plant-based dietary patterns are broadly characterized by a predominance of plant-derived foods and a lower intake of animal-source foods. Such patterns have been associated with lower risks of all-cause mortality, cardiovascular disease, type 2 diabetes, hypertension, and certain cancers. In nutritional psychiatry, which examines the relationships between diet, nutritional factors, and mental health, plant-based dietary patterns have also emerged as potentially relevant exposures for a range of mental health outcomes. Within this broad spectrum, vegetarian and vegan diets have been investigated in relation to eating disorders

and orthorexia nervosa symptoms. However, previous evidence syntheses findings remain have frequently grouped strict vegetarian and vegan diets together with less restrictive dietary patterns, such as pescatarian and semi-vegetarian diets, thereby limiting the ability to isolate associations specifically related to vegetarian and vegan dietary patterns.

Dietary quality represents an additional key dimension, as the restriction or exclusion of animal-source foods does not necessarily imply a nutritionally healthy dietary pattern. To capture these different dimensions, the Plant-Based Diet Index assesses overall adherence to a plant-based dietary pattern, whereas the Healthy and Unhealthy Plant-Based Diet Indices distinguish plant-based dietary patterns according to the healthfulness of the plant foods consumed. Emerging evidence suggests that greater adherence to healthy plant-based dietary patterns may be associated with more favorable mental health outcomes, including lower depressive symptoms. Nevertheless, evidence remains limited in young adults, particularly university students.

This doctoral dissertation was developed based on the following objectives:

- To evaluate the available evidence from cohort studies on the associations between cardiorespiratory fitness levels and the risk of mental and neurocognitive disorders at all ages in the general population.

- To synthesize the available evidence on the associations between vegetarian and vegan diets and orthorexia nervosa symptoms, compared with omnivorous diets, in the adult population.

- To quantify the associations between vegetarian and vegan diets and eating disorder symptoms, compared with omnivorous diets, across the lifespan.

- To examine the associations between adherence to plant-based diets, differentiating between healthy and unhealthy patterns, and depressive symptoms among Spanish university students.

The main conclusions derived from the studies included in this doctoral dissertation are as follows:

- Higher cardiorespiratory fitness was associated with a lower risk of depression and dementia in adults, as well as with a lower risk of psychotic disorders in men. However, the available evidence remains limited and of low certainty for several outcomes and age groups.

- Young and middle-aged adults following vegetarian or vegan diets showed higher symptoms of orthorexia nervosa than those following omnivorous diets. However, these findings should be interpreted cautiously because all included studies were cross-sectional and generally of low methodological quality.

- No significant differences in eating disorder symptoms were observed between individuals following vegetarian or vegan diets and those following omnivorous diets. These findings suggest that dietary pattern alone may not be associated with greater eating disorder symptomatology, although substantial heterogeneity limits the strength of this conclusion.

- Among Spanish university students, greater adherence to a healthy plant-based dietary pattern was associated with a lower likelihood of mild-to-severe depressive symptoms. Conversely, greater adherence to an unhealthy plant-based dietary pattern was associated with a higher likelihood of mild-to-severe depressive symptoms, although this association was attenuated after adjustment for lifestyle-related factors. These findings highlight the importance of plant-food quality, although the cross-sectional design precludes causal inference.

2
PRESENTACIÓN



Los trastornos mentales y neurocognitivos suponen un reto cada vez mayor para la salud pública mundial. Según el estudio *Global Burden of Disease*, los trastornos mentales afectaron a aproximadamente 1.17 mil millones de personas en todo el mundo en 2023 y contribuyeron de manera sustancial a la discapacidad global, con una carga especialmente elevada durante la adolescencia y la edad adulta temprana. En edades más avanzadas, los trastornos neurocognitivos, en particular la demencia, constituyen las principales causas de discapacidad, dependencia y necesidad de cuidados, y se prevé que su carga aumente en las próximas décadas. La depresión se encuentra entre los trastornos mentales más prevalentes e incapacitantes, mientras que también se prevé que aumente la carga mundial de los trastornos de la conducta alimentaria. La ortorexia nerviosa, caracterizada por una preocupación excesiva por el consumo de alimentos percibidos como saludables o puros, ha suscitado además una atención científica cada vez mayor, aunque su estatus diagnóstico y sus límites conceptuales siguen sin estar suficientemente definidos.

A pesar de su heterogeneidad diagnóstica y clínica, estas afecciones tienen etiologías multifactoriales en las que intervienen interacciones complejas entre factores genéticos, biológicos, conductuales, psicosociales y ambientales. Algunos de estos factores son potencialmente modificables y, por lo tanto, pueden constituir objetivos relevantes para la prevención, la reducción del riesgo y la intervención temprana. En este contexto, la presente tesis doctoral se centra en dos factores potencialmente modificables: la capacidad cardiorrespiratoria y los patrones alimentarios basados en vegetales.

La capacidad cardiorrespiratoria refleja la capacidad integrada de los sistemas cardiovascular, respiratorio y musculoesquelético para transportar y utilizar el oxígeno durante la actividad física sostenida. Aunque viene determinada en parte por características genéticas y otras características individuales, está fuertemente influenciada por la actividad física regular. Se ha asociado de forma sistemática una mayor capacidad cardiorrespiratoria con resultados de salud física más favorables, y recientemente se ha prestado una atención creciente a su posible papel en la salud mental y neurocognitiva. La evidencia existente sugiere que unos niveles más altos podrían estar asociados a un menor riesgo de depresión y demencia. Sin embargo, la evidencia prospectiva sigue siendo limitada para varios trastornos mentales y neurocognitivos y no es totalmente coherente entre los distintos grupos de edad, poblaciones y métodos de evaluación. Por lo tanto, es necesaria una síntesis exhaustiva para aclarar la magnitud y la coherencia de estas asociaciones e identificar las principales lagunas de investigación.

Los patrones alimentarios basados en vegetales se caracterizan, en términos generales, por un predominio de alimentos de origen vegetal y un menor consumo de alimentos de origen animal. Dichos patrones se han asociado con un menor riesgo de mortalidad por

todas las causas, enfermedades cardiovasculares, diabetes tipo 2, hipertensión y ciertos tipos de cáncer. En la psiquiatría nutricional, que analiza las relaciones entre la dieta, los factores nutricionales y la salud mental, los patrones alimentarios basados en vegetales también se han revelado como factores de exposición potencialmente relevantes para una serie de resultados relacionados con la salud mental. Dentro de este amplio espectro, se han investigado las dietas vegetarianas y veganas en relación con los trastornos alimentarios y los síntomas de la ortorexia nerviosa. Sin embargo, los resultados de síntesis de la evidencia previa han agrupado con frecuencia las dietas vegetarianas y veganas estrictas junto con patrones alimentarios menos restrictivos, como las dietas pescetarianas y semi-vegetarianas, lo que limita la capacidad de aislar las asociaciones relacionadas específicamente con los patrones alimentarios vegetarianos y veganos.

La calidad de la dieta representa otra dimensión clave, ya que la restricción o exclusión de alimentos de origen animal no implica necesariamente un patrón alimentario saludable desde el punto de vista nutricional. Para tener en cuenta estas diferentes dimensiones, el Índice de Dieta Basada en Plantas evalúa la adherencia general a un patrón alimentario basado en vegetales, mientras que los Índices de Dieta Basada en Plantas Saludable y Poco Saludable distinguen estos patrones alimentarios en función de lo saludables que sean los alimentos vegetales consumidos. Las pruebas más recientes sugieren que una mayor adherencia a patrones alimentarios de origen vegetal saludables podría estar asociada a resultados más favorables en materia de salud mental, incluyendo una reducción de los síntomas depresivos. No obstante, las pruebas siguen siendo limitadas en el caso de los adultos jóvenes, especialmente entre los estudiantes universitarios.

Esta tesis doctoral se ha elaborado partiendo de los siguientes objetivos:

- Evaluar la evidencia disponible procedente de estudios de cohortes sobre las asociaciones entre los niveles de capacidad cardiorrespiratoria y el riesgo de trastornos mentales y neurocognitivos en todas las edades de la población general.

- Sintetizar la evidencia disponible sobre las asociaciones entre las dietas vegetarianas y veganas y los síntomas de ortorexia nerviosa, en comparación con las dietas omnívoras, en la población adulta.

- Cuantificar las asociaciones entre las dietas vegetarianas y veganas y los síntomas de trastornos de la conducta alimentaria, en comparación con las dietas omnívoras, a lo largo de toda la vida.

- Examinar las asociaciones entre la adherencia a dietas de origen vegetal, diferenciando entre patrones saludables y no saludables, y los síntomas depresivos entre los estudiantes universitarios españoles.

Las principales conclusiones extraídas de los estudios incluidos en esta tesis doctoral son las siguientes:

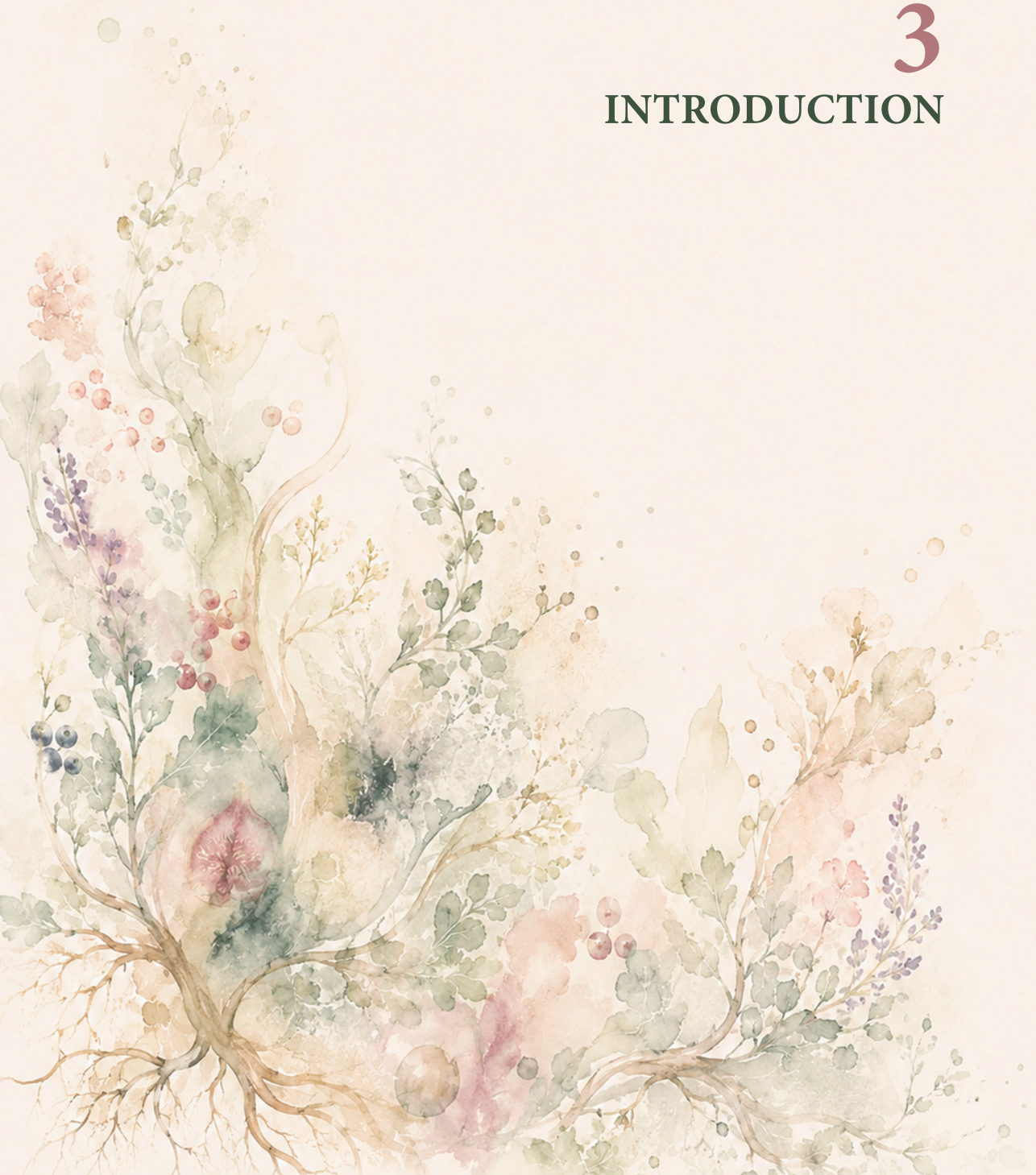
- Un mayor nivel de aptitud cardiorrespiratoria se asoció con un menor riesgo de depresión y demencia en adultos, así como con un menor riesgo de trastornos psicóticos en hombres. Sin embargo, la evidencia disponible sigue siendo limitada y de baja certeza para varios resultados y grupos de edad.

- Los adultos jóvenes y de mediana edad que seguían dietas vegetarianas o veganas presentaban más síntomas de ortorexia nerviosa que aquellos que seguían dietas omnívoras. No obstante, estos hallazgos deben interpretarse con cautela, ya que todos los estudios incluidos eran transversales y, en general, de baja calidad metodológica.

- No se observaron diferencias significativas en los sintomas de trastornos de la conducta alimentaria entre las personas que seguían dietas vegetarianas o veganas y aquellas que seguían dietas omnívoras. Estos hallazgos sugieren que el patrón alimentario por sí solo podría no estar asociado con una mayor sintomatología de trastornos de la conducta alimentaria, aunque una heterogeneidad sustancial limita la solidez de esta conclusión.

- Entre los estudiantes universitarios españoles, una mayor adherencia a un patrón alimentario saludable basado en plantas se asoció con una menor probabilidad de presentar síntomas depresivos de leves a graves. Por el contrario, una mayor adherencia a un patrón alimentario a base de plantas poco saludable se asoció con una mayor probabilidad de presentar síntomas depresivos de leves a graves, aunque esta asociación se atenuó tras ajustar los resultados por factores relacionados con el estilo de vida. Estos hallazgos ponen de relieve la importancia de la calidad de los alimentos de origen vegetal, aunque el diseño transversal impide establecer una relación causal.

3
INTRODUCTION



1. MENTAL AND NEUROCOGNITIVE DISORDERS AS A GLOBAL PUBLIC HEALTH CHALLENGE

1.1. Global burden of mental and neurocognitive disorders

The World Health Organization (WHO) defines mental health as a fundamental component of overall health. It is described as a state of mental well-being that allows individuals to cope with life's stresses, realize their abilities, learn, and work effectively while contributing to their communities[1]. However, when this state of well-being is significantly disrupted, individuals may develop mental disorders.

The global burden of mental disorders has increased in the last decades and currently represents a critical public health challenge worldwide. In 2023, mental disorders affected an estimated 1.17 billion people across all age groups and both sexes, corresponding to an age-standardized prevalence of approximately 14% of the global population[2]. Mental disorders accounted for an estimated 171 million disability-adjusted life years (DALYs), representing 6% of all DALYs globally, and were the leading cause of years lived with disability (YLDs), accounting for 17% of the global total[2].

Anxiety disorders, major depressive disorder, and schizophrenia were among the leading contributors to DALYs attributable to mental disorders[2]. Major depressive disorder alone affected approximately 236 million people worldwide in 2023 and accounted for 47.5 million DALYs, ranking as the 15th leading cause of DALYs among all diseases assessed in the Global Burden of Disease study[2]. Eating disorders, comprising anorexia nervosa and bulimia nervosa in the Global Burden of Disease framework, accounted for approximately 18.1 million prevalent cases and 3.8 million DALYs globally[2].

As shown in **Figure 1**, the absolute burden, though of mental disorders varies considerably across the life course and between sexes, with the highest DALY counts concentrated during adolescence and early adulthood, particularly between 15 and 34 years of age. Anxiety disorders and major depressive disorder account for a substantial proportion of this burden, especially among females, whereas conditions such as schizophrenia, autism spectrum disorders, and conduct disorder contribute relatively more among males[3]. Although the total number of DALYs decreases at older ages, mental disorders continue to generate a considerable burden throughout adulthood. Beyond their impact on health and disability, mental disorders also impose a substantial economic burden, which may be considerably greater than previously estimated[3].

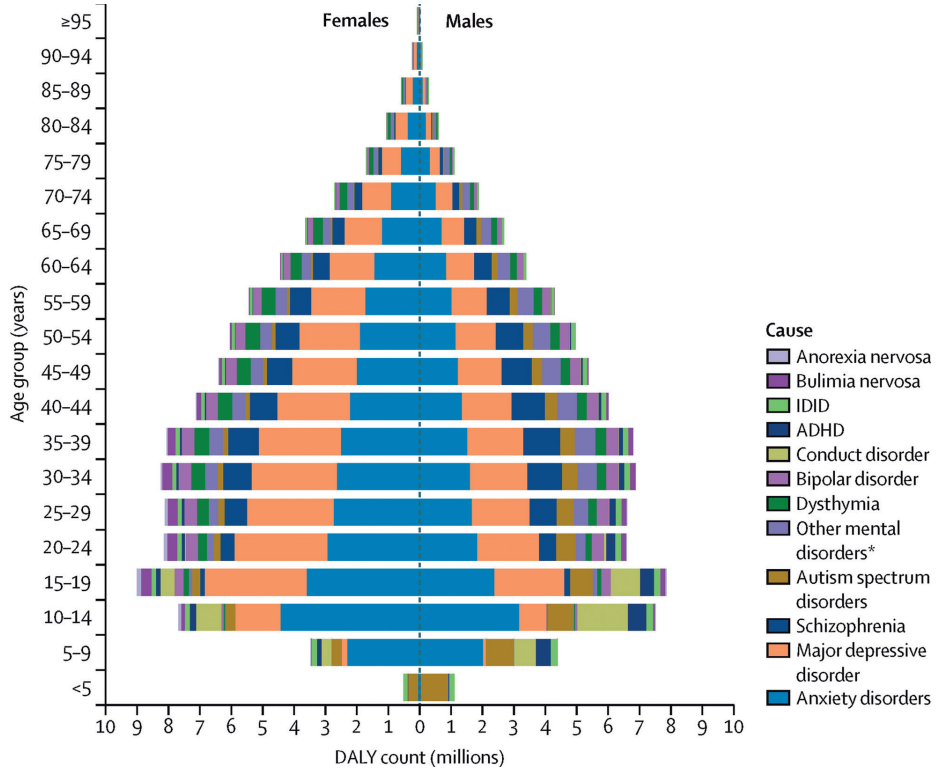


Figure 1. Global mental disorder DALYs, by age and sex. Reproduced from Santomauro et al.[2], with permission from Elsevier. Copyright © 2026 Elsevier Ltd. License N°: 6312560468827. Abbreviations: ADHD, attention-deficit hyperactivity disorder; DALYs, disability-adjusted life years; IDID, idiopathic developmental intellectual disability. *Other mental disorders include personality disorders without a comorbid mental or substance use disorder.

Neurocognitive disorders also represent a major and growing public health challenge, especially in the context of global population ageing. Dementia is one of the leading causes of disability and dependency among older adults worldwide[4]. An estimated 57.4 million people were living with dementia in 2019, and this number is projected to reach 152.8 million cases by 2050, representing an increase of approximately 166%[5]. This substantial rise is expected to be driven primarily by population growth and ageing, while the global age-standardized prevalence is projected to remain relatively stable (**Figure 2**). Due to its progressive nature and extensive care needs, dementia imposes a substantial burden on affected individuals, caregivers, healthcare systems, and society as a whole[6]. Consequently, its social and economic burden is also expected to rise substantially over the coming decades[5].

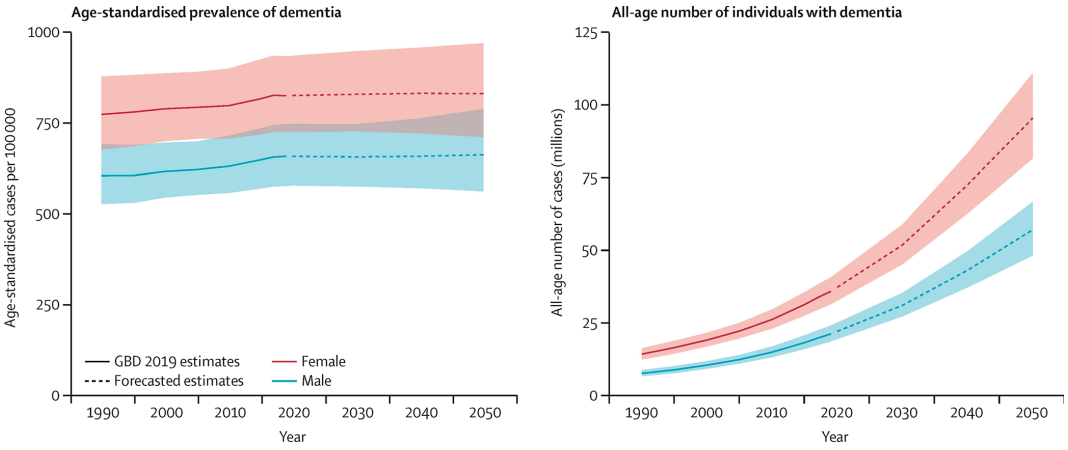


Figure 2. Global trends in age-standardized dementia prevalence and the number of people living with dementia, 1990–2050. Solid lines represent estimates for 1990–2019, whereas dashed lines represent projections for 2020–2050. Shaded areas indicate 95% uncertainty intervals. Reproduced from the GBD 2019 Dementia Forecasting Collaborators[5].

1.2. Definition and classification of mental and neurocognitive disorders

A mental disorder is characterized by clinically significant disturbances in cognition, emotional regulation, or behavior that reflect dysfunction in the psychological, biological, and/or developmental processes underlying mental functioning. These disturbances are typically associated with considerable distress and/or impairment in social, occupational, or other important areas of functioning[7].

According to the *Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition, Text Revision* (DSM-5-TR), mental disorders are a broad range of diagnostic categories, including neurodevelopmental disorders; schizophrenia spectrum and other psychotic disorders; bipolar and depressive disorders; anxiety disorders; obsessive-compulsive and related disorders; trauma and stressor related disorders; feeding and eating disorders; substance-related and addictive disorders; neurocognitive disorders; personality disorders; and other diagnostic conditions[7].

Despite their diagnostic heterogeneity, several mental disorders have an early age of onset[8]. Nearly half of first episodes occur before 18 years of age, and almost two-thirds develop before 25 years[9], underscoring the importance of research, prevention and early intervention during childhood, adolescence, and young adulthood[10].

Within this broad diagnostic spectrum, depressive disorders, eating disorders, and neurocognitive disorders are particularly relevant to the present doctoral thesis, as they constitute the main outcomes investigated across the studies included in this work. In these studies, mental and neurocognitive disorders were considered either as clinical diagnoses or as measures of symptom severity. Clinical diagnoses were established by physicians or trained health professionals using recognized diagnostic criteria, registry data, or self-reported medical diagnoses. Symptom severity, ranging from mild to severe, was assessed using validated observer-rated or self-reported instruments.

Depressive disorders

Depressive disorders are a group of conditions characterized by persistent feelings of sadness, emptiness, or irritability, accompanied by cognitive and somatic symptoms that significantly impair daily functioning. Although depressive disorders share common clinical features, they differ primarily in their duration, timing of onset, course, and underlying etiology[7]. As mentioned in the previous section, depression is one of the most prevalent and disabling mental disorders worldwide, affecting approximately 4% of the global population[11,12] and 6.5% of the European population[13].

Importantly, the clinical relevance of depression extends beyond formally diagnosed depressive disorders. Subclinical depressive symptoms are also clinically relevant and have been associated with impaired overall health, reduced functional capacity, poorer quality of life, increased healthcare utilization, and a higher risk of subsequently developing major depressive disorder[14,15]. Therefore, considering depressive symptoms across the full spectrum of severity may offer a more thorough understanding of their impact than focusing solely on clinical diagnoses.

The manifestation and prevalence of depressive symptoms vary substantially across the life course[16,17]. Although depression can occur at different ages, the prevalence of depressive symptoms is particularly high during young adulthood[18–20]. This heightened vulnerability may be attributed to the substantial developmental processes and social challenges characterizing this life stage, such as the transition to adulthood and the adoption of new roles and responsibilities[21]. These changes may contribute to increased psychological stress and vulnerability to depressive symptoms[22]. Furthermore, depression during young adulthood has been associated with an increased risk of persistence or recurrence later in life, suggesting that this developmental period may represent a critical window for reducing the long-term burden of depression[23]. Nevertheless, depressive disorders remain clinically relevant throughout the life course, and their determinants and consequences may differ across age groups.

Given their high prevalence, frequent early onset, potentially recurrent course, and long-term consequences[24,25], identifying modifiable factors associated with depressive symptoms has become a major public health priority.

Neurocognitive disorders

Neurocognitive disorders, which include delirium, mild and major neurocognitive disorders, and their various etiological subtypes, are a group of acquired conditions characterized by a decline in cognitive functioning relative to a previously attained level of performance. Although cognitive deficits are common across a wide range of mental disorders, only those in which cognitive impairment constitutes the primary clinical manifestation are classified as neurocognitive disorders[7].

According to the DSM-5-TR, neurocognitive disorders may involve impairment in one or more cognitive domains, including complex attention, executive function, learning and memory, language, perceptual-motor function, and social cognition (**Figure 3**). Cognitive impairment represents the clinical manifestation of these disorders and may result from a range of underlying diseases or conditions, such as Alzheimer's disease, Lewy body disease, cerebrovascular disease, Parkinson's disease, frontotemporal degeneration, or traumatic brain injury. They have the potential to compromise an individual's capacity to perform daily activities and maintain their independence over time[7].

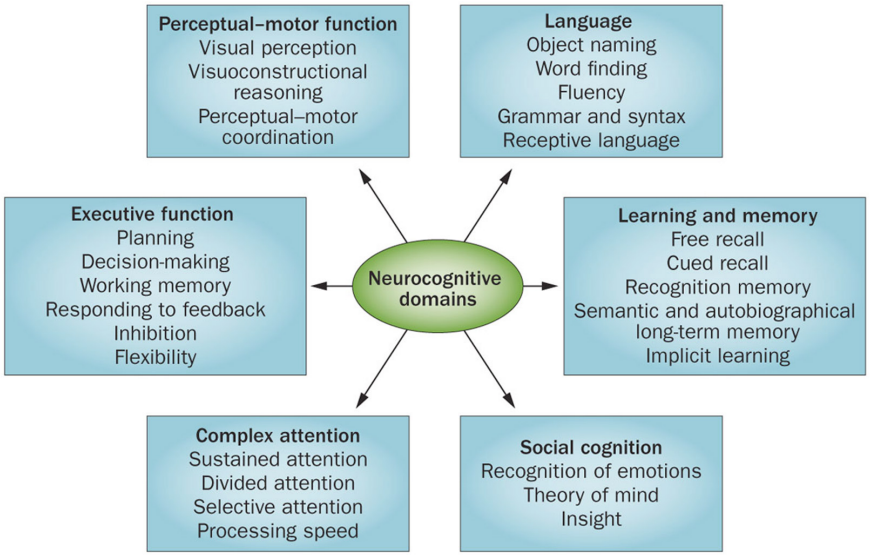


Figure 3. Cognitive domains affected in neurocognitive disorders. Reproduced from Sachdev et al. 2014[26], with permission from Springer Nature. Copyright © 2014 Springer Nature. License Nº: 6312931048997.

The distinction between major and mild neurocognitive disorders is primarily based on the underlying etiology, the pattern of progression, the severity of cognitive decline, and their associated clinical features[7]. In mild neurocognitive disorder, cognitive deficits do not interfere with the individual's capacity for independence in daily activities, although greater effort, compensatory strategies, or accommodations may be required. In major neurocognitive disorders, this refers to the clinical syndrome produced when cognitive decline becomes sufficiently severe to compromise functional independence[7].

The diagnosis of major neurocognitive disorders largely captures what has traditionally been understood as dementia. Dementia is therefore not a single disease, but a clinical syndrome that can arise from different underlying etiologies, with Alzheimer's disease being the most common[27]. Accordingly, Alzheimer's disease is an underlying disease, cognitive impairment is one of its principal clinical manifestations, and dementia or major neurocognitive disorder describes the syndrome that develops when this impairment substantially affects every day functioning.

Although the onset, clinical course, and progression of neurocognitive disorders vary considerably across individuals, part of this variability can be explained by the influence of risk factors, which are generally classified as non-modifiable and modifiable[6,28]. From a public health perspective, modifiable risk factors are of particular relevance because they represent potential targets for preventing or delaying cognitive decline and reducing the risk of major neurocognitive disorders[29,30]. This is especially important given that up to 45% of dementia risk has been estimated to be attributable to modifiable risk factors[31]. The 2024 Lancet Commission identified 14 potentially modifiable risk factors operating across different stages of the life course and estimated that addressing these factors could theoretically prevent or delay nearly half of dementia cases (**Figure 4**)[31].

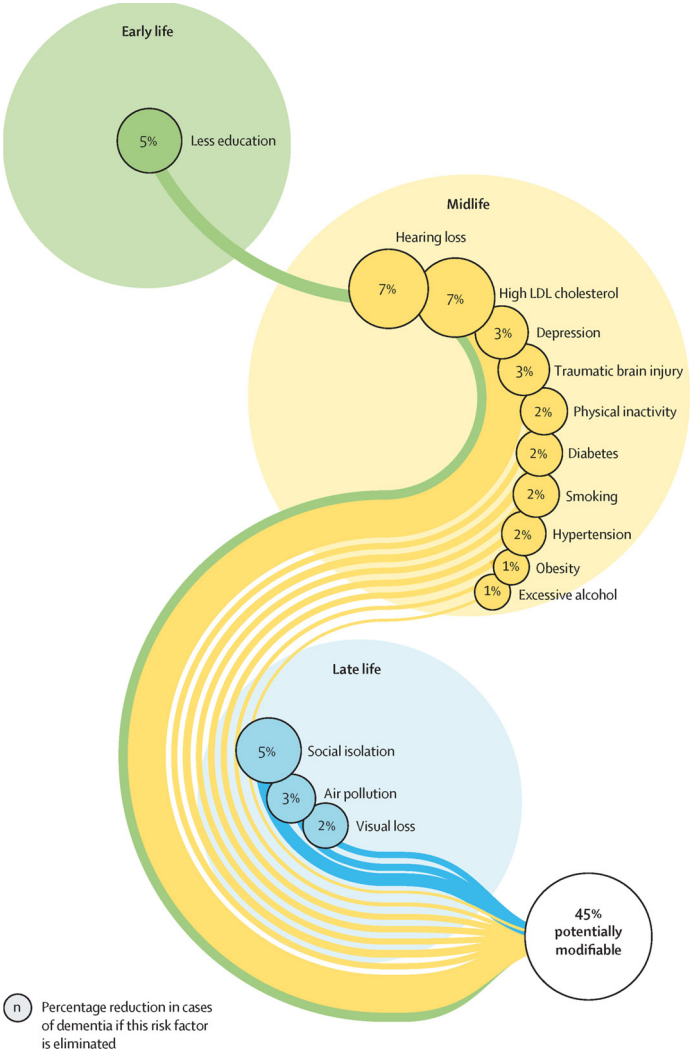


Figure 4. Potentially modifiable risk factors for dementia across the life course. Reproduced from Livingston et al. 2024[31], with permission from Elsevier. Copyright © 2024 Elsevier Ltd. License Nº: 6312931306188.

Eating Disorders

Eating disorders (EDs) comprise a spectrum of psychiatric conditions characterized by persistent disturbances in eating behaviors that adversely affect food intake, nutritional status, physical health, and psychosocial functioning[7]. According to the DSM-5-TR, this category includes pica, rumination disorder, avoidant/restrictive food intake disorder, anorexia nervosa, bulimia nervosa, binge-eating disorder, and other specified feeding or

eating disorders[7]. EDs are associated with substantial physical and psychological morbidity, impaired quality of life, and an increased risk of premature mortality, particularly in severe and persistent cases[32].

The etiology of EDs is multifactorial, involving complex interactions among genetic, biological, psychological, sociocultural, and environmental determinants[33–35]. Similarly to the commented for depression, rather than clinically diagnosed EDs, a broader spectrum of disordered eating symptoms constitutes an important subclinical phenomenon that may precede or predict the development of full-syndrome EDs. This spectrum includes abnormal behaviors such as restrictive dieting, binge-eating episodes, excessive preoccupation with body image, or driven exercise [36,37]. While these behaviors do not necessarily meet diagnostic criteria, they may be understood as an interconnected process where individual symptoms influence and reinforce each other instead of representing manifestations of a single underlying disorder[38].

Most EDs emerge before 25 years of age, making adolescence and young adulthood critical periods for their development[39]. As shown in **Figure 5**, the prevalence of EDs increases markedly during adolescence and generally reaches its highest levels during early adulthood. Prevalence is substantially higher among females than males for most diagnoses, although the magnitude and age distribution vary according to the specific disorder[40]. Other specified feeding or EDs and binge-eating disorder account for a considerable proportion of cases, particularly during early and middle adulthood[40]. These patterns underscore the importance of prevention strategies during childhood, adolescence, and young adulthood, as well as early detection and sustained access to treatment because of the potential persistence and recurrence of symptoms later in life[41].

The global burden of EDs is projected to increase in the coming years. By 2040, the age-standardized prevalence is projected to reach 373.5 cases per 100,000 population, with substantially higher rates among females than males, at 466 and 268 cases per 100,000 population, respectively. Similarly, incidence is projected to increase by 8.1%, while the burden attributable to EDs is expected to reach 79.6 DALYs per 100,000 population[42].

A better understanding of the factors associated with ED symptoms is therefore essential for developing effective public health, clinical, and educational strategies aimed at preventing these disorders and reducing their individual and societal burden[43].

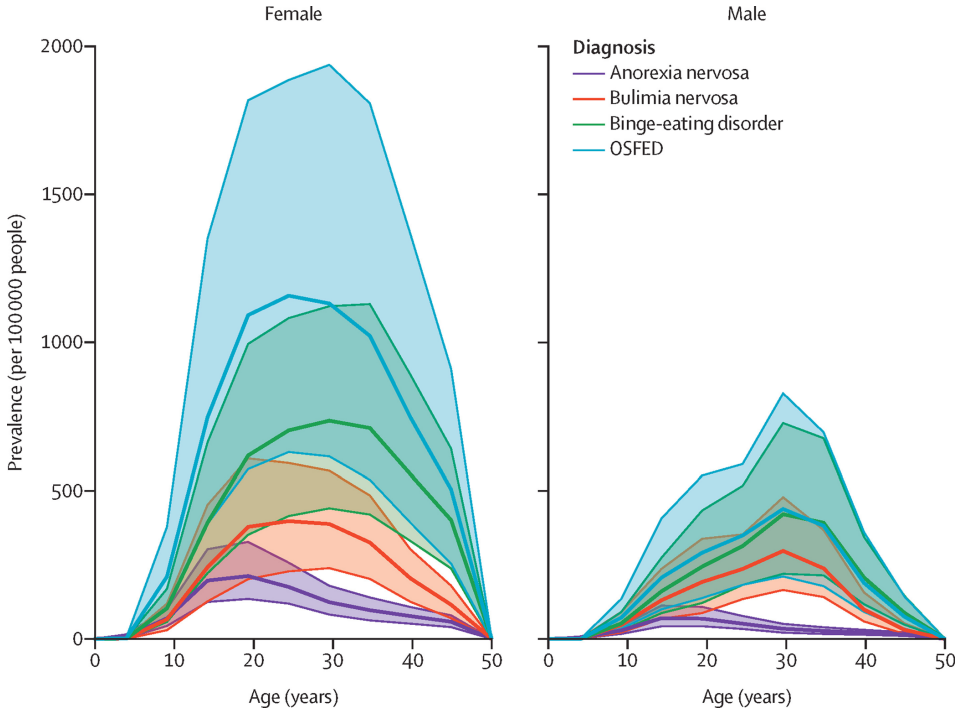


Figure 5. Global prevalence of eating disorders by diagnosis, sex, and age in 2019. Reproduced from Santomauro et al. 2021[40]. Abbreviations: OSFED: other specified feeding or eating disorder.

Orthorexia nervosa: an emerging eating-related condition

The term orthorexia nervosa (ON), derived from the Greek words "ortho", meaning correct, and "orexis", meaning appetite, was coined to describe an obsessive preoccupation with consuming foods perceived as healthy, pure, or "correct"[44]. This preoccupation may be based on characteristics such as nutritional composition, purity, naturalness, processing, ecological production, or sustainability[45]. Although an interest in healthy eating is not inherently pathological, ON is characterized by an excessive and rigid pursuit of dietary purity that may progressively impact psychological well-being and daily functioning[46].

Individuals presenting orthorexic features may devote substantial time and attention to planning, obtaining, preparing, and evaluating food. Dietary rules may become increasingly restrictive, and deviations from these rules may provoke guilt, anxiety, or self-punitive responses[47]. In severe cases, this pattern may lead to nutritional deficiencies, unintended weight loss, social isolation, and clinically significant impairment. However,

ON was not originally conceptualized as a formally recognized ED, and its boundaries with health-conscious eating and other psychiatric conditions remain a matter of debate[46].

A recent meta-analysis including data of participants aged 13–93 years from 18 countries reported a pooled prevalence of orthorexic symptoms of 27.5%[48]. However, research on ON remains methodologically challenging because no universally accepted diagnostic criteria have been established, and many available screening instruments have shown limited or inconsistent psychometric properties. Consequently, prevalence estimates vary substantially across studies and should be interpreted cautiously because some instruments may identify healthy eating interests or behaviors rather than clinically relevant psychopathology[49–51].

Although ON is not currently included as a distinct ED diagnosis in the DSM-5-TR, some authors have suggested that it may be conceptualized within the residual category of "Other Specified Feeding or Eating Disorders" (OSFED), given its clinical overlap with disorders such as anorexia nervosa, bulimia nervosa, avoidant/restrictive food intake disorder, and obsessive-compulsive disorder[45,48]. These proposed relationships reflect overlapping clinical features rather than diagnostic equivalence. Such features may include restrictive eating behaviors, intrusive or persistent food-related thoughts, rigid dietary rules, self-punitive responses, escalating food restriction, rigid meal planning, and distress following perceived dietary transgresions[47,52,53]. These behavioral and cognitive patterns are similar to those observed in established EDs[46]. Nevertheless, ON may differ from conventional EDs in that the principal concern is generally focused on the perceived quality, healthfulness, or purity of food rather than primarily on body weight or shape[49].

Given the lack of clear diagnostic criteria and the conceptual overlap with other psychiatric conditions, the diagnostic classification of ON remains unresolved. Further research is, therefore, needed to improve the conceptualization, assessment, and diagnostic classification, of ON to distinguish pathological orthorexic features from non-pathological health-conscious eating, and to expand the available evidence across more diverse populations and age groups.

2. MODIFIABLE DETERMINANTS OF MENTAL AND NEUROCOGNITIVE DISORDERS

Although genetic susceptibility contributes to the development of mental and neurocognitive disorders[54,55], their occurrence and progression are also influenced by a broad range of potentially modifiable determinants[56–58].

These determinants include behavioral, clinical, social, and environmental factors that may be modified through individual actions, clinical interventions, or population-level policies. Lifestyle-related behaviors include dietary habits, physical activity, sleep, sedentary activities, smoking, and alcohol consumption, among others[57].

The present doctoral thesis focuses on two potentially modifiable factors: dietary patterns and cardiorespiratory fitness, with the latter being strongly influenced by regular physical activity, although also determined by genetic and other individual characteristics[59]. The following sections conceptualize these two modifiable factors and summarize the current evidence regarding their associations with mental and neurocognitive disorders.

2.1. Cardiorespiratory fitness

Cardiorespiratory fitness (CRF) is a component of physical fitness[60] and is defined as the ability of multiple physiological systems to efficiently deliver and utilize oxygen during sustained physical activity[61]. CRF reflects the integrated functioning of the cardiovascular, respiratory, and musculoskeletal systems, and is therefore considered an objective indicator of functional capacity and the ability to sustain prolonged physical exertion[62].

Over recent decades, CRF has become one of the most robust predictors of overall health status[63,64]. A substantial body of epidemiological evidence has indicated that higher levels of CRF were associated with a lower risk of multimorbidity, all-cause mortality, cardiovascular disease, type 2 diabetes, several types of cancer, and other chronic conditions[64–68]. Longitudinal evidence further suggests that maintaining higher CRF may be associated with more favorable trajectories of chronic disease accumulation over time (**Figure 6**)[68]. However, international trends indicate that CRF levels have declined since the 1980s, suggesting an unfavorable change in an important marker of population health[69] and highlighting the need to promote maintenance and improvement of CRF as a public health priority.

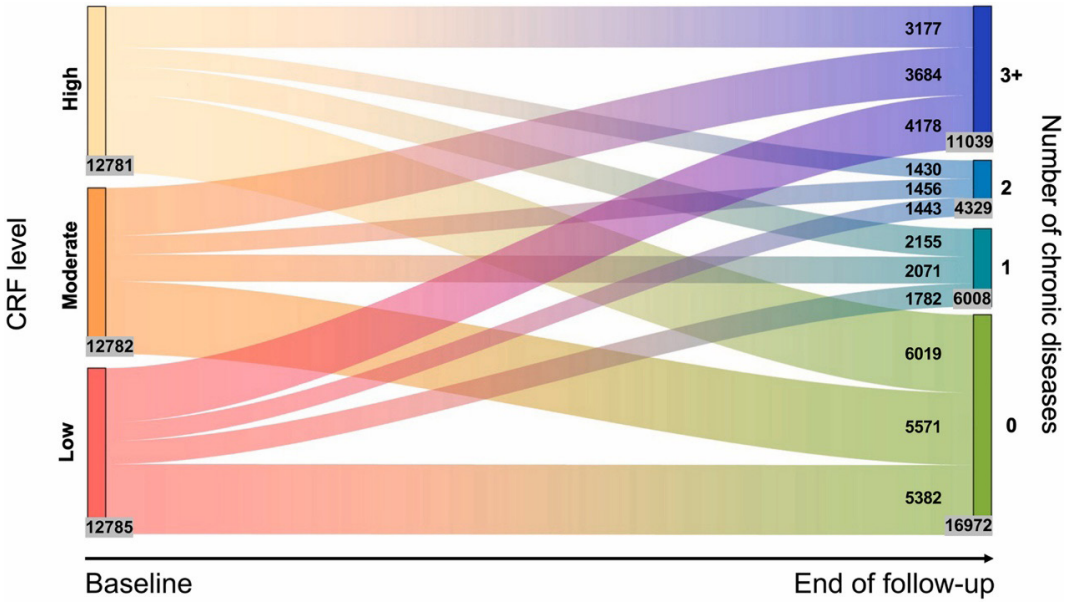


Figure 6. Changes in chronic disease status according to cardiorespiratory fitness level. Reproduced from Xu et al. 2025[68]. Box height and stripe thickness reflect the number of participants represented in each state.

Although CRF is partly determined by genetic factors[70,71], regular physical activity is one of its main modifiable determinants[59,72,73]. Nevertheless, the relationship between physical activity and CRF is not interchangeable: physical activity refers to behavior, whereas CRF represents an attribute that reflects the body's physiological capacity and its adaptation to habitual activity[74]. CRF is also influenced by age, sex, body composition, health status, and other lifestyle habits[75].

CRF can be evaluated in both laboratory and field settings using direct or indirect methods based on maximal or submaximal exercise tests[62]. The gold standard for quantifying CRF is the direct measurement of maximum or peak oxygen consumption (VO_2max or VO_2peak) during cardiopulmonary exercise testing with respiratory gas analysis[62]. However, due to the logistical and economic limitations of these tests (i.e., specialized equipment, trained personnel, and considerable time and financial resources), field-based exercise tests and non-exercise prediction equations are frequently used in epidemiological studies and clinical practice to provide a valid and feasible measure of CRF[76].

CRF varies considerably across the life course. During childhood and adolescence, CRF generally develops in parallel with growth and biological maturation[77]. After reaching its peak in early adulthood, absolute CRF progressively declines with advancing age, and the rate of decline may accelerate in later adulthood[78]. Although this age-related decline reflects

normal physiological changes, evidence suggests that its magnitude can be attenuated through regular physical activity and the maintenance of healthy lifestyles[75]. Consequently, promoting and preserving CRF throughout the life course may represent an important strategy for improving health and maintaining functional capacity[79].

Cardiorespiratory fitness and mental and neurocognitive disorders

Beyond these well-established benefits for physical health, increasing attention has been directed over recent decades toward the relationship between CRF and mental and neurocognitive health[80]. Evidence suggests that individuals with higher levels of CRF may have a lower risk of developing some mental and neurocognitive disorders, including depression and dementia[81,82].

Among these conditions, depression has been the most extensively investigated in relation to CRF. An inverse association between CRF and depression has been observed in children, adolescents, and adults[83,84]. A pooled analysis including more than one million adults indicated a graded inverse association, with individuals presenting low and moderate CRF levels exhibiting 75% and 23% higher risks of incident depression, respectively, than those with high CRF[85]. Prospective evidence regarding CRF and anxiety remains limited. In one adult cohort, a decline from moderate or high estimated CRF to low estimated CRF was associated with a higher risk of incident anxiety, whereas an increase from moderate to high estimated CRF was associated with a modestly lower risk[86]. In a large cohort of children and adolescents, better CRF performance was also associated with a lower subsequent risk of anxiety in both females and males[87].

An inverse association has also been observed between CRF and the risk of neurocognitive disorders. In a long-term cohort study of adult females, high CRF was associated with more than an 80% lower risk of developing dementia[88]. A meta-analysis of prospective cohort studies also suggested that higher CRF was associated with a lower subsequent risk of dementia, although the estimate was based on a limited number of studies and should therefore be interpreted with caution[82]. Nevertheless, prospective evidence remains limited for several outcomes, and findings are not yet consistent across age groups, populations, and methods of CRF assessment. A comprehensive synthesis of the available evidence is therefore needed to clarify the strength and consistency of these associations and to identify important research gaps.

Potential pathways linking cardiorespiratory fitness to mental and neurocognitive health

Several complementary biological pathways have been proposed to explain the associations between CRF and better mental and neurocognitive health. Regular exercise, which is a major modifiable determinant of CRF, induces structural, cellular, and molecular adaptations in the brain that may enhance neuroplasticity and support cognitive and emotional functioning[89–91]. Higher CRF has also been associated with lower levels of systemic inflammation and oxidative stress, two biological processes that are strongly implicated in the pathophysiology of mental and neurocognitive disorders[89,92].

Higher CRF levels are also associated with more favorable cardiovascular and cerebrovascular function, including enhanced vascular health and cerebral blood flow, which may contribute to maintaining brain integrity[89]. These adaptations may reduce inflammatory and oxidative damage and help preserve synaptic function and neurotransmitter regulation, processes implicated in the development and progression of disorders such as depression[92] and dementia[89]. Furthermore, regular exercise and higher CRF have been shown to preserve hippocampal structure and function. This may be particularly relevant because the hippocampus plays an essential role in memory, emotional regulation, and cognitive resilience[89].

Other potentially relevant pathways include enhanced neurotrophic signaling, improved metabolic regulation, reduced hypothalamic–pituitary–adrenal axis dysregulation, and greater cognitive reserve[93–95]. Because CRF is influenced by physical activity, genetic characteristics, health status, body composition, and other lifestyle factors, it should be understood as an integrative physiological marker rather than as an isolated exposure[75]. Beyond these biological pathways, psychosocial, environmental, and behavioral mechanisms may also contribute to the association between CRF and mental and neurocognitive health, although they have been less frequently examined in relation to CRF specifically. Evidence from the broader physical activity literature suggests that factors such as self-efficacy, self-esteem, social support, stress regulation, sleep, and exposure to supportive environments may partly explain the beneficial relationship between physical activity and mental health[96]. Therefore, the association between CRF and mental and neurocognitive health is likely to be multifactorial, involving the interaction of biological, behavioral, psychosocial, and environmental pathways.

2.2. Plant-based dietary patterns

In recent years, plant-based dietary patterns have gained considerable attention among researchers and the general population[97]. Among the more restrictive forms of plant-based eating, vegetarian and vegan diets show substantial regional variation in prevalence, with estimates typically ranging from 1% to 9% and reaching up to 36% in South Asia[98,99]. This growing interest reflects the diverse motivations underlying their adoption, including health promotion, environmental sustainability, animal welfare, ethical beliefs, cultural traditions, and religious practices[97,100–105].

Despite their increasing visibility, there is still considerable heterogeneity in the terminology used to describe plant-based dietary patterns. The literature employs a variety of definitions[106], reflecting the broad range of dietary approaches encompassed by this concept. In general, plant-based dietary patterns are characterized by a greater relative intake of plant-derived foods, such as legumes, fruits, vegetables, nuts, seeds, and whole grains, together with a lower consumption of animal-derived foods[107–109]. Rather than representing a single dietary pattern, they represent a continuum that differs according to the type and quantity of animal-source foods consumed[107]. This continuum includes vegetarian and vegan diets, as well as less restrictive dietary patterns such as flexitarian diets, including pescatarian and semi-vegetarian diets (**Figure 7**). In addition, predominantly plant-based dietary patterns, including the Mediterranean diet, the Dietary Approaches to Stop Hypertension diet, the Healthy U.S.-Style Dietary Pattern, the Planetary Health Diet, and the Nordic diet, also emphasize plant foods while allowing varying amounts of animal-derived products[108].

Given this heterogeneity, the present doctoral thesis adopts an integrative approach. Specifically, it examines both restrictive plant-based dietary patterns, namely vegetarian and vegan diets, which exclude all types of meat or animal-derived foods, and broader plant-based patterns that emphasize plant-derived foods while allowing some consumption of animal-source foods. The latter are evaluated using dietary quality indices, such as the Plant-Based Diet Index (PDI), which capture adherence to plant-based eating patterns beyond conventional dietary classifications.

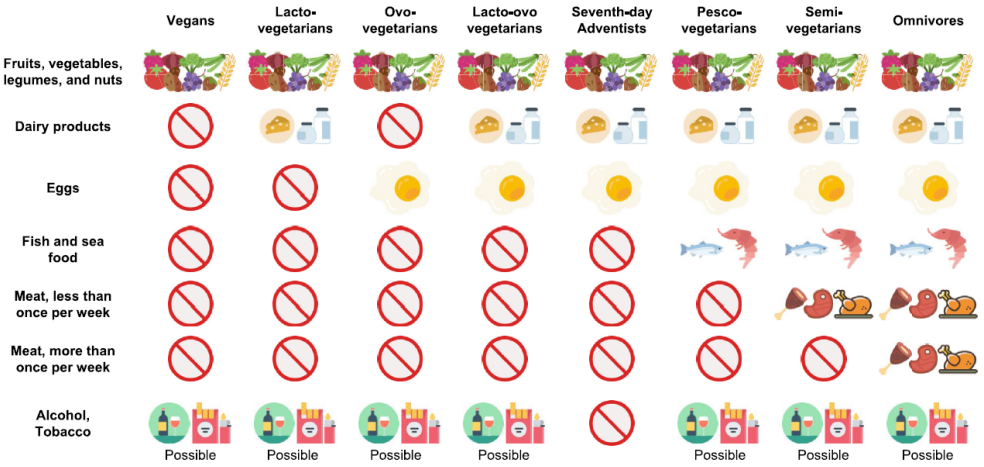


Figure 7. Classification of dietary patterns from vegan to omnivorous diets. Reproduced from Oussalah et al. 2020[110], with permission from Elsevier. Copyright © 2020 Elsevier Ltd. License Nº: 6312940565291.

Vegan diets represent one of the most restrictive plant-based patterns, as they exclude meat, fish, dairy products, eggs, and other foods of animal origin. Veganism is a broader philosophy and lifestyle that seeks to avoid animal exploitation beyond dietary choices[111]. From a health perspective, appropriately planned vegan diets have been associated with improvements in several cardiometabolic risk markers and may contribute to the prevention of some chronic diseases[112]. However, potential concerns have also been raised regarding the adequacy of specific nutrients and certain outcomes, including bone health[112]. Consequently, vegan diets require careful planning, individualization, and, when necessary, supplementation to avoid nutritional deficiencies that could compromise health[113].

Vegetarian diets are distinguished by the exclusion of meat and fish while emphasizing foods such as legumes, fruits, vegetables, nuts, seeds, and grains[114]. Their classification varies according to the animal-derived foods that remain included. Ovo-vegetarian diets exclude meat, fish, and dairy products but include eggs. Lacto-vegetarian diets exclude meat, fish, and eggs but include dairy products. Lacto-ovo-vegetarian diets include both eggs and dairy products while excluding meat and fish[115].

Furthermore, there exist diets that, while predominantly plant-based, incorporate a modest amount of meat. These dietary regimens are designated as flexitarian diets, which are further categorized into pescatarian diets, encompassing fish and seafood, and semi-vegetarian diets, involving the sporadic consumption of meat (e.g., red meat, pork, or chicken)[110].

When appropriately planned, these dietary patterns can adequately support nutritional status throughout the life course by providing the energy and essential nutrients required for growth, development, and healthy ageing[116]. Dietary patterns that emphasize whole grains, fruits, vegetables, nuts, and legumes have been associated with numerous health benefits[117], including lower risks of all-cause mortality[118,119], cardiovascular disease[118,119], type 2 diabetes[120,121], some cancers[119,120], and hypertension[122]. These potential benefits, together with proposed effects on cardiometabolic, gastrointestinal, and other dimensions of health, are summarized in **Figure 8**.

However, these health benefits cannot be attributed solely to the restriction or exclusion of animal-source foods. They also depend on the overall nutritional quality of the diet, particularly the extent to which it emphasizes nutrient-dense and minimally processed plant foods. A plant-based diet may still be nutritionally poor when it is dominated by refined grains, sugar-sweetened beverages, confectionery products, or other highly processed foods. The quality of diet can be characterized through multiple dimensions (e.g., dietary diversity, nutrient adequacy, balance and moderation, and patterns of food consumption) is influenced by various factors, including age, educational and socioeconomic status, and geographical context[123]. These factors contribute to significant variations in dietary habits across different populations. Poor diet quality contributes to multiple forms of malnutrition, including undernutrition, overweight, obesity, and persistent micronutrient deficiencies[117]. High-quality diets provide adequate nutrients and energy, are safe, prevent all forms of malnutrition, promote overall health, and, ideally, are environmentally sustainable[124]. Therefore, whenever feasible, studies should differentiate between healthful and less healthful plant-based dietary patterns when assessing their associations with health outcomes[107].

In this context, the Plant-Based Diet Index (PDI) was developed to quantify adherence to an overall plant-based dietary pattern. In turn, the Healthy Plant-Based Diet Index (hPDI) and the Unhealthy Plant-Based Diet Index (uPDI) were proposed to differentiate plant-based diets according to the nutritional quality of the foods consumed[126,127]. The development of these indices is based on the classification of 18 food groups into three broad categories according to their nutritional characteristics. Healthy plant foods include fruits, vegetables, whole grains, nuts, legumes, vegetable oils, and tea or coffee, whereas less healthy plant foods comprise fruit juices, refined grains, potatoes, sugar-sweetened beverages, and sweets or desserts. A third category includes animal-derived foods, such as animal fats, dairy products, eggs, fish and seafood, red and white meat, and other miscellaneous animal-based foods[126]. The overall PDI assigns positive scores to all plant foods and reverse scores to animal foods. By contrast, the hPDI assigns higher scores to healthy plant foods, whereas the uPDI assigns higher scores to less healthy plant foods.

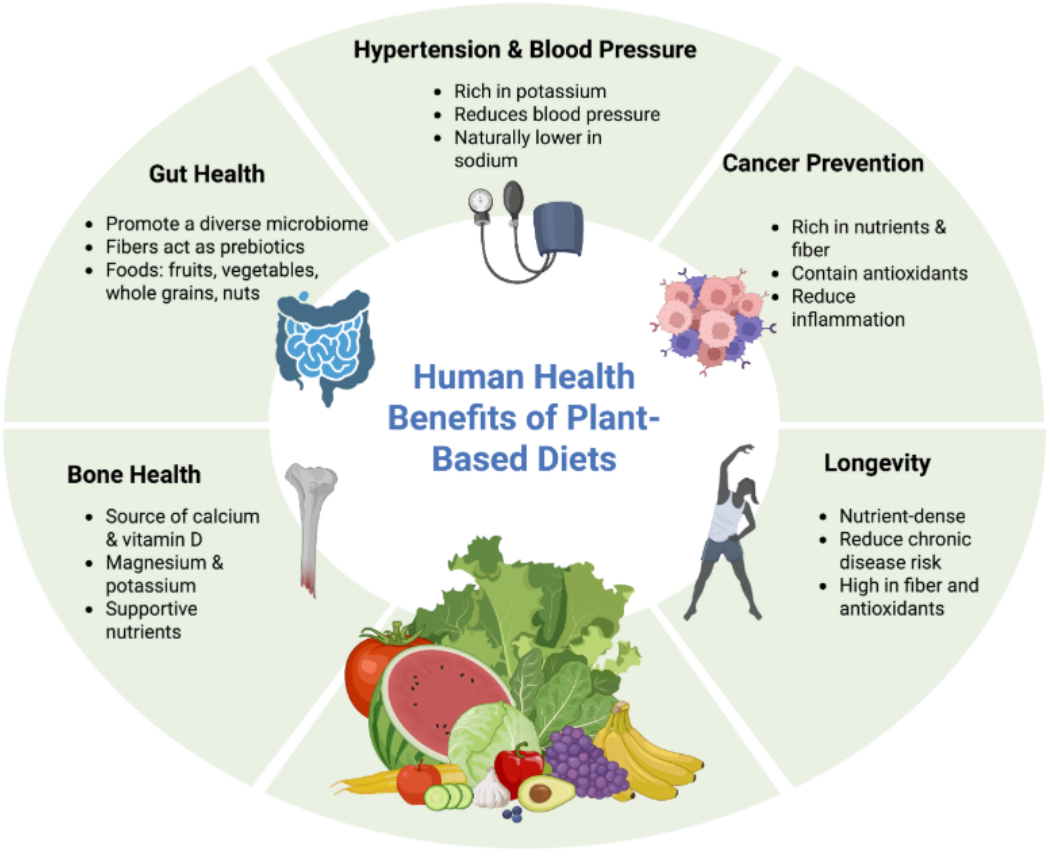


Figure 8. Health benefits of plant-based diets. Reproduced from Koli et al. 2025[125].

Although the associations of high-quality plant-based dietary patterns with physical health have been widely investigated, considerably less is known about their potential role in mental health[128]. Moreover, restrictive vegetarian and vegan diets and broader plant-based dietary indices represent related but distinct exposures and may have different implications for mental health.

Plant-based dietary patterns and mental disorders

Beyond its fundamental role in physical health, diet has increasingly been recognized as an important determinant of mental health throughout the life course[129,130]. Early research on the relationship between nutrition and mental health focused primarily on individual nutrients and their potential influence on brain function and psychological outcomes[131].

However, the study of overall dietary patterns in relation to mental health is comparatively more recent, with epidemiological interest increasing substantially over the past two decades[132]. This shift reflects the recognition that foods are not consumed in isolation, but as part of complex dietary patterns that may better capture real-world eating behaviors and the cumulative or synergistic effects of foods consumed in combination[133,134].

Within the field of nutritional psychiatry, which examines the relationships between diet, nutritional factors, and mental health, plant-based dietary patterns have received increasing attention as potentially relevant exposures for a range of mental health outcomes[134]. Two complementary approaches have generally been used to investigate these relationships. The first evaluates the degree of adherence to predominantly plant-based dietary patterns and their nutritional quality, commonly through indices such as the PDI, hPDI, and uPDI. The second compares individuals following vegetarian or vegan diets with those following omnivorous or other dietary patterns. Although related, these approaches capture different aspects of dietary behavior and should not be considered interchangeable.

Recent evidence suggests that greater adherence to high-quality plant-based dietary patterns may be associated with more favorable mental health outcomes, particularly with a lower risk of depression in middle-aged and older adults[128]. By contrast, plant-based patterns characterized by a high intake of refined grains, sugar-sweetened beverages, sweets, and other less healthy plant foods may not confer the same benefits and could be associated with less favorable mental health outcomes[128]. This distinction highlights the importance of considering diet quality rather than assuming that all plant-based dietary patterns are inherently healthy.

As discussed earlier, these dietary patterns may be adopted for a wide range of reasons, and the motivations underlying their adoption may shape their associations with psychological outcomes[135]. In particular, the exclusion of animal-derived foods may reflect a stable ethical or cultural choice, but in some individuals, it may also coexist with restrictive eating behaviors, weight-control practices, or heightened concerns about food purity[136,137]. Therefore, dietary identity alone cannot be interpreted as evidence of either healthy or pathological eating behavior.

Research examining vegetarian and vegan diets in relation to ED symptoms has produced inconsistent findings[138–140]. Some studies have raised concerns that the exclusion of entire food groups could be associated with restrictive eating or serve as a socially acceptable framework for dietary restraint[137]. However, it remains uncertain whether vegetarian or vegan dietary status is independently associated with ED symptoms or whether any observed associations are explained by factors such as motivations for dietary adoption,

body image concerns, and pre-existing disordered eating. The relationship between vegetarian and vegan diets and ON symptoms also remains unclear, and interpretation is complicated by the absence of universally accepted diagnostic criteria, the use of different assessment instruments[51,141], and the predominantly cross-sectional nature of the available evidence. Further synthesis is therefore needed to clarify these relationships and identify relevant methodological limitations and research gaps.

Despite growing evidence on plant-based diets and mental health, important knowledge gaps remain. Nutritional epidemiology is inherently complex, given the challenges of accurately assessing dietary intake, accounting for changes in diet over time, and disentangling dietary effects from other lifestyle, social, and health-related factors[142]. These challenges may be particularly relevant for mental disorders, where the relationship with diet may be bidirectional. Dietary habits may influence psychological outcomes through several biological and behavioral pathways, while mental disorders themselves may also affect appetite, food choices, eating behaviors, and overall diet quality[143,144].

Potential pathways linking plant-based dietary patterns to mental health

The distinctive nutritional composition of high-quality plant-based dietary patterns provides several biologically plausible mechanisms through which they may influence mental health. Fruits, vegetables, legumes, nuts, whole grains, and extra-virgin olive oil are rich sources of dietary fiber, polyphenols, unsaturated fatty acids, vitamins, minerals, and other bioactive compounds that may act synergistically to influence brain function[145,146]. Dietary fiber and polyphenols can modulate the composition and activity of the gut microbiota, promoting the production of short-chain fatty acids, which contribute to maintaining intestinal barrier integrity, regulating immune responses, and reducing chronic low-grade systemic inflammation[145,147]. In parallel, the antioxidant and anti-inflammatory properties of polyphenols may support the gut–brain axis and promote the expression of brain-derived neurotrophic factor (BDNF), a key mediator of neuroplasticity, learning, and emotional regulation[145].

Furthermore, healthy plant-based dietary patterns are generally rich in foods providing unsaturated fatty acids, including alpha-linolenic acid and other plant-derived fatty acids from nuts, seeds, and certain vegetable oils. These nutrients play an important role in maintaining neuronal membrane integrity, supporting neurotransmission, modulating neuroinflammatory pathways, and enhancing BDNF-related signaling[148]. Collectively, these plant foods provide dietary fiber, antioxidants, vitamins, minerals, and numerous bioactive compounds that have been associated with a lower likelihood of depression[149,150].

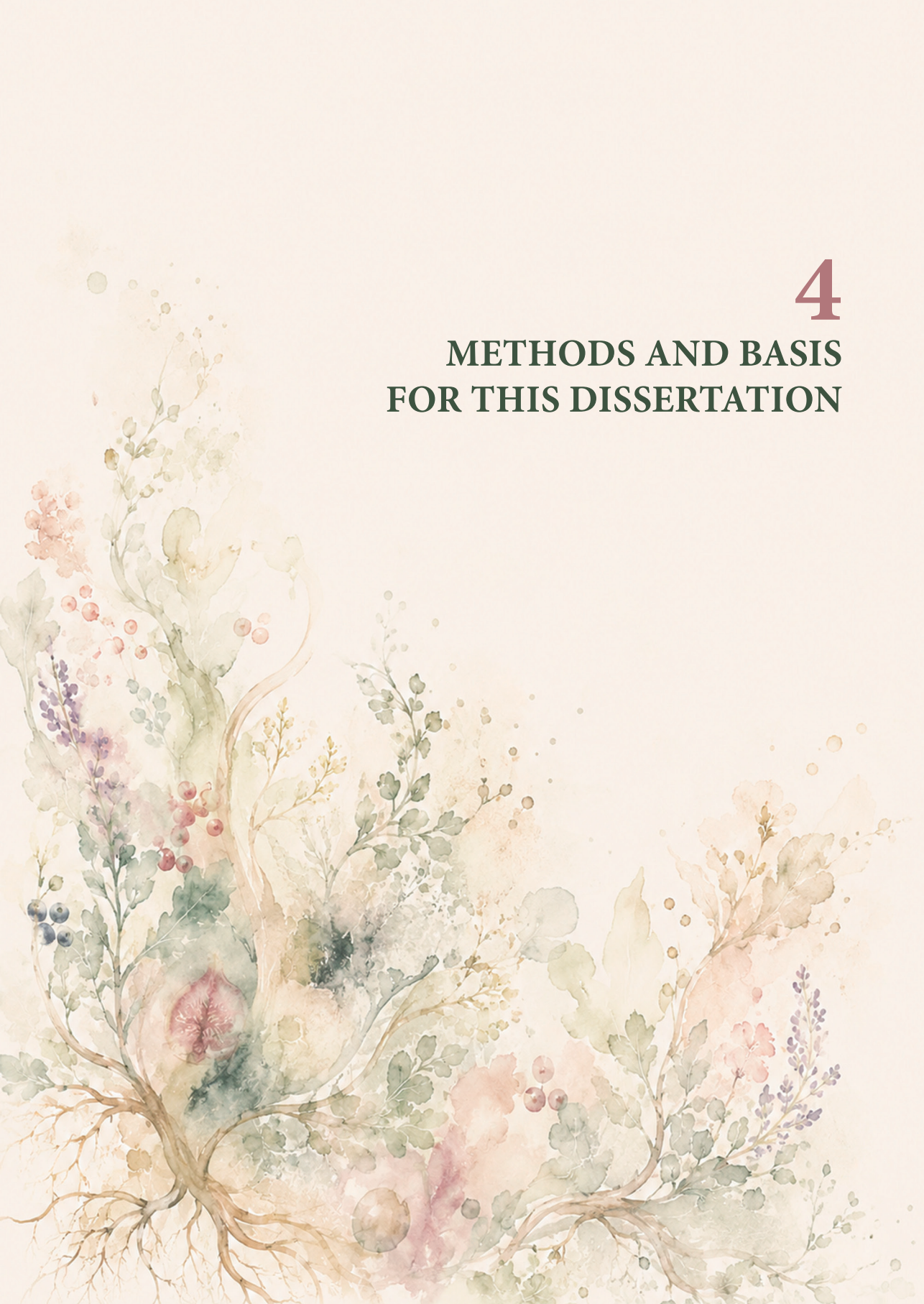
Taken together, these mechanisms provide biological plausibility for the potential influence of plant-based dietary patterns on brain function and mental health. However, these pathways remain complex and interrelated, and their relative contribution may vary according to the nutritional quality, composition, and degree of restriction of the dietary pattern. Moreover, these relationships may also be shaped by behavioral and psychosocial pathways, including dietary motivations, alignment with personal or ethical values, social identity, perceived social support, dietary rigidity, and difficulties participating in shared meals[135,151]. In addition, the accessibility, affordability, and availability of healthy plant foods may influence the choice of these types of diets[152] as well as their potential health effects.

Despite growing interest in plant-based dietary patterns and mental health, important gaps remain in the available evidence. Research on vegetarian and vegan diets in relation to ED and ON symptoms has not yet been comprehensively synthesized to clarify the magnitude and consistency of the observed associations and to identify the main methodological limitations and research gaps. In parallel, relatively little is known about the association between the nutritional quality of plant-based dietary patterns and depressive symptoms in young adults, particularly university students. These two gaps provide the rationale for the studies included in the present doctoral thesis.

Although the relationship between dietary patterns and neurocognitive disorders is also an emerging area of research, it was not directly examined in this thesis and is therefore considered a relevant direction for future research.

4

METHODS AND BASIS FOR THIS DISSERTATION



GENERAL METHODS

This doctoral thesis uses different epidemiological study designs to achieve its research objectives and provide a thorough understanding of the links between certain lifestyle factors and mental health outcomes. Integrating different methodological approaches enables evidence to be examined from various perspectives, combining evidence synthesis with original observational research. While the methodological procedures, ethical considerations and statistical analyses are detailed in each manuscript, the following section provides an overview of the main methodological approaches underlying this thesis.

Systematic review and meta-analysis

Systematic reviews offer a rigorous approach to synthesizing evidence by using transparent and reproducible predefined methods to identify, select and critically appraise all relevant studies addressing a specific research question. This structured methodology minimizes the risk of bias and offers a comprehensive overview of the available evidence. Where appropriate, a meta-analysis can be conducted to statistically combine the results of individual studies, providing an overall effect estimate and enhancing the precision of the available evidence.

Cross-sectional studies

There are many types of observational studies, which differ according to their objectives, how participants are selected, and when data is collected. Cross-sectional studies assess exposures and outcomes simultaneously at a single point in time within a defined population. This design is widely used in epidemiological research to estimate the prevalence of health conditions, describe population characteristics and examine potential associations between exposures and outcomes. However, because participants are not followed over time, cross-sectional studies cannot establish temporal relationships or causality. Nevertheless, they can provide valuable evidence for identifying potential risk factors and generating hypotheses for future longitudinal research.

BASIS FOR THIS DISSERTATION

This doctoral thesis is based on the following statements:

The influence of cardiorespiratory fitness on the risk of mental and neurocognitive disorders across the lifespan

Mental and neurocognitive disorders are among the leading causes of disability worldwide, highlighting the need to identify modifiable factors that may contribute to their prevention. Cardiorespiratory fitness, a key indicator of overall physical health, has emerged as a promising predictor of several chronic health outcomes, and may also play an important role in mental and neurocognitive health through multiple biological and psychological mechanisms. However, the available evidence remains limited, as previous evidence syntheses included few cohort studies, focused on a restricted number of outcomes, and were largely confined to adult populations. Therefore, a comprehensive, systematic review and meta-analysis was warranted to synthesize the available longitudinal evidence on the associations between cardiorespiratory fitness and the risk of mental and neurocognitive disorders across the lifespan.

The associations between vegetarian and vegan diets and orthorexia nervosa symptoms in adults

Orthorexia nervosa is characterized by an obsessive preoccupation with eating foods perceived as healthy or "pure." This often leads to restrictive eating behaviors, psychological distress, and impairment in daily functioning. While orthorexia nervosa has not yet been formally recognized as a distinct psychiatric disorder, there is growing evidence that orthorexic symptoms are relatively common and may overlap with other eating disorders and obsessive-compulsive behaviors. As interest in healthy eating continues to grow, vegetarian and vegan diets have become popular due to their potential health, ethical, and environmental benefits. However, the restrictive nature of these dietary patterns raises concerns about their potential relationship with disordered eating behaviors, particularly orthorexic symptoms. Despite the increasing amount of research on this topic, the available evidence remains fragmented and inconsistent. Previous reviews have suggested a possible association between vegetarian and vegan diets and orthorexia nervosa symptoms, but these reviews were narrative in nature or focused broadly on eating disorders without providing a quantitative synthesis of the available evidence. Consequently, a systematic review and meta-analysis were conducted to comprehensively evaluate the association between adherence to vegetarian and vegan diets and orthorexia nervosa symptoms in adults, as well as providing a more robust estimate of this relationship.

The associations between vegetarian and vegan diets and eating disorder symptoms across the lifespan

Vegetarian and vegan diets have become increasingly popular worldwide due to health, ethical, environmental, and cultural reasons. However, concerns have emerged about their potential association with eating disorder symptoms. The existing evidence remains inconclusive, partly because previous reviews often grouped strict vegetarian and vegan diets with other partially plant-based dietary patterns, such as pescatarian, flexitarian, or semi-vegetarian diets. This grouping occurs despite important differences in dietary composition and adherence motivations between these diets. Furthermore, the available evidence has been generated in specific age groups, which limits our understanding of this association across the lifespan. Therefore, clarifying whether strict vegetarian and vegan diets are associated with eating disorder symptoms from adolescence to older adulthood is essential to better inform future research, clinical assessments, and public health recommendations.

The associations between plant-based diet indices and depression among university students

Among lifestyle behaviors, diet has emerged as a modifiable determinant of mental health. Plant-based dietary patterns have gained considerable attention due to their potential health benefits. However, the effects of plant-based diets may depend on the quality of the plant foods consumed rather than on the predominance of plant foods alone because these diets are heterogeneous. Healthier plant-based dietary patterns have been associated with a lower risk of depression in adult populations. However, evidence among young adults is limited and largely restricted to non-European populations. Furthermore, few studies have evaluated both healthy and unhealthy plant-based dietary patterns simultaneously. Therefore, improving the understanding of these associations in university students is important to identify potentially modifiable dietary factors that may contribute to the prevention of depression during early adulthood.

5

MÉTODOS Y PLANTEAMIENTOS PARA ESTA DISERTACIÓN



MÉTODOS GENERALES

La presente tesis doctoral utiliza diferentes diseños de estudios epidemiológicos para alcanzar sus objetivos de investigación y proporcionar una comprensión integral de las relaciones entre algunos factores de estilo de vida y los resultados en salud mental. La integración de distintos enfoques metodológicos permite examinar la evidencia desde diversas perspectivas, combinando la síntesis de la evidencia con investigación observacional original. Aunque los procedimientos metodológicos, las consideraciones éticas y los análisis estadísticos se describen detalladamente en cada uno de los manuscritos, en la presente sección se ofrece una visión general de los principales enfoques metodológicos que sustentan esta tesis.

Revisión sistemática y metaanálisis

Las revisiones sistemáticas ofrecen un enfoque riguroso para sintetizar la evidencia mediante el uso de métodos predefinidos, transparentes y reproducibles para identificar, seleccionar y evaluar críticamente todos los estudios relevantes que abordan una pregunta de investigación específica. Esta metodología estructurada minimiza el riesgo de sesgo y proporciona una visión integral de la evidencia disponible. Cuando resulta apropiado, puede realizarse un metaanálisis para combinar estadísticamente los resultados de los estudios individuales, proporcionando una estimación global del efecto y mejorando la precisión de la evidencia disponible.

Estudios transversales

Los estudios observacionales abarcan una variedad de diseños de investigación que difieren según sus objetivos, la forma en que se seleccionan los participantes y el momento en que se recogen los datos. Los estudios transversales evalúan simultáneamente las exposiciones y los desenlaces en un único momento temporal dentro de una población definida. Este diseño se utiliza ampliamente en investigación epidemiológica para estimar la prevalencia de problemas de salud, describir las características de la población y examinar posibles asociaciones entre las exposiciones y los desenlaces. Sin embargo, dado que los participantes no son seguidos a lo largo del tiempo, los estudios transversales no permiten establecer relaciones temporales ni inferir causalidad. No obstante, pueden aportar evidencia valiosa para identificar posibles factores de riesgo y generar hipótesis que posteriormente podrán evaluarse mediante estudios longitudinales.

PLANTEAMIENTOS PARA ESTA DISERTACIÓN

La presente tesis doctoral se fundamenta en los siguientes planteamientos:

La influencia de la aptitud cardiorrespiratoria sobre el riesgo de trastornos mentales y neurocognitivos a lo largo del ciclo vital

Los trastornos mentales y neurocognitivos se encuentran entre las principales causas de discapacidad en todo el mundo, lo que pone de manifiesto la necesidad de identificar factores modificables que puedan contribuir a su prevención. La aptitud cardiorrespiratoria, un indicador clave de la salud física general, ha surgido como un prometedor predictor de diversos desenlaces crónicos de salud y también podría desempeñar un papel importante en la salud mental y neurocognitiva a través de múltiples mecanismos biológicos y psicológicos. Sin embargo, la evidencia disponible sigue siendo limitada, ya que las síntesis previas de la evidencia incluyeron un número reducido de estudios de cohortes, se centraron en un número restringido de desenlaces y estuvieron mayoritariamente limitadas a poblaciones adultas. Por ello, fue necesaria la realización de una revisión sistemática y un metaanálisis exhaustivo para sintetizar la evidencia longitudinal disponible sobre las asociaciones entre la aptitud cardiorrespiratoria y el riesgo de trastornos mentales y neurocognitivos a lo largo del ciclo vital.

Las asociaciones entre las dietas vegetarianas y veganas y los síntomas de ortorexia nerviosa en adultos

La ortorexia nerviosa se caracteriza por una preocupación obsesiva por consumir alimentos percibidos como saludables o "puros". Esto suele conducir a conductas alimentarias restrictivas, malestar psicológico y deterioro del funcionamiento cotidiano. Aunque la ortorexia nerviosa aún no ha sido reconocida formalmente como un trastorno psiquiátrico independiente, existe una creciente evidencia de que los síntomas ortoréxicos son relativamente frecuentes y pueden solaparse con otros trastornos de la conducta alimentaria y con comportamientos obsesivo-compulsivos. A medida que aumenta el interés por la alimentación saludable, las dietas vegetarianas y veganas han ganado popularidad debido a sus potenciales beneficios para la salud, así como por motivos éticos y medioambientales. Sin embargo, el carácter restrictivo de estos patrones dietéticos ha suscitado preocupación sobre su posible relación con conductas alimentarias desordenadas, en particular con los síntomas de ortorexia nerviosa. A pesar del creciente número de investigaciones sobre este tema, la evidencia disponible continúa siendo fragmentada e inconsistente. Las revisiones previas han sugerido una posible asociación entre las dietas vegetarianas y veganas y los síntomas de ortorexia nerviosa, aunque estas revisiones fueron de carácter narrativo o

abordaron de forma amplia los trastornos de la conducta alimentaria sin proporcionar una síntesis cuantitativa de la evidencia disponible. En consecuencia, se llevó a cabo una revisión sistemática con metaanálisis para evaluar de manera exhaustiva la asociación entre la adherencia a dietas vegetarianas y veganas y los síntomas de ortorexia nerviosa en adultos, así como para proporcionar una estimación más robusta de esta relación.

Las asociaciones entre las dietas vegetarianas y veganas y los síntomas de trastornos de la conducta alimentaria a lo largo del ciclo vital

Las dietas vegetarianas y veganas han adquirido una creciente popularidad en todo el mundo debido a motivos relacionados con la salud, la ética, el medio ambiente y la cultura. Sin embargo, también han surgido preocupaciones sobre su posible asociación con los síntomas de los trastornos de la conducta alimentaria. La evidencia existente sigue siendo inconclusa, en parte porque las revisiones previas agruparon con frecuencia las dietas vegetarianas y veganas estrictas con otros patrones dietéticos parcialmente basados en plantas, como las dietas flexitarianas o semi-vegetarianas. Esta agrupación se realizó a pesar de las importantes diferencias existentes en la composición de estas dietas y en las motivaciones para su seguimiento. Además, la evidencia disponible se ha generado en grupos de edad específicos, lo que limita la comprensión de esta asociación a lo largo del ciclo vital. Por ello, esclarecer si las dietas vegetarianas y veganas estrictas se asocian con los síntomas de los trastornos de la conducta alimentaria desde la adolescencia hasta la vejez resulta esencial para orientar futuras investigaciones, mejorar la evaluación clínica y fundamentar las recomendaciones de salud pública.

Las asociaciones entre los índices de dieta basada en plantas y la depresión en estudiantes universitarios

Entre los comportamientos relacionados con el estilo de vida, la alimentación ha emergido como un determinante modificable de la salud mental. Los patrones dietéticos basados en plantas han recibido una atención creciente debido a sus potenciales beneficios para la salud. Sin embargo, los efectos de las dietas basadas en plantas pueden depender más de la calidad de los alimentos de origen vegetal consumidos que del predominio de estos alimentos en la dieta, dado que estos patrones dietéticos son heterogéneos. Los patrones de alimentación basados en plantas de mayor calidad se han asociado con un menor riesgo de depresión en poblaciones adultas. No obstante, la evidencia en adultos jóvenes es limitada y se restringe principalmente a poblaciones no europeas. Asimismo, pocos estudios han evaluado simultáneamente patrones de alimentación basados en plantas saludables y no saludables. Por tanto, profundizar en el conocimiento de estas asociaciones en estudiantes universitarios resulta importante para identificar factores dietéticos potencialmente

modificables que puedan contribuir a la prevención de la depresión durante la adultez temprana.

6
AIMS



The objectives of each manuscript included in this doctoral thesis are shown below:

Manuscript I: Cardiorespiratory fitness and risk of mental disorders and dementia: a systematic review and meta-analysis

1. Synthesize the available evidence from cohort studies on the associations between cardiorespiratory fitness levels and the risk of mental and neurocognitive disorders at all ages in the general population.

Manuscript II: The Associations Between Vegetarian and Vegan Diets and Orthorexia Nervosa Symptoms in Adults: A Systematic Review and Meta-Analysis

2. Synthesize the evidence on the associations of vegetarian and vegan diets with orthorexia nervosa symptoms compared with omnivorous diets in the adult population.

Manuscript III: Are vegetarian and vegan diets associated with eating disorder symptoms? A systematic review and meta-analysis

3. To synthesize the evidence on the associations between vegetarian/vegan diets and eating disorder symptoms compared with omnivorous diets across the lifespan.

Manuscript IV: Plant-Based Diet Indices and Depression in University Students: The Nuts4Brain-Z Study

4. To examine the associations between adherence to plant-based diets, differentiating between healthy and unhealthy patterns, and depression among Spanish university students.

7
OBJETIVOS



A continuación, se enumeran los objetivos de cada artículo incluido en esta tesis doctoral:

Manuscrito I: Capacidad cardiorrespiratoria y riesgo de trastornos mentales y demencia: una revisión sistemática y un metaanálisis

1 Sintetizar la evidencia disponible procedente de estudios de cohortes sobre las asociaciones entre los niveles de capacidad cardiorrespiratoria y el riesgo de trastornos mentales y neurocognitivos en todas las edades en la población general.

Manuscrito II: Las asociaciones entre las dietas vegetarianas y veganas y los síntomas de ortorexia nerviosa en adultos: una revisión sistemática y un metaanálisis

2 Sintetizar la evidencia sobre las asociaciones de las dietas vegetarianas y veganas con los síntomas de ortorexia nerviosa, en comparación con las dietas omnívoras, en la población adulta.

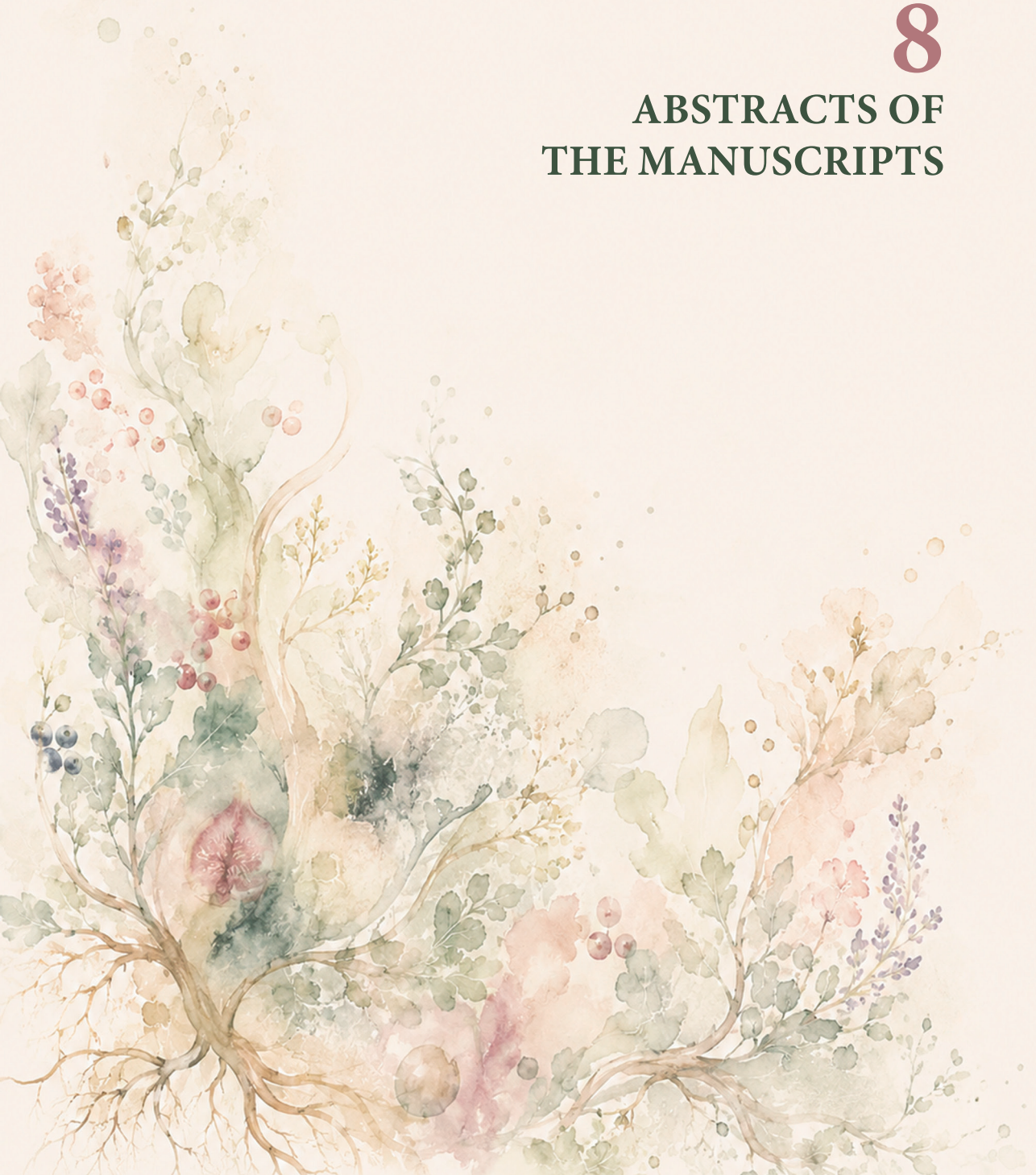
Manuscrito III: ¿Están las dietas vegetarianas y veganas asociadas a síntomas de trastornos alimentarios? Una revisión sistemática y un metaanálisis

3 Sintetizar la evidencia sobre las asociaciones entre las dietas vegetarianas/veganas y los síntomas de los trastornos alimentarios, en comparación con las dietas omnívoras, a lo largo de toda la vida.

Manuscrito IV: Índices de dietas basadas en vegetales y depresión en estudiantes universitarios: el estudio Nuts4Brain-Z

4 Examinar las asociaciones entre la adherencia a dietas basadas en vegetales, distinguiendo entre patrones saludables y poco saludables, y la depresión entre los estudiantes universitarios españoles.

8
ABSTRACTS OF THE MANUSCRIPTS



MANUSCRIPT I

Cardiorespiratory fitness and risk of mental disorders and dementia: a systematic review and meta-analysis.

Cardiorespiratory fitness (CRF) is a strong indicator of overall physical health, but its relevance for mental and neurocognitive health across the life course remains unclear. Here we synthesize evidence from cohort studies examining the associations between CRF and the risk of mental and neurocognitive disorders across all age groups in the general population. Twenty-seven studies comprising 4,007,638 individuals were included. Compared with low CRF, high CRF was associated with a reduced risk of depression (hazard ratio (HR) = 0.64; 95% confidence interval (CI), 0.56–0.74), all-cause dementia (HR = 0.61; 95% CI: 0.55–0.68) and psychotic disorders (HR = 0.71; 95% CI: 0.65–0.77) in adults. A one metabolic equivalent of task (1 MET; 3.5 ml kg−1 min−1) higher level of CRF was associated with lower risks of depression (HR = 0.95; 95% CI: 0.92–0.98) and all-cause dementia (HR = 0.81; 95% CI: 0.67–0.98). Overall certainty of evidence ranged from very low to moderate. These findings suggest that CRF may be a useful marker for identifying adults at increased risk of depression, dementia and psychotic disorders, highlighting the need for further large-scale longitudinal studies.

Systematic review registration: PROSPERO CRD42024547081

MANUSCRIPT II

The Associations Between Vegetarian and Vegan Diets and Orthorexia Nervosa Symptoms in Adults: A Systematic Review and Meta-Analysis

Objective: To synthesize the evidence on the associations between vegetarian and/or vegan diets (VVDs) and symptoms of orthorexia nervosa (ON) compared with omnivorous diets in the adult population. **Method**: Following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) and the Meta-analyses of Observational Studies in Epidemiology (MOOSE) guidelines, we conducted a systematic review and meta-analysis. We searched the MEDLINE/PubMed, Embase/Scopus, PsycINFO, and Web of Science databases up to June 17, 2025, with no language or date restrictions. Random effects models with the Sidik–Jonkman method were used to estimate pooled effect sizes. **Results**: The meta-analysis included 26 cross-sectional studies with a total of 23,783 participants (72.0% female; mean age range: 19.6–51.0 years). Adults who followed VVDs had moderately higher ON symptoms compared to omnivores (standardized mean differences using Cohen's d index = 0.46; 95% confidence interval [CI]: 0.33, 0.60; inconsistency index [I2] = 81.0%). Additionally, categorical data revealed that VVD adherents were approximately twice as likely to report ON symptoms as omnivores (odds ratio = 1.99; 95% CI: 1.21–3.25; I2 = 92.8%). Vegetarians and vegans were similarly associated with ON symptoms compared with omnivorous (p = 0.855).

Keywords: cross-sectional, dietary patterns, disordered eating behavior, feeding and eating disorders, mental health, obsessive healthy eating, orthorexia, plant-based diet, vegetarian

Systematic review registration: PROPSERO CRD42024527351

MANUSCRIPT III

Are vegetarian and vegan diets associated with eating disorder symptoms? A systematic review and meta-analysis

Objective: To synthesize the evidence on the associations between vegetarian and vegan diets (VVDs) and eating disorder (ED) symptoms compared with omnivorous diets across the lifespan. **Method**: Following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines, we searched PubMed, Scopus, Cochrane Library, PsycINFO, and Web of Science databases up to May 1, 2026, with no language or date restrictions. Random effects models with the Hartung-Knapp-Sidik-Jonkman method were used to estimate pooled effect sizes (standardized mean difference [SMD] with 95% confidence interval [CIs]). **Results**: We included 24 cross-sectional studies with a total of 25,223 participants (67.7% female; mean age range: 14.9–49.6 years). ED symptoms did not differ significantly between participants who followed VVDs and those following omnivorous diets in analyses including all eligible studies (SMD=0.07; 95% CI: –0.04 to 0.19; I^2=80.3%; 95% prediction interval: –0.44 to 0.59). Results were unchanged when analyses were restricted to adult populations. No significant differences in ED symptoms were observed according to diet type (p=0.524), measurement scale (p=0.392), or geographic region (p=0.633). In analyses restricted to adults, sex significantly moderated the pooled estimates (p=0.028), with studies including a higher proportion of females reporting lower ED symptom scores among individuals following VVDs compared with omnivores. **Discussion**: ED symptom levels do not appear to differ between individuals following VVDs and those following omnivorous diets. Longitudinal studies accounting for dietary quality, duration of adherence, dietary motivations, and psychosocial factors are also needed to clarify this association.

Keywords: plant-based diet, dietary patterns, feeding and eating disorders, disordered eating behavior, pathological eating, mental disorders.

Systematic review registration: PROPSERO CRD42024527351

MANUSCRIPT IV

Plant-Based Diet Indices and Depression in University Students: The Nuts4Brain-Z Study

Background/Objectives: Evidence on the associations between adherence to different plant-based diet indices and depression in young adults remains limited. This study aimed to analyze the associations of overall, healthy, and unhealthy plant-based diet indices with depressive symptoms in university students. **Methods**: A cross-sectional study was conducted in 2023 with self-reported data from university students in Cuenca, Spain. Adherence to the overall plant-based diet index (PDI) and to the healthy (hPDI) and unhealthy (uPDI) plant-based diet indices were calculated using data from a 137-item food-frequency questionnaire. Mild-to-severe depression was defined as a Beck Depression Inventory II score > 13 points. Linear and logistic regression models were adjusted for sociodemographic and lifestyle-related confounders. **Results**: A total of 392 students (mean age: 20.9 ± 2.4 years; 70.4% female) were included. The prevalence of mild-to-severe depression was 36.0%. Higher hPDI and overall PDI scores were associated with lower depressive symptom scores, whereas uPDI scores showed a positive but non-significant association after full adjustment. In logistic regression analyses, high adherence to the hPDI was associated with lower odds of mild-to-severe depression (OR = 0.51; 95% CI: 0.28–0.95; p-for-trend = 0.030). In contrast, higher uPDI adherence was associated with greater odds of depression, although the association was attenuated after adjustment for lifestyle-related variables. **Conclusions**: Greater adherence to a healthy plant-based diet was associated with lower depressive symptoms and lower odds of mild-to-severe depression among university students. These findings highlight the importance of plant food quality, rather than plant-based diets per se, in relation to depression in young adults.

Keywords: diet; lifestyle; depressive symptoms; college students; young adult

9
ORIGINAL MANUSCRIPTS



MANUSCRIPT I

Title: Cardiorespiratory fitness and risk of mental disorders and dementia: a systematic review and meta-analysis

Authors: Valentina Diaz-Goni, José Francisco López-Gil, Eva Rodriguez-Gutierrez, María Eugenia Visier-Alfonso, Estela Jiménez-López, Irene Sequi-Dominguez, Francisco B. Ortega, José Castro-Pinero, Arthur Eumann Mesas, Mairena Sánchez-López, Vicente Martínez-Vizcaíno, Bruno Bizzozero-Peroni.

Type: Systematic review and meta-analysis.

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Analysis

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Cardiorespiratory fitness and risk of mental disorders and dementia: a systematic review and meta-analysis

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Cardiorespiratory fitness (CRF) is a strong indicator of overall physical health, but its relevance for mental and neurocognitive health across the life course remains unclear. Here we synthesize evidence from cohort studies examining the associations between CRF and the risk of mental and neurocognitive disorders across all age groups in the general population. Twenty-seven studies comprising 4,007,638 individuals were included. Compared with low CRF, high CRF was associated with a reduced risk of depression (hazard ratio (HR) = 0.64; 95% confidence interval (CI), 0.56–0.74), all-cause dementia (HR = 0.61; 95% CI: 0.55–0.68) and psychotic disorders (HR = 0.71; 95% CI: 0.65–0.77) in adults. A one metabolic equivalent of task (1 MET; 3.5 ml kg^{-1} min^{-1}) higher level of CRF was associated with lower risks of depression (HR = 0.95; 95% CI: 0.92–0.98) and all-cause dementia (HR = 0.81; 95% CI: 0.67–0.98). Overall certainty of evidence ranged from very low to moderate. These findings suggest that CRF may be a useful marker for identifying adults at increased risk of depression, dementia and psychotic disorders, highlighting the need for further large-scale longitudinal studies.

Mental and neurocognitive disorders are among the leading causes of disability burden worldwide[1], affecting over 1.15 billion individuals in 2021[2]. In addition, subthreshold symptoms can substantially impair quality of life and are associated with an increased risk of progression to a clinical diagnosis[3]. The etiology of mental and neurocognitive disorders involves a complex interaction of genetic, neurological, psychosocial, environmental and lifestyle factors, thus posing a challenge for the development of primary prevention strategies[4,5].

Cardiorespiratory fitness (CRF) is a pivotal indicator of overall physical health, representing the ability of multiple physiological systems to efficiently deliver and use oxygen during sustained physical activity[6]. Genetics account for nearly half of the variation in CRF[7], with the remaining influence being predominantly shaped by regular physical activity patterns[8]. Since early meta-analyses examining CRF utility as a predictor of health outcomes[9], a substantial corpus of evidence from cohort studies has consistently highlighted the value of CRF in identifying individuals at heightened risk of mortality[10] and cardiovascular diseases[11]. Consequently, CRF has been recognized as an important, readily measurable risk factor[12,13], and its integration as a clinical vital sign has been specifically proposed for cardiovascular disease risk assessment[14], providing precise insights that facilitate the development of physical activity recommendations and exercise prescriptions[15].

A 2024 overview of meta-analyses of cohort studies indicates that CRF is a strong and consistent predictor of mortality and future chronic

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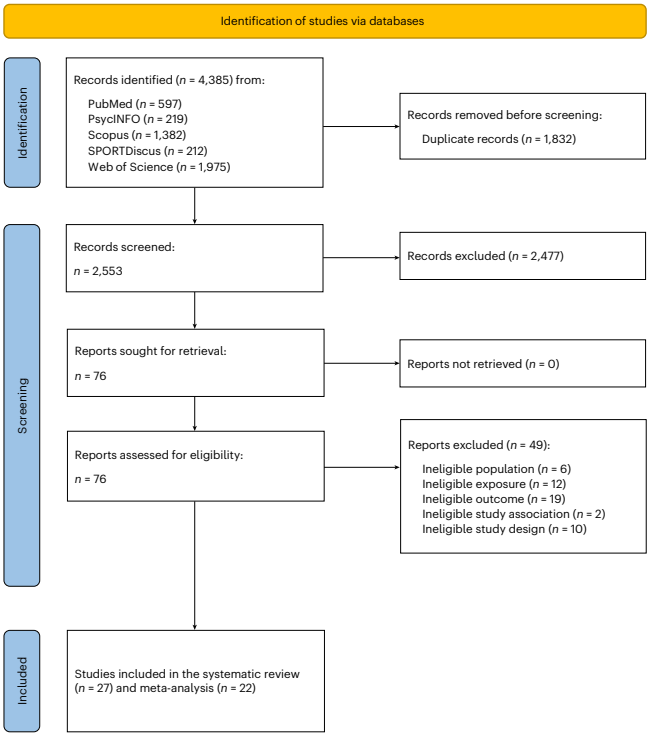


Fig. 1 | Flow diagram of the study selection process. Inclusion criteria were as follows: (1) general populations without mental or neurocognitive disorders at baseline, across all age groups, (2) CRF levels, (3) mental and neurocognitive health outcomes assessed either as clinical diagnoses or symptom severity measures, and (4) prospective or retrospective cohort studies published in peer-reviewed journals.

conditions such as stroke and type 2 diabetes mellitus among adults in the general population[16]. However, this study revealed the need for further evidence across additional health outcomes. CRF has been hypothesized to influence mental and neurocognitive health through various physiological and psychological mechanisms, including enhanced neuroplasticity, increased cerebral blood flow, reduced systemic inflammation and improved stress regulation[17]. So far, few meta-analyses have examined the associations between CRF and mental or neurocognitive disorders[18,19]. Each synthesized fewer than five primary studies, limiting the certainty of the available evidence and underscoring the need for additional high-quality research[16]. Furthermore, both meta-analyses were limited to adult populations and focused on anxiety, depression and all-cause dementia[18,19]. The recent surge in research on the determinants of mental and neurocognitive disorders underscores the urgent need to update this body of research[4,5]. From both clinical and public health perspectives, it is also important to clarify the role of CRF in the prevention of mental and neurocognitive health conditions across the lifespan, including less prevalent mental disorders such as neurodevelopmental and psychotic disorders. Accordingly, this Analysis synthesizes the available evidence from cohort studies on the associations between CRF levels and the risk of mental and neurocognitive disorders across all ages in the general population.

Results

Study selection

A total of 2,553 studies were considered for this title–abstract review; of these, 76 were fully assessed for eligibility and 49 were finally excluded (Supplementary Table 1), leaving a total of 27 cohort studies[20–46] in the systematic review (Fig. 1).

Study characteristics

Supplementary Tables 2 and 3 summarize the main characteristics of the studies included. The studies were published between 2009[28] and 2025[22]. The follow-up period ranged from 4 (ref. 26) to 29 years[46]. The studies included a total of 4,007,638 individuals (30.5% female participants) in nine different countries, including Finland[32,34,45], Germany[41], Italy[26], the Netherlands[35], Norway[27,29,31], Sweden[24,25,30,34,39,42,43,46], Taiwan[44], the United Kingdom[20,22,33] and the United States[21,23,28,36–38,40]. The participants across studies were predominantly white (either of European ancestry or non-Hispanic in US cohorts). The mean age at baseline ranged from 10.6 (ref. 44) to 72.5 years[26], comprising children under 12 years[44] and adults aged 18–64 years[20–43,45,46] and 65 years or older[26].

The CRF levels were estimated using direct[32,41,45] or indirect[20–31,33–40,42–44,46] measures through maximal or submaximal tests.

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Table 1 | Summary of the available cohort evidence on the associations between CRF and mental and neurocognitive disorders in the general population

Mental and neurocognitive disorders	Cohort evidence in the general population[a]			References
	<18 years	18–64 years	≥65 years	
Anxiety disorders	✓	✓✓✓✓	†	24,29,33,41,44
Depressive disorders	✓	✓✓✓✓✓✓ ✓✓✓✓	✓†	23–26,28,29,33,35,37,40–42,44
Neurocognitive disorders (all-cause dementia)	—	✓✓✓✓✓✓ ✓✓✓✓✓	††††††	20–22,27,30–32,34,36,38,46
Neurodevelopmental disorders[b]	✓	—	—	44
Bipolar and related disorders	—	✓	—	43
Obsessive-compulsive and related disorders	—	✓	—	43
Schizophrenia spectrum and other psychotic disorders	—	✓✓	†	43,45
Somatic symptom and related disorders	—	✓	—	43
Trauma- and stressor-related disorders	—	✓	—	43
Sleep–wake disorders[c]	—	✓	—	39
Other mental disorders[d]	—	—	—	NA
Total number of outcome-specific associations	3	32	1	20–46

[a]Cohort studies were classified according to the age range (<18 years, 18–64 years and ≥65 years) of the study population, based on the mean age of the total sample at baseline. Check marks (✓) indicate cohort studies that examined associations between CRF and risk of mental or neurocognitive disorders. Dashes (—) indicate that no cohort studies examined associations between CRF and risk of mental or neurocognitive disorders. Dagger symbols (†) indicate studies in which the mean age at baseline was between 18 and 64 years and extended beyond 65 years during follow-up. [b]Attention-deficit/hyperactivity disorder. [c]Sleep apnea (obstructive, central and mixed). [d]Disruptive, impulse-control and conduct disorders; dissociative disorders; elimination disorders; feeding and eating disorders; medication-induced movement disorders and other adverse effects of medication; other neurocognitive (that is, delirium) and neurodevelopmental (that is, autism spectrum disorders, communication disorders, intellectual developmental disorders, motor disorders, and specific learning disorders) disorders; personality disorders; paraphilic disorders; sexual dysfunctions; and substance-related and addictive disorders. NA, not applicable.

The included studies provided data for CRF categories by standardizing the cutoff point for high and low levels according to participant's age and sex[22,23,26–33,35,36,38,40,42,43,45]. Alternatively, data on age and sex were only adjusted in the estimate risk model[25]. Six studies were conducted exclusively among male participants[30,32,39,42,43,45], and five studies disclosed data regarding study associations by sex[20,26,28,37,40,44]. The metrics used were distance[26] or duration[40,44] of field-based tests, metabolic equivalent of task (MET)[20–23,28,33,34,36,37], peak workload[30,35,39,42,43,46] and maximum oxygen consumption (VO_{2max})[24,25,27,29,31,32,41,45]. Cohort studies employed a single baseline assessment of CRF levels, with subsequent repeated measurements[24,27,28,31,36,37]. Analysis of CRF was performed as a continuous variable[20–23,25,27–29,34–39,41,45] or as a comparison between categories[22,23,25–33,35,36,38,40,42–46].

Mental and neurocognitive disorders, whether clinical diagnoses[20–25,27,30–32,34,36,38,39,41–46] or manifestations of mild to severe symptoms[26,28,29,33,35,37,40,41], primarily included anxiety disorders (hereafter anxiety)[24,29,33,41,44], depressive disorders (hereafter depression)[23–26,28,29,33,35,37,40–42,44], all-cause dementia[20–22,27,30–32,34,36,38,46] and schizophrenia spectrum and other psychotic disorders (hereafter psychotic disorders)[43,45]. Table 1 summarizes the available cohort evidence on the associations between CRF and mental disorders in the general population.

Methodological quality and certainty of evidence

Among the included studies, 57.1% were rated as good quality and 42.9% were rated as fair quality (Supplementary Table 4). Cohort studies with fair quality were deficient in three key criteria: (1) a detailed definition of exposure measures; (2) multiple exposure measurements; and (3) an acceptable overall follow-up rate (>80%). A Grading of Recommendations, Assessment, Development and Evaluation (GRADE) assessment indicated moderate certainty of evidence for all-cause dementia and a very low certainty of evidence for anxiety, depression and psychotic disorders when comparing high versus low CRF. The GRADE assessment for a 1-MET increase in CRF indicated very low certainty of evidence for both depression and all-cause dementia. The very low certainty of evidence was primarily driven by risk of bias, inconsistency, imprecision and the inability to assess publication bias (Supplementary Tables 5 and 6).

Summary of outcomes not meta-analyzed

The prospective associations between CRF levels and some mental disorders were only analyzed in one study and were not included in the meta-analyses (Supplementary Table 3). In the general adult population, higher levels of CRF were significantly associated with a lower risk of bipolar and related disorders[42], dissociative, obsessive–compulsive, somatic symptom and stressor-related disorders[43], and sleep apnea[39]. Furthermore, higher levels of CRF were significantly associated with a reduced risk of anxiety and attention-deficit/hyperactivity disorder in children (boys and girls), whereas the association with depression was significant only in girls[44].

Summary of outcomes meta-analyzed

A total of 22 cohort studies[20–23,25–33,35–38,40,42–45] were included in the meta-analyses. Given that the general adult population was mostly aged 18–64 years at baseline, the pooled hazard ratios (HRs) comparing the associations between the highest (versus lowest) category of CRF and the risk of mental and neurocognitive disorders (Fig. 2) were (1) 0.90 (95% CI: 0.75–1.09; *I*-squared (I^2) = 56.9%; n = 2 (refs. 29,33)) for anxiety (n = 36,687; incident cases, 1,009; mild to severe symptoms; follow-up, 7–11 years); (2) 0.64 (95% CI: 0.56–0.74; I^2 = 67.9%; predication interval (PI), 0.43–0.97; n = 9 (refs. 23,25,26,28,29,33,35,40,42)) for depression (n = 1,504,915; incident cases, 18,958; medical registry-based or mild to severe symptoms; follow-up, 4–17 years); (3) 0.61 (95% CI: 0.55–0.68; I^2 = 0%; PI, 0.47–0.79; n = 7 (refs. 22,27,30–32,36,38)) for all-cause dementia (n = 1,287,561; incident cases, 4,170; medical registry-based; follow-up, 8–29 years); and (4) 0.71 (95% CI: 0.65–0.77; I^2 = 0%; n = 2, male-only cohorts[43,45]) for psychotic disorders (n = 1,112,007; incident cases, 10,420; medical registry-based; follow-up, 23–25 years). One of the included studies did not report the number of incident cases for anxiety and depression[33]. In the meta-analysis of CRF as a continuous variable (Fig. 3), an increase of 1 MET (3.5 ml kg^{-1} min^{-1}) was associated with a lower incidence of depression (HR = 0.95; 95% CI: 0.92–0.98; I^2 = 17.0%; PI,

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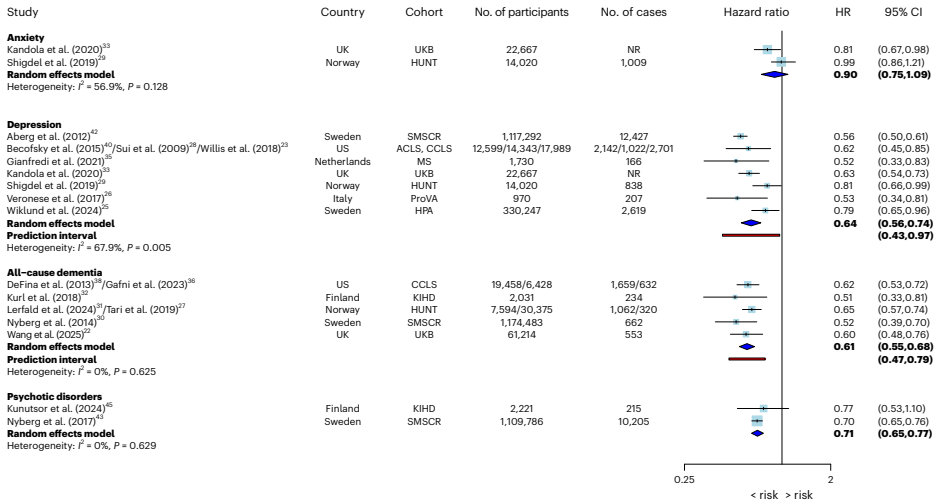


Fig. 2 | Pooled HRs between high versus low levels of CRF and the risk of mental and neurocognitive disorders. Results from two-sided random-effects meta-analyses of prospective cohort studies are shown categorized by disorder: anxiety[29,33], depression[23–26,28,29,33,35,40,42], all-cause dementia[22,27,30–32,34,38] and psychotic disorders[43,45]. Individual squares represent study-specific HRs, with horizontal lines indicating 95% CIs. Diamond symbols denote pooled HRs from random-effects models, and red horizontal bars indicate 95% prediction intervals where available (that is, when more than two studies are included). Point estimates represent HRs. HR values < 1 indicate a lower risk associated with higher CRF. Statistical inference is two-sided and based on 95% CIs, with no adjustments for multiple comparisons. ACLS, Aerobics Center Longitudinal Study; CCLS, Cooper Center Longitudinal Study; HPA, Health Profile Assessment; HUNT, Trøndelag Health Study; KIHD, Kuopio Ischemic Heart Disease study; MS, Maastricht Study; NR, not reported; ProVA, Progetto Veneto Anziani study; SMSCR, Swedish Military Service Conscription Register; UK, United Kingdom; UKB, UK Biobank; US, United States of America.

0.72–1.25; n = 5 (refs. 23,25,28,29,37); n = 362,256; incident cases, 6,158; medical registry-based or mild to severe symptoms; follow-up, 5–12 years) and all-cause dementia (HR = 0.81; 95% CI: 0.67–0.98; I^2 = 97.3%; PI, 0.07–9.12; n = 5 (refs. 20,21,27,36,38); n = 123,229; incident cases, 2,971; medical registry-based; follow-up, 8–24 years).

Subgroup and sensitivity analysis

Subgroup analyses are presented in Supplementary Table 7. High (versus low) CRF was significantly associated with a lower risk of depression and all-cause dementia in participants younger than 50 years (HR = 0.64, 95% CI: 0.52–0.79 and HR = 0.62, 95% CI: 0.54–0.70, respectively) and those aged older than 50 years (HR = 0.65, 95% CI: 0.52–0.80 and HR = 0.60, 95% CI: 0.47–0.72, respectively). Similar associations were observed in both female (HR = 0.51; 95% CI: 0.39–0.66) and male (HR = 0.55; 95% CI: 0.51–0.60) participants for depression. In turn, the pooled HR remained statistically significant in studies of good and fair methodological quality, as well as in those assessing CRF using indirect maximal or submaximal tests and depression defined either by clinical diagnosis or by mild to severe self-reported symptoms. No significant differences were observed across subgroup comparisons (P > 0.05). Furthermore, the findings of sensitivity analyses were consistent with the primary results. The pooled effect sizes comparing the associations between the highest (versus lowest) category of CRF and the risk of depression and all-cause dementia were not modified when applying separate analyses by the type of risk estimate (Supplementary Table 8) and removing each study one by one (Supplementary Figs. 1 and 2). Finally, when a standardized effect size correction (Hedges' g) was applied to mitigate potential biases, the results remained consistent (Supplementary Figs. 3 and 4).

Discussion

This systematic review and meta-analysis synthesizes the available evidence on the associations between CRF and the risk of mental and neurocognitive disorders in the general population across all age groups. Overall, high (versus low) CRF was associated with a reduced risk of depression (very low certainty), all-cause dementia (moderate certainty) and psychotic disorders (very low certainty, male-only evidence) in adults. No significant associations were found for anxiety (very low certainty). Furthermore, an increase of 1 MET (3.5 ml kg^{-1} min^{-1}) in CRF was associated with a lower risk of depression and all-cause dementia (very low certainty). These findings suggest a potential role for CRF in mental and neurocognitive health, but given the very low certainty for most outcomes, the results should be interpreted with caution. Additional cohort studies are needed to confirm these findings, particularly for underrepresented populations (that is, individuals under 18 years and over 65 years), and to investigate mental disorders that are currently understudied or have not yet been examined.

The results align with previous systematic reviews and meta-analyses[18,19] suggesting an inverse association of CRF with depression and all-cause dementia but extend the evidence base by incorporating a broader range of outcomes and a more comprehensive synthesis of available cohort studies. Specifically, this meta-analysis updates previous evidence in adults regarding anxiety, depression and all-cause dementia in adults[18,19]. Additionally, it integrates evidence on other mental disorders, including bipolar and related disorders, psychotic disorders, stressor-related disorders and sleep–wake disorders in adults, and anxiety, attention-deficit/hyperactivity disorder and depression in children. However, the limited number of studies restricts the ability to draw firm conclusions. Furthermore, no studies

Analysis

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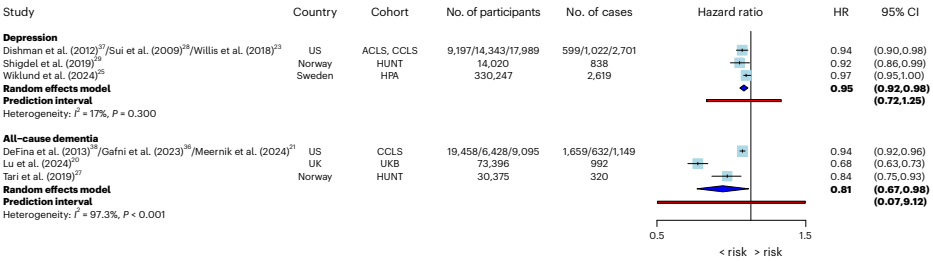


Fig. 3 | Pooled HRs between 1-MET increase in CRF and the risk of mental and neurocognitive disorders. Results from two-sided random-effects meta-analyses of prospective cohort studies are shown categorized into depression[23–25,28,29,37] and all-cause dementia[20,21,27,36,38]. Individual squares represent study-specific HRs, with horizontal lines indicating 95% CIs. Diamond symbols denote pooled HRs from random-effects models, and red horizontal bars indicate 95% prediction intervals. Point estimates represent HRs. HR values < 1 indicate a lower risk associated with higher CRF. Statistical inference is two-sided and based on 95% CIs, with no adjustments for multiple comparisons. Abbreviations as in Fig. 2.

were found on certain mental disorders, such as autism spectrum disorders, disruption, impulse-control and conduct disorders, and feeding and eating disorders.

Several potential mechanisms may explain the observed protective associations of CRF on mental and neurocognitive disorders. From a physiological perspective, exercise and CRF improvements induce structural, cellular and molecular adaptations in the brain that enhance neuroplasticity and support cognitive and emotional regulation[17,47,48]. One key pathway involves the reduction of systemic inflammation and oxidative stress, both of which are implicated in the pathophysiology of mental and neurocognitive disorders[17,49]. Improvements in cardiovascular health may further mediate this relationship, as higher CRF is linked to better vascular function and cerebral perfusion, which help reduce inflammation and support brain integrity[17]. Chronic inflammation and oxidative damage have been associated with neurodegeneration, impaired synaptic function and disruptions in neurotransmitter systems, which may contribute to the onset and progression of conditions such as depression[49] and dementia[17]. Additionally, exercise and higher CRF has been shown to promote hippocampal volumetric retention, a key neuroprotective adaptation given the hippocampus' role in emotion regulation, memory and cognitive resilience[17]. Atrophy in this region has been consistently linked to mental[50,51] and neurocognitive[52] disorders. Moreover, higher CRF has been associated with increased global white-matter volume and local integrity[53], which are essential for maintaining efficient neural connectivity and information processing. Deficits in white-matter microstructure have been observed in individuals with mental and neurocognitive disorders[54–57], suggesting that CRF-related improvements may contribute to better cognitive and emotional stability. Furthermore, regular physical activity[58], a major determinant of CRF[59], has been shown to regulate the hypothalamic–pituitary–adrenal axis by reducing cortisol levels and blunting excessive stress responses[60]. Dysregulation of this axis is a well-established mechanism in the development of certain mental and neurocognitive disorders[61,62], highlighting the potential role of CRF in modulating neuroendocrine function and improving stress resilience.

Despite biological plausibility, reverse causation remains a major challenge in disentangling the relationship between CRF and mental or neurocognitive health. Prodromal disorders and subthreshold symptoms may precede the observed associations and contribute to higher risk of mental and neurocognitive disorder[63,64] and to lower CRF levels[65–67], for instance through reduced motivation or engagement in physical activity[49,68]. Such temporal bias could lead to overestimation of the protective effects attributed to CRF. Although all studies included in this meta-analysis excluded participants with clinically diagnosed mental or neurocognitive disorders at baseline, there remains a possibility that early, undetected symptoms could have influenced CRF trajectories. However, bidirectional Mendelian randomization studies suggest a causal effect of physical activity on depression, with no evidence for the reverse direction[69]. So far, one genetically informed analysis examining CRF and Alzheimer's disease has reported no statistically significant findings[20], underscoring the need for further studies applying this approach. Addressing this challenge will require longitudinal cohorts with repeated CRF and mental and neurocognitive health assessments, the use of time-varying exposure models and, where feasible, multistate approaches to capture dynamic transitions between health states. Beyond observational evidence, randomized controlled trials are needed to establish whether specifically improving CRF can prevent the onset or progression of mental and neurocognitive disorders. Although numerous trials show robust antidepressant effects of exercise across baseline depression severity[70], as well as promising cognitive benefits[17], few have formally examined whether gains in CRF mediate these outcomes. Future trials should therefore incorporate neurobiological markers of neuroplasticity and behavioral indices of self-regulation to stratify participants, identify responders and optimize design[48]. Embedding such precision approaches into trial methodology will maximize CRF improvements, strengthen causal inference, and clarify the contribution of CRF to mental and neurocognitive health trajectories.

Genetic factors also warrant consideration when interpreting the link between CRF and mental or neurocognitive outcomes. In adults, responses to physical training vary considerably, with some individuals showing large improvements in CRF, and others only minimal gains[71,72]. Approximately half of this interindividual variability appears to be heritable[7], suggesting that genetic factors may contribute to the observed findings. It is therefore plausible that part of the associations between CRF and mental or neurocognitive disorders reflects genetic pleiotropy, whereby individuals genetically predisposed to higher CRF also have a lower genetic liability for these disorders. However, evidence supporting this hypothesis remains limited. For instance, a large genome-wide association study found no single-nucleotide polymorphisms reaching statistical significance for exercise-induced changes in VO_{2max}[72], although recent evidence has identified candidate loci and polygenic predictors explaining a proportion of its variance[73]. The biological mechanisms through which these genetic variants influence CRF remain largely unclear[71,74]. Notably, CRF-associated genetic variants are involved in the regulation of gene expression in key cardiometabolic tissues[75], and exercise may induce epigenetic modifications such as DNA methylation and microRNA activity[76] that could mediate its

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long-term neuroprotective effects[17]. In addition, evidence on racial and ethnic differences in CRF remains inconsistent and often attenuates after adjustment for metabolic, lifestyle and socioeconomic factors[77], suggesting that observed disparities are largely explained by modifiable environmental influences rather than fixed biological differences.

Importantly, CRF is a highly modifiable trait, and physical activity and exercise interventions can substantially improve it while simultaneously activating converging molecular and systemic pathways that support neuroplasticity, neurovascular health, immune regulation and metabolic resilience, including the upregulation of brain-derived neurotrophic factor and other neurotrophins, enhanced angiogenesis, modulation of gut microbiota, improved mitochondrial function, and reduced neuroinflammation and oxidative stress[17,78]. They also confer psychosocial benefits such as enhanced social support, self-esteem, self-efficacy and body image[79,80]. Overall, these considerations underscore the need for future research integrating genomic data and family-based designs to disentangle causality and to clarify the relative contributions of genetic, sociocultural and behavioral components of CRF to mental and neurocognitive health outcomes.

Despite the robust methodology employed in this meta-analysis, several limitations should be acknowledged. First, the limited number of available studies restricted the ability to explore or complete subgroup analyses (for example, by geographic region or CRF assessment method) and was insufficient ($n < 10$) to allow additional statistical assessments such as meta-regression or publication bias analyses[81,82]. As a result, the potential influence of sources of heterogeneity, residual confounding, and unpublished or selectively reported findings cannot be excluded. Second, some pooled estimates were accompanied by moderate to substantial between-study heterogeneity. Part of this heterogeneity may reflect methodological differences, such as variation in CRF assessments, outcome definitions and covariate adjustment strategies, which could introduce bias. Third, residual confounding due to mostly unmeasured factors—such as genetic predispositions, chronic pain, multimorbidity, social support and lifestyle behaviors (for example, physical activity, diet, smoking status)—cannot be ruled out. Fourth, subgroup analyses by age were based on aggregated study-level data rather than individual participant data, limiting the ability to draw definitive conclusions about age-specific associations. Fifth, because most cohorts consisted predominantly of white participants (either of European ancestry or non-Hispanic in US cohorts), generalizability to racially and ethnically diverse populations may be limited. Similarly, evidence for psychotic disorders was derived exclusively from two male conscript cohorts, limiting generalizability to female participants. Lastly, future studies should explore within-person variability in CRF over time and develop standardized CRF categories with defined cutoff values to enable dose–response analyses and inform thresholds for mental and neurocognitive risk reduction.

The findings have important implications for public health, clinical practice and future research. Given the inverse associations observed with depression, psychotic disorders (male-only evidence) and particularly all-cause dementia (moderate-certainty evidence for high versus low CRF), incorporating CRF into population-based evaluations could be considered. Measuring CRF may help identify individuals at increased risk of mental and neurocognitive disorders and inform interventions such as structured exercise programs and physical activity promotion aimed at improving CRF. This study underscores key limitations in the current body of evidence and offers specific recommendations to enhance the methodological quality and comparability of future research on the study associations (Supplementary Table 9). Briefly, it is recommended that future studies concentrate on identifying optimal CRF thresholds for mental and neurocognitive health benefits and explore potential sex- and age-specific associations. Accordingly, normalizing CRF to fat-free mass in future studies would improve the precision and comparability of measurements[83]. Additionally, subsequent studies should track co-existing long-term health conditions as part of the clinical complexity of general adult populations and examine how specific patterns (for example, accumulation, clusters, trajectories) may influence the associations under investigation. Genetically informed designs, such as Mendelian randomization studies using genetic variants associated with CRF, could help clarify the causal direction of these associations and disentangle genetic from behavioral or environmental pathways. Considering that physical activity and CRF are related but distinct phenotypes, future studies employing this approach should examine their independent and combined associations with mental and neurocognitive disorders. In addition, methods such as linkage disequilibrium score regression could be applied to quantify genetic correlations, providing complementary evidence on shared genetic architecture even in the absence of genome-wide significant variants. Finally, given the potential influence of population health profiles, healthcare systems, socioeconomic conditions, lifestyle factors and disease burden across different contexts, the results of this study underscore the need for future research to include underrepresented populations—both racially and ethnically diverse groups and those from regions such as Africa, Asia, Latin America and the Caribbean, and Oceania—to enhance the generalizability and applicability of evidence related to CRF and mental and neurocognitive disorders.

Conclusion

This systematic review and meta-analysis provides a comprehensive synthesis of the evidence on the associations between CRF and the incidence of mental and neurocognitive disorders in the general population across all age groups. The findings suggest that higher CRF is associated with lower risks of depression, dementia and psychotic disorders (male-only evidence) in adults. CRF may be considered a candidate marker for risk stratification. However, additional cohort studies are needed to clarify its preventive potential, particularly for anxiety, depression and psychotic disorders, where evidence remains of very low certainty. Other mental disorders have only been examined in single studies, limiting the ability to draw firm conclusions. Evidence across specific age groups, including children, adolescents and older adults, should be examined for all mental disorders to ensure comprehensive coverage across the lifespan.

Methods

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 (ref. 84) and the Meta-analysis of Observational Studies in Epidemiology (MOOSE)[85] statements. The study protocol was registered with PROSPERO (CRD42024547081). Two researchers (V.D.-G. and B.B.-P.) independently conducted the literature search, screening, study selection, data extraction, methodological quality, and certainty of evidence assessments. Any disagreements were resolved by consensus after consultation with a third investigator (V.M.-V.). The following sections provide a concise overview of the methods employed. Additional methodological details are available in Supplementary Methods.

Data sources and search strategy

The search process was conducted in accordance with the PRISMA-S guidelines[86]. Systematic searches were conducted in the following electronic databases from inception to 20 January 2025: PsycINFO, PubMed, Scopus, SPORTDiscus and Web of Science. Additional search methods were performed on online resources (Google Scholar) and citation searching (references of included studies and relevant systematic reviews). A comprehensive account of the search strategies employed is provided in Supplementary Table 10.

Eligibility criteria

To be included, studies retrieved from the scientific literature must report the following: (1) participants (general populations without

mental or neurocognitive disorders at baseline assessments, encompassing all age groups); (2) exposure (CRF levels estimated via three methods[16]: (i) maximal cardiopulmonary exercise tests with gas analysis (that is, direct measures of VO_{2max}), (ii) maximal or submaximal exercise tests (laboratory or field-based) without gas analysis (that is, indirect measures using exercise prediction equations or exercise performance data) or (iii) non-exercise prediction equations); (3) comparison (low levels of CRF); (4) outcome (mental and neurocognitive disorders, categorized according to the DSM-5-TR (*Diagnostic and Statistical Manual of Mental Disorders*, 5th edition–text revision) classification of the American Psychiatric Association[87], were considered either as clinical diagnoses or as measures of symptom severity); and (5) study design (prospective or retrospective cohort studies published in peer-reviewed journals). No language or publication date restrictions were applied. The eligibility criteria are detailed in Supplementary Methods.

Study selection

All identified studies were uploaded to the Rayyan review system online[88] and underwent deduplication. Subsequently, a two-step process was used. First, studies that did not address the study associations in the general population, as indicated by their title and abstract, were excluded. Second, the remaining studies were analyzed in full to ascertain whether they met the eligibility criteria.

Data extraction

The following data were extracted from the included studies: (1) authors and year of publication; (2) country where the data were collected; (3) main cohort or register; (4) data collection period and years of follow-up; (5) characteristics of the study population, including sample size, age, percentage of female participants, and body mass index; (6) characteristics related to CRF, including type of measure, assessment test, metric applied, mean value and data analysis (comparison across CRF categories and/or higher CRF as a continuous variable); (7) mental and neurocognitive health outcomes and assessment tools; and (8) prospective study associations, including effect size estimates and covariate adjustments. Data extraction was performed using Microsoft Excel (version 2510; Microsoft Corporation) between March and May 2025.

Methodological quality and certainty of evidence

The methodological quality of the cohort studies was evaluated using the National Institutes of Health (NIH) Quality Assessment Tool for Observational Cohort Studies[89]. The GRADE methodology was employed to determine the certainty of the evidence[90]. A summary of the details pertaining to the quality assessment tools for grading cohort studies is provided in Supplementary Methods.

Effect sizes

The studies mostly used HRs and odds ratios (ORs) as effect size estimators. Given the analysis of general populations (that is, excluding individuals with mental and neurocognitive disorders at baseline) and the low incidence of events across most included studies during follow-up periods (<12%), ORs and HRs were assumed to be equivalent and were thus combined as HRs[82,91,92]. Accordingly, the HRs and 95% CIs were considered the effect size for the meta-analyses and subjected to log transformations before being analyzed[82]. An HR value of less than 1 indicates a lower risk of mental and neurocognitive disorders in favor of higher levels of CRF. A complete list of effect sizes and the primary results from the studies included are provided in Supplementary Table 3.

Data synthesis

Meta-analyses were performed when at least two studies addressed the same outcome[93]. To facilitate the interpretation and comparison between studies, separate analyses were performed depending on whether CRF was reported as categorical (highest versus lowest levels as the reference category) or continuous (1-MET increase, that is, 3.5 ml kg^{-1} min^{-1}) variables. Meta-analyses were conducted using a random effect model with the Sidik–Jonkman method[94]. Heterogeneity was estimated using the I^2 statistic and classified as not important (0–40%), moderate (30–60%), substantial (50–90%) or considerable (75–100%)[82]. For I^2 values falling within overlapping ranges, the corresponding P values were incorporated to enhance interpretation[83]. PIs were also reported to quantify the expected between-study dispersion of true effects[82]. Forest plots were used to display the pooled HRs for the associations between CRF (that is, highest versus lowest levels or 1-MET increase) and the risk of mental and neurocognitive disorders. Subgroup analyses were performed according to participant characteristics (age and sex), CRF assessment method, outcome measure and methodological quality of the included studies. Given the limited availability of stratified results by age groups within individual studies, subgroup analyses were performed based on the mean age of the study participants at baseline. Sensitivity analyses were performed to assess the robustness of the summary estimates using the leave-one-out method[82] and performing separate analyses by the type of risk estimate applied in the included studies (HR and OR). Additionally, a sensitivity analysis was performed to calculate the standardized effect size, expressed as Hedges' g, to account for potential biases arising from unequal sample sizes and variability in the outcome assessment tools[82]. Other methodological considerations pertaining to data collection and analysis are provided in Supplementary Methods.

Statistics and reproducibility

This study was a systematic review and meta-analysis of previously published data (observational cohort evidence). No statistical method was used to predetermine sample size, as sample sizes were defined by the included studies. No data were excluded from the analyses other than those not meeting the predefined eligibility criteria. Randomization and blinding were not applicable. All analyses were conducted following established Cochrane methodological guidelines to ensure transparency and reproducibility[82]. Statistical significance was set at a two-sided $P < 0.05$. All analyses were conducted using R software version 4.4.0 (R Foundation for Statistical Computing) with the meta[95] and metafor[96] packages.

Reporting summary

Further information on research design is available in the Nature Portfolio Reporting Summary linked to this article.

Data availability

This systematic review and meta-analysis does not include original data. All data were extracted from published studies and are publicly available. The unprocessed data correspond to the original effect size estimates and related values reported in the included studies. The meta-analytic database generated and analyzed in this study, including study identifiers, effect sizes, confidence intervals and data used for visualization, is available via the Open Science Framework repository[97].

Code availability

Analyses were performed using standard functions in R software with the meta and metafor packages. The R code used to conduct the meta-analysis is available via the Open Science Framework repository[97].

References

1. GDB Mental Disorders Collaborators. Global, regional, and national burden of 12 mental disorders in 204 countries and territories, 1990-2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet Psychiatry* **9**, 137–150 (2022).
2. *2021 Global Burden of Disease study* (Institute of Health Metrics and Evaluation and Global Health Data Exchange (GHDx), 2025); https://vizhub.healthdata.org/gbd-results/

3. Volz, H. P., Stirnweiß, J., Kasper, S., Möller, H. J. & Seifritz, E. Subthreshold depression – concept, operationalisation and epidemiological data. A scoping review. *Int. J. Psychiatry Clin. Pract.* **27**, 92–106 (2023).
4. Herrman, H. et al. Time for united action on depression: a Lancet–World Psychiatric Association Commission. *Lancet* **399**, 957–1022 (2022).
5. Livingston, G. et al. Dementia prevention, intervention and care: 2024 report of the Lancet standing Commission. *Lancet* **404**, 572–628 (2024).
6. Caspersen, C. J., Powell, K. E. & Christenson, G. M. Physical activity, exercise and physical fitness: definitions and distinctions for health-related research. *Public Health Rep* **100**, 126–131 (1985).
7. Bouchard, C. et al. Familial resemblance for VO_{2max} in the sedentary state: the HERITAGE family study. *Med. Sci. Sports Exerc.* **30**, 252–258 (1998).
8. Myers, J., Kokkinos, P., Arena, R. & LaMonte, M. J. The impact of moving more, physical activity, and cardiorespiratory fitness: why we should strive to measure and improve fitness. *Prog. Cardiovasc. Dis.* **64**, 77–82 (2021).
9. Kodama, S. et al. Cardiorespiratory fitness as a quantitative predictor of all-cause mortality and cardiovascular events in healthy men and women: a meta-analysis. *JAMA.* **301**, 2024–2035 (2009).
10. Myers, J. et al. Exercise capacity and mortality among men referred for exercise testing. *N. Engl. J. Med.* **346**, 793–801 (2002).
11. Pettee Gabriel, K. et al. Analysis of cardiorespiratory fitness in early adulthood and midlife with all-cause mortality and fatal or nonfatal cardiovascular disease. *JAMA Netw. Open* **6**, e230842 (2023).
12. Nauman, J. et al. Prediction of cardiovascular mortality by estimated cardiorespiratory fitness independent of traditional risk factors: the HUNT Study. *Mayo Clin. Proc.* **92**, 218–227 (2017).
13. Kaminsky, L. A. et al. Cardiorespiratory fitness and cardiovascular disease—the past, present and future. *Prog. Cardiovasc. Dis.* **62**, 86–93 (2019).
14. Ross, R. et al. Importance of assessing cardiorespiratory fitness in clinical practice: a case for fitness as a clinical vital sign: a scientific statement from the American Heart Association. *Circulation* **134**, e653–e699 (2016).
15. Fletcher, G. F. et al. Exercise standards for testing and training: a scientific statement from the American Heart Association. *Circulation* **128**, 873–934 (2013).
16. Lang, J. J. et al. Cardiorespiratory fitness is a strong and consistent predictor of morbidity and mortality among adults: an overview of meta-analyses representing over 20.9 million observations from 199 unique cohort studies. *Br. J. Sports Med.* **58**, 556–566 (2024).
17. Tari, A. R., Walker, T. L., Huuha, A. M., Sando, S. B. & Wisloff, U. Neuroprotective mechanisms of exercise and the importance of fitness for healthy brain ageing. *Lancet* **405**, 1093–1118 (2025).
18. Lee, J. Influence of cardiorespiratory fitness on risk of dementia and dementia mortality: a systematic review and meta-analysis of prospective cohort studies. *J. Aging Phys. Act.* **29**, 878–885 (2021).
19. Kandola, A., Ashdown-Franks, G., Stubbs, B., Osborn, D. P. J. & Hayes, J. F. The association between cardiorespiratory fitness and the incidence of common mental health disorders: a systematic review and meta-analysis. *J. Affect. Disord.* **257**, 748–757 (2019).
20. Lu, H. et al. Observational and genetic associations between cardiorespiratory fitness and age-related diseases: longitudinal analyses in the UK Biobank study. *EPMA J.* **15**, 629–641 (2024).
21. Meernik, C. et al. Dietary patterns and cardiorespiratory fitness in midlife and subsequent all-cause dementia: findings from the cooper center longitudinal study. *Int. J. Behav. Nutr. Phys. Act.* **21**, 109 (2024).
22. Wang, S. et al. Association of cardiorespiratory fitness with dementia risk across different levels of genetic predisposition: a large community-based longitudinal study. *Br. J. Sports Med.* **59**, 150–158 (2025).
23. Willis, B. L. et al. Association of midlife cardiorespiratory fitness with incident depression and cardiovascular death after depression in later life. *JAMA Psychiatry* **75**, 911–917 (2018).
24. Wiklund, C. A. et al. Change in cardiorespiratory fitness and risk of depression, anxiety, and cerebrovascular disease. *Am. J. Prev. Med.* **67**, 849–858 (2024).
25. Wiklund, C. A., Ekblom, Ö., Paulsson, S., Lindwall, M. & Ekblom-Bak, E. Cardiorespiratory fitness in midlife and subsequent incident depression, long-term sickness absence, and disability pension due to depression in 330,247 men and women. *Prev. Med.* **181**, 107916 (2024).
26. Veronese, N. et al. Poor physical performance predicts future onset of depression in elderly people: Progetto Veneto Anziani longitudinal study. *Phys. Ther.* **97**, 659–668 (2017).
27. Tari, A. R. et al. Temporal changes in cardiorespiratory fitness and risk of dementia incidence and mortality: a population-based prospective cohort study. *Lancet Public Health* **4**, e565–e574 (2019).
28. Sui, X. et al. Prospective study of cardiorespiratory fitness and depressive symptoms in women and men. *J. Psychiatr. Res.* **43**, 546–552 (2009).
29. Shigdel, R., Stubbs, B., Sui, X. & Ernstsen, L. Cross-sectional and longitudinal association of non-exercise estimated cardiorespiratory fitness with depression and anxiety in the general population: the HUNT study. *J. Affect. Disord.* **252**, 122–129 (2019).
30. Nyberg, J. et al. Cardiovascular and cognitive fitness at age 18 and risk of early-onset dementia. *Brain* **137**, 1514–1523 (2014).
31. Lerfald, M. et al. Longitudinal patterns of systolic blood pressure, diastolic blood pressure, cardiorespiratory fitness, and their association with dementia risk: the HUNT study. *J. Gerontol. A* **79**, glae161 (2024).
32. Kurl, S., Laukkanen, J. A., Lonnroos, E., Remes, A. M. & Soininen, H. Cardiorespiratory fitness and risk of dementia: a prospective population-based cohort study. *Age Ageing* **47**, 611–614 (2018).
33. Kandola, A. A., Osborn, D. P. J., Stubbs, B., Choi, K. W. & Hayes, J. F. Individual and combined associations between cardiorespiratory fitness and grip strength with common mental disorders: a prospective cohort study in the UK Biobank. *BMC Med.* **18**, 303 (2020).
34. Hietanen, H., Pietilä, A., Kähönen, M. & Salomaa, V. Ankle blood pressure and dementia: a prospective follow-up study. *Blood Press Monit* **18**, 16–20 (2013).
35. Gianfredi, V. et al. The association between cardio-respiratory fitness and incident depression: the Maastricht Study. *J. Affect. Disord.* **279**, 484–490 (2021).
36. Gafni, T. et al. Independent and joint associations of cardiorespiratory fitness and BMI with dementia risk: the Cooper Center Longitudinal Study. *BMJ Open.* **13**, e075571 (2023).
37. Dishman, R. K. et al. Decline in cardiorespiratory fitness and odds of incident depression. *Am. J. Prev. Med.* **43**, 361–368 (2012).
38. DeFina, L. F. et al. The association between midlife cardiorespiratory fitness levels and later-life dementia: a cohort study. *Ann. Intern. Med.* **158**, 162–168 (2013).
39. Crump, C., Sundquist, J., Winkleby, M. A. & Sundquist, K. Cardiorespiratory fitness and long-term risk of sleep apnea: a national cohort study. *J. Sleep Res.* **28**, e12851 (2019).
40. Becofsky, K. M. et al. A prospective study of fitness, fatness and depressive symptoms. *Am. J. Epidemiol.* **181**, 311–320 (2015).

41. Baumeister, S. E. et al. Associations of leisure-time and occupational physical activity and cardiorespiratory fitness with incident and recurrent major depressive disorder, depressive symptoms, and incident anxiety in a general population. *J. Clin. Psychiatry* **78**, e41–e47 (2017).
42. Åberg, M. A. I. et al. Cardiovascular fitness in males at age 18 and risk of serious depression in adulthood: Swedish prospective population-based study. *Br. J. Psychiatry* **201**, 352–359 (2012).
43. Nyberg, J. et al. Cardiovascular fitness in late adolescent males and later risk of serious non-affective mental disorders: a prospective, population-based study. *Psychol. Med.* **48**, 416–425 (2017).
44. Chiang, H. L. et al. Physical fitness and risk of mental disorders in children and adolescents. *JAMA Pediatr* **178**, 595–607 (2024).
45. Kunutsor, S. K., Kauhanen, J. & Laukkanen, J. A. Frequent sauna bathing and psychosis: interrelationship with cardiorespiratory fitness. *J. Psychiatr. Res.* **175**, 75–80 (2024).
46. Hörder, H. et al. Midlife cardiovascular fitness and dementia: a 44-year longitudinal population study in women. *Neurology* **90**, e1298–e1305 (2018).
47. Kandola, A., Hendrikse, J., Lucassen, P. J. & Yücel, M. Aerobic exercise as a tool to improve hippocampal plasticity and function in humans: practical implications for mental health treatment. *Front. Hum. Neurosci.* **10**, 373 (2016).
48. Smith, P. J. & Merwin, R. M. The role of exercise in management of mental health disorders: an integrative review. *Annu. Rev. Med.* **72**, 45–62 (2021).
49. Hird, E. J., Slanina-Davies, A., Lewis, G., Hamer, M. & Roiser, J. P. From movement to motivation: a proposed framework to understand the antidepressant effect of exercise. *Transl. Psychiatry* **14**, 273 (2024).
50. Bray, M. J. C. et al. Hippocampal atrophy is associated with psychotic symptom severity following traumatic brain injury. *Brain Commun.* **3**, fcab026 (2021).
51. Cole, J., Costafreda, S. G., McGuffin, P. & Fu, C. H. Y. Hippocampal atrophy in first episode depression: a meta-analysis of magnetic resonance imaging studies. *J. Affect. Disord.* **134**, 483–487 (2011).
52. Song, T. et al. Mitochondrial dysfunction, oxidative stress, neuroinflammation, and metabolic alterations in the progression of Alzheimer's disease: a meta-analysis of in vivo magnetic resonance spectroscopy studies. *Ageing Res. Rev.* **72**, 101503 (2021).
53. Maleki, S. et al. Associations of cardiorespiratory fitness and exercise with brain white matter in healthy adults: a systematic review and meta-analysis. *Brain Imaging Behav* **16**, 2402–2425 (2022).
54. Fields, R. D. White matter in learning, cognition and psychiatric disorders. *Trends Neurosci* **31**, 361–370 (2008).
55. Flinkenflügel, K. et al. Associations between white matter microstructure and cognitive decline in major depressive disorder versus controls in Germany: a prospective case-control cohort study. *Lancet Psychiatry* **11**, 899–909 (2024).
56. Koshiyama, D. et al. White matter microstructural alterations across four major psychiatric disorders: mega-analysis study in 2,937 individuals. *Mol. Psychiatry* **25**, 883–895 (2019).
57. Shafer, A. T. et al. Accelerated decline in white matter microstructure in subsequently impaired older adults and its relationship with cognitive decline. *Brain Commun.* **4**, fcac051 (2022).
58. Bizzozero-Peroni, B. et al. Daily step count and depression in adults: a systematic review and meta-analysis. *JAMA Netw. Open* **7**, e2451208 (2024).
59. Knaeps, S., Bourgois, J. G., Charlier, R., Mertens, E. & Lefevre, J. Associations between physical activity and health-related fitness - volume versus pattern. *J. Sports Sci.* **35**, 539–546 (2017).
60. Anderson, T., Berry, N. T. & Wideman, L. Exercise and the hypothalamic-pituitary-adrenal axis: a special focus on acute cortisol and growth hormone responses. *Curr. Opin. Endocr. Metab. Res.* **9**, 74–77 (2019).
61. Misiak, B. et al. The HPA axis dysregulation in severe mental illness: can we shift the blame to gut microbiota? *Prog. Neuropsychopharmacol. Biol. Psychiatry* **102**, 109951 (2020).
62. Sharan, P. & Vellapandian, C. Hypothalamic-pituitary-adrenal (HPA) axis: unveiling the potential mechanisms involved in stress-induced Alzheimer's disease and depression. *Cureus* **16**, e67595 (2024).
63. Zhang, R. et al. The prevalence and risk of developing major depression among individuals with subthreshold depression in the general population. *Psychol. Med.* **53**, 3611–3620 (2023).
64. Michaud, T. L., Su, D., Siahpush, M. & Murman, D. L. The risk of incident mild cognitive impairment and progression to dementia considering mild cognitive impairment subtypes. *Dement. Geriatr. Cogn. Dis. Extra* **7**, 15–29 (2017).
65. Koivukangas, J. et al. Physical activity and fitness in adolescents at risk for psychosis within the Northern Finland 1986 Birth Cohort. *Schizophr. Res.* **116**, 152–158 (2010).
66. Pinto Pereira, S. M., Geoffroy, M. C. & Power, C. Depressive symptoms and physical activity during 3 decades in adult life: bidirectional associations in a prospective cohort study. *JAMA Psychiatry* **71**, 1373–1380 (2014).
67. Stavrakakis, N., De Jonge, P., Ormel, J. & Oldehinkel, A. J. Bidirectional prospective associations between physical activity and depressive symptoms. The TRAILS study. *J. Adolesc. Health* **50**, 503–508 (2012).
68. Farholm, A. & Sørensen, M. Motivation for physical activity and exercise in severe mental illness: a systematic review of intervention studies. *Int. J. Ment. Health Nurs.* **25**, 194–205 (2016).
69. Choi, K. W. et al. Assessment of bidirectional relationships between physical activity and depression among adults: a 2-sample Mendelian randomization study. *JAMA Psychiatry* **76**, 399–408 (2019).
70. Noetel, M. et al. Effect of exercise for depression: systematic review and network meta-analysis of randomised controlled trials. *BMJ* **384**, e075847 (2024).
71. Williams, C. J. et al. Genes to predict VO_{2max} trainability: a systematic review. *BMC Genomics* https://doi.org/10.1186/S12864-017-4192-6 (2017).
72. Bouchard, C. et al. Genomic predictors of the maximal O_2 uptake response to standardized exercise training programs. *J. Appl. Physiol.* **110**, 1160–1170 (2011).
73. Yang, X. et al. Genotype-phenotype models predicting VO_{2max} response to high-intensity interval training in physically inactive Chinese. *Med. Sci. Sports Exerc.* **55**, 1905–1912 (2023).
74. Klevjer, M., Nordeidet, A. N. & Bye, A. The genetic basis of exercise and cardiorespiratory fitness – relation to cardiovascular disease. *Curr. Opin. Physiol.* **33**, 100649 (2023).
75. Hanscombe, K. B. et al. The genetic case for cardiorespiratory fitness as a clinical vital sign and the routine prescription of physical activity in healthcare. *Genome Med* **13**, 180 (2021).
76. Brown, W. M. & Exercise-associated, D. N. A. methylation change in skeletal muscle and the importance of imprinted genes: a bioinformatics meta-analysis. *Br. J. Sports Med.* **49**, 1568–1578 (2015).
77. Raghuveer, G. et al. Cardiorespiratory fitness in youth: an important marker of health: a scientific statement from the American Heart Association. *Circulation.* **142**, E101–E118 (2020).
78. Ashdown-Franks, G. et al. Exercise as medicine for mental and substance use disorders: a meta-review of the benefits for neuropsychiatric and cognitive outcomes. *Sports Med* **50**, 151–170 (2020).

79. White, R. L. et al. Physical activity and mental health: a systematic review and best-evidence synthesis of mediation and moderation studies. *Int. J. Behav. Nutr. Phys. Act.* **21**, 134 (2024).
80. Nguyen Ho, P. T. et al. Mechanisms linking physical activity with psychiatric symptoms across the lifespan: a systematic review. *Sports Med* **53**, 2171–2190 (2023).
81. Sterne, J. A. et al. Recommendations for examining and interpreting funnel plot asymmetry in meta-analyses of randomised controlled trials. *BMJ* **343**, d4002 (2011).
82. Higgins, J. P. T. et al. *Cochrane Handbook for Systematic Reviews of Interventions* (John Wiley & Sons, 2019).
83. Tripp, T. R., Kontro, H., Gillen, J. B. & MacInnis, M. J. Fit for comparison: controlling for cardiorespiratory fitness in exercise physiology studies of sex as a biological variable. *J. Physiol.* **603**, 2219–2230 (2025).
84. Page, M. J. et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ* **372**, n71 (2021).
85. Stroup, D. F. et al. Meta-analysis of observational studies in epidemiology: a proposal for reporting. *JAMA* **283**, 2008–2012 (2000).
86. Rethlefsen, M. L. et al. PRISMA-S: an extension to the PRISMA statement for reporting literature searches in systematic reviews. *Syst. Rev.* **10**, 39 (2021).
87. *Diagnostic and Statistical Manual of Mental Disorders* 5th edn, Revision DSM-5-TR (American Psychiatric Publishing, 2022).
88. Ouzzani, M., Hammady, H., Fedorowicz, Z. & Elmagarmid, A. Rayyan—a web and mobile app for systematic reviews. *Syst. Rev.* **5**, 210 (2016).
89. *Quality Assessment Tool for Observational Cohort and Cross-sectional Studies* (National Heart Lung and Blood Institute, 2021); https://www.nhlbi.nih.gov/health-topics/study-quality-assessment-tools
90. Guyatt, G. H., Oxman, A. D., Schünemann, H. J., Tugwell, P. & Knottnerus, A. GRADE guidelines: a new series of articles in the Journal of Clinical Epidemiology. *J. Clin. Epidemiol.* **64**, 380–382 (2011).
91. Davies, H. T. O., Crombie, I. K. & Tavakoli, M. When can odds ratios mislead? *BMJ* **316**, 989–991 (1998).
92. Greenland, S. Interpretation and choice of effect measures in epidemiologic analyses. *Am. J. Epidemiol.* **125**, 761–768 (1987).
93. Valentine, J. C., Pigott, T. D. & Rothstein, H. R. How many studies do you need?: a primer on statistical power for meta-analysis. *J. Educ. Behav. Stat.* **35**, 215–247 (2010).
94. Sidik, K. & Jonkman, J. N. Simple heterogeneity variance estimation for meta-analysis. *J. R. Stat. Soc. Ser. C* **54**, 367–384 (2005).
95. Balduzzi, S., Rücker, G. & Schwarzer, G. How to perform a meta-analysis with R: a practical tutorial. *BMJ Ment. Health* **22**, 153–160 (2019).
96. Viechtbauer, W. Conducting meta-analyses in R with the metafor package. *J. Stat. Softw.* **36**, 1–48 (2010).
97. Díaz-Goñi, V. & Bizzozero-Peroni, B. Dataset for: Cardiorespiratory fitness and risk of mental disorders and dementia—a systematic review and meta-analysis. *Open Science Framework* https://doi.org/10.17605/OSF.IO/BJSGN (2025).

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Author contributions

V.D.-G. and B.B.-P. conceived and designed the study. V.D.-G., V.M.-V. and B.B.-P. performed the screening and study selection. V.D.-G., V.M.-V. and B.B.-P. conducted the quality and certainty of evidence assessments. E.R.-G., M.E.V.-A., E.J.-L. and I.S.-D. contributed to data collection. V.D.-G., V.M.-V. and B.B.-P. performed the statistical analysis. J.F.L.-G., E.R.-G., M.E.V.-A., E.J.-L., I.S.-D., F.B.O., J.C.-P., A.E.M. and M.S.-L. contributed to data interpretation. V.D.-G., J.F.L.-G. and B.B.-P. drafted the paper, with input from E.R.-G., M.E.V.-A., E.J.-L., I.S.-D., F.B.O., J.C.-P., A.E.M., M.S.-L., V.M.-V. and B.B.-P. supervised the work. All authors have read and approved the final version of the paper.

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Analysis

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Research sample	The included studies comprised both population-representative and non-representative cohort samples from the general population across all age groups, free of mental disorders/dementia at baseline. In total, 4,007,638 participants (30.5% women) from Finland, Italy, the Netherlands, Norway, Sweden, Taiwan, the UK, and the USA were included.
Sampling strategy	Not applicable. This study is a meta-analysis of observational cohort studies; sampling strategies were defined within the original studies and are described in the respective publications.
Data collection	Data extraction was conducted between March and May 2026 and included study characteristics, participant characteristics, CRF tests, outcomes with their assessment tools, and prospective associations.
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☐	☐	Crops and/or livestock
☐	☐	Ecosystems
☐	☐	Any other significant area

Experiments of concern

Does the work involve any of these experiments of concern:

No	Yes	
☐	☐	Demonstrate how to render a vaccine ineffective
☐	☐	Confer resistance to therapeutically useful antibiotics or antiviral agents
☐	☐	Enhance the virulence of a pathogen or render a nonpathogen virulent
☐	☐	Increase transmissibility of a pathogen
☐	☐	Alter the host range of a pathogen
☐	☐	Enable evasion of diagnostic/detection modalities
☐	☐	Enable the weaponization of a biological agent or toxin
☐	☐	Any other potentially harmful combination of experiments and agents

Plants

Seed stocks

Novel plant genotypes

Authentication

ChIP-seq

Data deposition

☐ Confirm that both raw and final processed data have been deposited in a public database such as GEO.

☐ Confirm that you have deposited or provided access to graph files (e.g. BED files) for the called peaks.

Data access links
May remain private before publication.

Files in database submission

Genome browser session
(e.g. UCSC)

Methodology

Replicates

Sequencing depth

Antibodies

Peak calling parameters

Data quality

Software

Flow Cytometry

Plots

Confirm that:

☐ The axis labels state the marker and fluorochrome used (e.g. CD4-FITC).

☐ The axis scales are clearly visible. Include numbers along axes only for bottom left plot of group (a 'group' is an analysis of identical markers).

☐ All plots are contour plots with outliers or pseudocolor plots.

☐ A numerical value for number of cells or percentage (with statistics) is provided.

Methodology

Sample preparation

Instrument

Software

Cell population abundance

Gating strategy

☐ Tick this box to confirm that a figure exemplifying the gating strategy is provided in the Supplementary Information.

Magnetic resonance imaging

Experimental design

Design type

Design specifications

Behavioral performance measures

Imaging type(s)

Field strength

Sequence & imaging parameters

Area of acquisition

Diffusion MRI ☐ Used ☐ Not used

Preprocessing

Preprocessing software

Normalization

Normalization template

Noise and artifact removal

Volume censoring

Statistical modeling & inference

Model type and settings

Effect(s) tested

nature portfolio | reporting summary

April 2023

#

Specify type of analysis: ☐ Whole brain ☐ ROI-based ☐ Both

Statistic type for inference

(See Eklund et al. 2016)

Correction

Models & analysis

n/a	Involved in the study
☐	☐ Functional and/or effective connectivity
☐	☐ Graph analysis
☐	☐ Multivariate modeling or predictive analysis

Functional and/or effective connectivity

Graph analysis

Multivariate modeling and predictive analysis

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MANUSCRIPT II

Title: The Associations Between Vegetarian and Vegan Diets and Orthorexia Nervosa Symptoms in Adults: A Systematic Review and Meta-Analysis

Authors: Valentina Díaz-Goñi, Bruno Bizzozero-Peroni, María Eugenia Visier-Alfonso, Estela Jiménez-López, Ruben Fernandez-Rodriguez, José Francisco López-Gil, Tomás Olivo Martins-de-Passos, Alberto Duran Gonzalez, Vicente Martínez-Vizcaíno, Arthur Eumann Mesas.

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The Associations Between Vegetarian and Vegan Diets and Orthorexia Nervosa Symptoms in Adults: A Systematic Review and Meta-Analysis

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Keywords: cross-sectional | dietary patterns | disordered eating behavior | feeding and eating disorders | mental health | obsessive healthy eating | orthorexia | plant-based diet | vegetarian

ABSTRACT

Objective: To synthesize the evidence on the associations between vegetarian and/or vegan diets (VVDs) and symptoms of orthorexia nervosa (ON) compared with omnivorous diets in the adult population.

Method: Following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) and the Meta-analyses of Observational Studies in Epidemiology (MOOSE) guidelines, we conducted a systematic review and meta-analysis. We searched the MEDLINE/PubMed, Embase/Scopus, PsycINFO, and Web of Science databases up to June 17, 2025, with no language or date restrictions. Random effects models with the Sidik–Jonkman method were used to estimate pooled effect sizes.

Results: The meta-analysis included 26 cross-sectional studies with a total of 23,783 participants (72.0% female; mean age range: 19.6–51.0 years). Adults who followed VVDs had moderately higher ON symptoms compared to omnivores (standardized mean differences using Cohen's d index = 0.46; 95% confidence interval [CI]: 0.33, 0.60; inconsistency index [I^2] = 81.0%). Additionally, categorical data revealed that VVD adherents were approximately twice as likely to report ON symptoms as omnivores (odds ratio = 1.99; 95% CI: 1.21–3.25; I^2 = 92.8%). Vegetarians and vegans were similarly associated with ON symptoms compared with omnivorous (p = 0.855).

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Discussion: Adherence to VVD is associated with higher ON symptoms in young and middle-aged adults. However, these results should be interpreted with caution due to high heterogeneity and the low overall methodological quality of the exclusively cross-sectional studies included. Higher-quality longitudinal studies using validated assessment tools are needed to establish clearer causal relationships and inform clinical screening and intervention strategies.

1 | Introduction

The term "orthorexia" refers to an obsessive preoccupation with consuming healthy, "pure" and health-promoting foods (Bratman 2017). Orthorexia nervosa (ON) is characterized by intense anxiety and distress due to extreme dietary restrictions, which can lead to changes in daily functioning (Horovitz and Argyrides 2023; Atchison and Zickgraf 2022). Although ON shares symptoms with some mental disorders including anorexia nervosa, bulimia nervosa, food avoidance/restriction disorders and obsessive-compulsive disorders, such as restrictive eating, intrusive thoughts, and extreme meal planning, it has not been officially recognized as a disorder in the Diagnostic and Statistical Manual of Mental Disorders (DSM-V-TR) (Horovitz and Argyrides 2023; Niedzielski and Kaźmierczak-Wojtaś 2021; Diagnostic and Statistical Manual of Mental Disorders 2022). A recent meta-analysis of 30,476 individuals (61.2% female and aged 13–93 years) across 18 countries reported an ON symptoms prevalence of 27.5% (López-Gil et al. 2023). However, this estimate may be inflated due to limitations in the screening tool (i.e., ORTO-15) used to assess ON symptoms (Barrada and Meule 2024), as well as the lack of standardized diagnostic criteria (Niedzielski and Kaźmierczak-Wojtaś 2021), which may lead to confusion between the pursuit of a healthier diet and ON (Gkiouleka et al. 2022).

The growing interest in healthy eating has been associated with the adoption of dietary restrictions, often leading individuals to follow dietary regimens that are perceived as more beneficial to health (Gortat et al. 2021), such as vegetarian and/or vegan diets (VVDs). These dietary patterns have grown in popularity because of their potential health and sustainability benefits (Hopwood et al. 2021). Vegetarian diets vary in strictness (Forestell et al. 2012), ranging from those that exclude meat but include eggs and/or dairy (i.e., ovo-vegetarian, lacto-vegetarian, and ovo-lacto-vegetarian diets) to those that avoid all animal products (i.e., vegan diets) (Hargreaves et al. 2023). The prevalence of VVDs varies substantially across regions. It generally ranges from 1% to 9% but can be as high as 36% in South Asia (Ruby 2012; Cramer et al. 2017).

VVDs have been associated with a lower risk of developing chronic conditions, such as cardiovascular disease, diabetes, hypertension, cancer, and dementia (Wang et al. 2023; Oussalah et al. 2020; Agnoli et al. 2023; Raj et al. 2025). However, these associations largely derive from observational studies and may be influenced by residual confounding, such as the clustering of healthier lifestyle behaviors (e.g., lower tobacco and alcohol use) among vegetarians (Gacek 2010). It is important to note that VVDs are not always associated with better health outcomes. In particular, strict vegan diets have been linked to an increased risk of hemorrhagic stroke, bone fractures and deficiencies in multiple vitamins and minerals (Wang et al. 2023). In addition, emerging evidence suggests that VVDs may be associated with adverse mental health outcomes in young and middle-aged adults, including symptoms of depression and anxiety (Iguacel et al. 2021) and eating disorders (EDs) (McLean et al. 2022), while data on adolescents and older adults remain limited despite potential nutritional risks. The obsessive pursuit of healthy eating seen in individuals with ON, combined with the perceived health benefits of VVDs, may contribute to a reinforcing cycle in which restrictive dietary patterns both contribute to and are maintained by disordered eating behaviors (Szulc et al. 2025).

A previous narrative review on VVDs and ON suggested that individuals following these diets exhibit higher levels of ON symptoms than omnivores (Brytek-Matera 2021). These results were recently confirmed by another narrative review (Szulc et al. 2025), suggesting a potential association between VVDs and ON, with evidence indicating that adopting such diets may sometimes serve to mask orthorexic behaviors. This overlap may be explained by shared characteristics, including selective food choices, rigid rules about "allowed" and "forbidden" foods, the central role of food in daily life, and inflexible eating patterns (Szulc et al. 2025). However, findings from two previous systematic reviews examining the relationship between VVDs and other EDs have been inconsistent. While some studies have identified an association between VVDs and EDs among adolescents and young adults (Sergentanis et al. 2020), others have reported mixed and inconclusive findings for both EDs and ON, suggesting that the way these diets are followed—rather than the diet itself—may constitute a risk factor for the development of disordered eating patterns (Mathieu et al. 2023). Despite these findings, a comprehensive and systematic synthesis of the literature on VVDs and ON symptoms is still lacking. Therefore, this systematic review and meta-analysis synthesized evidence on the associations between VVDs and ON symptoms compared with omnivorous diets in the adult population.

2 | Method

This systematic review with meta-analysis was conducted according to the 2020 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Page et al. 2021) and the Meta-analyses of Observational Studies in Epidemiology (MOOSE) (Sergentanis et al. 2020) guidelines (Stroup et al. 2000). The systematic review protocol was registered in the PROSPERO database (reference number: CRD42024527351). Two researchers (VDG and BBP) independently conducted the literature search, screening, study selection, data extraction, and methodological quality assessment. Any discrepancies were resolved through consultation with a third researcher (A.E.M.).

Summary

- This is the first meta-analysis to estimate the magnitude of the association between following vegetarian and/or vegan diets, compared to omnivorous diets, and symptoms of orthorexia nervosa.
- Higher adherence to vegetarian and/or vegan diets was associated with higher symptoms of orthorexia nervosa.
- These findings should be interpreted with caution due to the cross-sectional design and overall low methodological quality of the available evidence, substantial between-study heterogeneity, and limitations of the orthorexia assessment scales.

2.1 | Search Strategy

The search process followed PRISMA-S guidelines (Rethlefsen et al. 2021). A systematic search was conducted in the following electronic databases from the date of inception to September 9, 2024: MEDLINE (via PubMed), Embase (via Scopus), PsycINFO and the Web of Science Core Collection (via Clarivate's Web of Science). The search was subsequently updated to include the period from September 10, 2024 to June 17, 2025. Additional search methods were performed on Google Scholar along with citation searches (i.e., reviewing the references of the included studies and relevant systematic reviews [McLean et al. 2022; Mathieu et al. 2023; Brytek-Matera 2021]). The search strategy included terms related to the objective of the study, including "vegetarian," "vegan," "plant-based diets," and "orthorexia." The full approach to the search strategies is detailed in Table S1.

2.2 | Eligibility Criteria

Eligibility criteria were based on the population, exposure, comparator, outcome (PECO) and study design (Morgan et al. 2018). To be included, studies had to report the following: (i) *population*: general adult population, with a reported mean age ≥ 18 years; (ii) *exposure*: vegetarian (i.e., ovo-vegetarian, lacto-vegetarian, or lacto-ovo-vegetarian) and/or vegan (i.e., exclusively plant-derived foods) diets; (iii) *comparison*: omnivorous (nonvegetarian) diets that encompassed the consumption of any type of meat; (iv) *outcome*: ON symptoms, indicated by the number of symptoms (continuous outcome) or the presence of mild to severe symptoms (categorical outcome) using observer rating or self-rating scales; and (v) *study design*: observational studies (i.e., cross-sectional and longitudinal) published in peer-reviewed academic journals. No language, publication date or other restrictions were applied.

Studies were excluded if they reported (i) data exclusively on populations with participants presenting specific pathologies (e.g., EDs, celiac disease) or conditions (e.g., athletes, pregnant); (ii) exposure diets categorized as vegetarian but consuming some type of meat (i.e., pescatarians, flexitarians, or semivegetarians); (iii) comparison diets classified as special diets (e.g., gluten free, paleo); (iv) ON data in conjunction with disordered eating symptoms or dietary restraint as outcomes; and (v) studies that reported results by individual items without an overall score.

2.3 | Study Selection

All identified studies were uploaded to the Rayyan review system online (Ouzzani et al. 2016) and underwent deduplication. Two reviewers (V.D.G. and B.B.P.) subsequently conducted an independent title–abstract review, and studies deemed potentially eligible were then subjected to a full-text screening to ascertain their compliance with the established eligibility criteria.

2.4 | Data Extraction

Two independent reviewers (V.D.G. and B.B.P.) extracted the following information from each study: (i) first author surname, publication year and country; (ii) sample characteristics, including total sample size, mean age, sex assigned at birth and/or gender, race and/or ethnicity, socioeconomic status, body mass index (BMI), educational level (percentage of university degree), and subsamples according to diet type; (iii) exposure diets, including vegetarian, vegan, or mixed (vegetarian plus vegan) diets; (iv) measure of ON symptoms: ON symptoms by validated observer rating or self-rating scales; and (v) main results, including ON symptoms as both continuous (means) and categorical (prevalence) data for each type of diet.

2.5 | Methodological Quality Assessment

The National Institutes of Health (NIH) Quality Assessment Tool for Observational Cohorts and Cross-Sectional Studies was used to assess the methodological quality of the included studies (National Heart Lung and Blood Institute 2021). This tool assesses 14 items across a range of domains, including the study population, the timeframe for associations, the exposure and outcome measures, and the statistical analyses. The responses to these domains (i.e., yes, no, not reported, not applicable, and cannot be determined) were used to inform the overall judgment. The quality of each study was evaluated according to the NIH quality rating guide (National Heart Lung and Blood Institute 2021), and each cross-sectional study was rated as good (if most criteria were met), fair (if some criteria were met), or poor (if few criteria were met).

2.6 | Effect Sizes

In this meta-analysis, standardized mean differences (SMDs) determined via Cohen's *d* index (Cohen 1988) and odds ratios (ORs) with 95% confidence intervals (CIs) were used as the main effect sizes.

For continuous ON symptoms data, the means, standard deviations (SDs), and number of participants within each type of diet were extracted to estimate the SMDs. If the outcome data were reported as the means and CIs or standard errors, the SD was calculated with the appropriate formula following the Cochrane recommendations (Higgins et al. 2024). One study (Novara et al. 2022) reported outcome data as a beta coefficient, and the appropriate formula was used to determine the SMD (Borenstein et al. 2009). To estimate the pooled OR for categorical ON data, the number of participants and the cases within each type of diet

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were extracted. All effect sizes and main results of the included studies are listed in Table S2.

Positive SMD values indicate that individuals adhering to VVDs reported greater symptoms of ON than those following an omnivorous diet did. The criterion devised by Cohen was used to categorize the effect size estimator as either small (SMD = 0.2), moderate (SMD = 0.5), or large (SMD = 0.8) (Cohen 1988). OR values less than 1 indicate that individuals who followed a VVD had lower odds of ON than those who followed an omnivorous diet did.

2.7 | Data Synthesis

The meta-analyses were performed when at least five studies analyzed the outcome (Jackson and Turner 2017). A meta-analysis of cross-sectional studies comparing ON symptoms of VVDs with those of omnivorous diets was conducted via a random effects model with the Sidik–Jonkman method (Sidik and Jonkman 2005). Heterogeneity across studies was assessed via the inconsistency index [I^2], which was classified as not important (0%–40%), moderate (30%–60%), substantial (50%–90%), or considerable (75%–100%). The corresponding p values were also considered (Higgins et al. 2024).

Subgroup analyses were performed according to VVDs, geographic location, and self-reported scales applied. Univariate mixed effects meta-regression models were used to assess whether the characteristics of participants (i.e., age [years], sex [% females], BMI [kg/m^2], and educational level [% university degree]) as continuous independent variables influenced the pooled estimate and between-study heterogeneity. Furthermore, sensitivity analyses were performed to assess the robustness of the summary estimates via the leave-one-out method (Higgins et al. 2024). Publication bias was assessed by performing an Egger regression asymmetry test and visually inspecting funnel plots (Sterne et al. 2001).

Statistical significance was set at $p < 0.05$. All analyses were conducted via the Comprehensive Meta-Analysis program (version 2; Biostat Inc.) and R software (version 4.2.3; R Foundation for Statistical Computing) with the *meta* (Balduzzi et al. 2019) package.

2.8 | Additional Methodological Considerations

If the same study reported data from different ON scales (Ruiz and Quiles 2021) or from different motivations to follow a vegetarian diet (Dai and Leung 2024), the SMDs were pooled into a single result. When studies provided separate data for vegetarian and vegan diets (Barnett et al. 2016; Barthels et al. 2018; Coimbra and Ferreira 2021; Dunn et al. 2017; Ferreira and Coimbra 2021; Heiss et al. 2019; Missbach et al. 2015; Oberle et al. 2021; Yücel et al. 2021; Şentürk et al. 2022), these data were included in their respective subgroup analyses. In these cases, data on symptoms of ON were also combined to calculate a single pooled SMD for the inclusion of each study in the main meta-analysis (VVDs vs. omnivorous diets). If ON scales reported scores inversely (i.e., higher score, higher ON symptoms vs. higher score, lower ON symptoms), we placed all effect sizes in a common frame (i.e., higher score, higher ON symptoms). When studies employed distinct cutoff points for establishing the prevalence of ON (Heiss et al. 2019), the data derived from the most severe cutoff point were included.

2.9 | Studies With Missing Data

The first or corresponding authors of five studies (Ruiz and Quiles 2021; Missbach et al. 2015; Luck-Sikorski et al. 2019; Parra-Fernández et al. 2020; Brytek-Matera 2020) were contacted at least twice via e-mail to request substantial missing data for the study association (i.e., study sample according to diet type and prevalence of ON). Responses from three studies (Ruiz and Quiles 2021; Missbach et al. 2015; Brytek-Matera 2020) provided sufficient data for inclusion, whereas the remaining two (Luck-Sikorski et al. 2019; Parra-Fernández et al. 2020) were classified as having missing data due to nonresponse.

3 | Results

3.1 | Study Selection

After removing duplicates, a total of 942 studies were eligible for title–abstract review, 81 of which were fully assessed for eligibility, and 57 were ultimately excluded for various reasons (Table S3). Two additional studies (Strahler et al. 2018; Tarsitano et al. 2022) were identified through complementary searches in Google Scholar and subsequently included. A total of 26 cross-sectional studies were ultimately included in the systematic review and meta-analysis (Figure 1).

3.2 | Study Characteristics

Table 1 shows the main characteristics of the included studies. The 26 cross-sectional studies were published between 2015 (Missbach et al. 2015) and 2025 (Albery et al. 2025). Of these, 15 (Novara et al. 2022; Dai and Leung 2024; Barnett et al. 2016; Barthels et al. 2018; Coimbra and Ferreira 2021; Dunn et al. 2017; Ferreira and Coimbra 2021; Missbach et al. 2015; Oberle et al. 2021; Yücel et al. 2021; Şentürk et al. 2022; Albery et al. 2025; Çiçekoğlu and Tunçay 2018; Dell'Osso et al. 2016; Hessler-Kaufmann et al. 2020) reported continuous outcomes only, six (Luck-Sikorski et al. 2019; Strahler et al. 2018; Tarsitano et al. 2022; Chard et al. 2019; Dittfeld et al. 2017; Gwioździk et al. 2022) reported categorical outcomes only, and five (Ruiz and Quiles 2021; Heiss et al. 2019; Reynolds et al. 2023; Dell'Osso et al. 2016; Białek-Dratwa et al. 2024) reported both outcome types. Five studies (Çiçekoğlu and Tunçay 2018; Dittfeld et al. 2017; Gwioździk et al. 2022; Białek-Dratwa et al. 2024; Brytek-Matera et al. 2019) reported on the duration of adherence to VVD, but only one examined its relationship with ON (Dittfeld et al. 2017). Furthermore, only one study (Dai and Leung 2024) reported outcomes related to the ON diet according to the reason for choosing the diet. Two studies (Dittfeld et al. 2017; Reynolds et al. 2023) reported ON results according to different categories of vegetarian diets (ovo-vegetarian, lacto-vegetarian, and ovo-lacto-vegetarian). A paucity of studies (Çiçekoğlu and Tunçay 2018; Dell'Osso et al. 2016) have reported results according to sex concerning both VVDs and omnivorous diets. With respect to the instruments used to assess ON symptoms, 10 studies employed

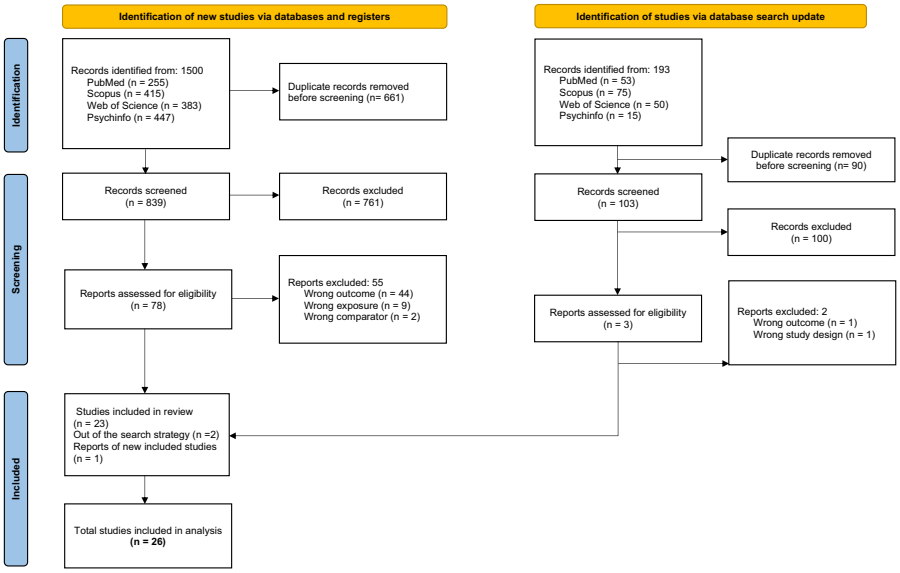


FIGURE 1 | Flow diagram of study selection.

the Duesseldorf Orthorexia Scale (DOS) (Dai and Leung 2024; Barthels et al. 2018; Coimbra and Ferreira 2021; Ferreira and Coimbra 2021; Oberle et al. 2021; Luck-Sikorski et al. 2019; Strahler et al. 2018; Tarsitano et al. 2022; Hessler-Kaufmann et al. 2020; Chard et al. 2019), twelve studies utilized one of the versions of the Questionnaire for the Diagnosis of Orthorexia (ORTO-15,ORTO-11,ORTO-R) (Ruiz and Quiles 2021; Barnett et al. 2016; Dunn et al. 2017; Heiss et al. 2019; Missbach et al. 2015; Yücel et al. 2021; Çiçekoğlu and Tunçay 2018; Dell'Osso et al. 2016, 2022; Hessler-Kaufmann et al. 2020; Reynolds et al. 2023; Białek-Dratwa et al. 2024), three studies employed the Teruel Orthorexia Scale (TOS) (Ruiz and Quiles 2021; Şentürk et al. 2022; Albery et al. 2025), one study used the Bratman Test for Orthorexia (BOT) (Dittfeld et al. 2017), and one study used the Eating Habits Questionnaire (EHQ) (Novara et al. 2022).

3.3 | Participants

The studies included a total of 23,783 individuals (72.0% females) with a mean age ranging from 19.6 (Chard et al. 2019) to 51.0 (Luck-Sikorski et al. 2019) years and a mean BMI ranging from 22.1 (Dittfeld et al. 2017) to 27.0 kg/m^2 (Reynolds et al. 2023) at baseline. The participants were recruited from diverse geographical locations, including Australia (Missbach et al. 2015; Reynolds et al. 2023), Canada (Reynolds et al. 2023), Germany (Barthels et al. 2018; Luck-Sikorski et al. 2019; Strahler et al. 2018; Hessler-Kaufmann et al. 2020), India (Reynolds et al. 2023), Italy (Novara et al. 2022; Dell'Osso et al. 2016, 2022; Dittfeld et al. 2017; Tarsitano et al. 2022), Poland (Białek-Dratwa et al. 2024), Portugal (Coimbra and Ferreira 2021; Ferreira and Coimbra 2021), Spain (Ruiz and Quiles 2021), Turkey (Yücel et al. 2021; Şentürk et al. 2022; Çiçekoğlu and Tunçay 2018), the United Kingdom (Albery et al. 2025; Reynolds et al. 2023), and the United States (Dai and Leung 2024; Barnett et al. 2016; Dunn et al. 2017; Heiss et al. 2019; Oberle et al. 2021; Chard et al. 2019; Reynolds et al. 2023). The studies included data from vegetarians (Luck-Sikorski et al. 2019; Chard et al. 2019; Dittfeld et al. 2017; Gwioździk et al. 2022), vegetarians and vegans combined (Ruiz and Quiles 2021; Dai and Leung 2024; Tarsitano et al. 2022; Çiçekoğlu and Tunçay 2018; Dell'Osso et al. 2016, 2022; Hessler-Kaufmann et al. 2020; Reynolds et al. 2023; Białek-Dratwa et al. 2024), and vegetarians and vegans separately (Novara et al. 2022; Barnett et al. 2016; Barthels et al. 2018; Coimbra and Ferreira 2021; Dunn et al. 2017; Ferreira and Coimbra 2021; Heiss et al. 2019; Missbach et al. 2015; Oberle et al. 2021; Yücel et al. 2021; Şentürk et al. 2022; Strahler et al. 2018; Albery et al. 2025).

3.4 | Methodological Quality of the Included Studies

According to the NIH Quality Assessment Tool (National Heart Lung and Blood Institute 2021), cross-sectional studies were scored between 3 and 7 points (no studies were rated as good quality, 15.4% were rated as fair quality, and 84.6% were rated as poor quality). Most studies had methodological limitations on six key criteria: (i) justified sample size; (ii) exposure assessed prior to outcome; (iii) sufficient time frame; (iv) valid measure of exposure; (v) repeated exposure assessment; and

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TABLE 1 | Characteristics of the included studies.

Author, year, country	*N* (Total)	Age (mean years)	Sex assigned at birth and/or gender	Race/ethnicity (*n*)	SES	BMI	Education level (% university degree)	*n* (VVD/OMN)	Dietary exposition	Measure of orthorexia nervosa symptoms
Albery et al. (2025), UK	144	35	Female = 45.8%; male = 51.4; nonbinary = 2.8%	NR	NR	NR	NR	95/49	Vegetarian, vegan	TOS
Barnett et al. (2016), USA	284	38	Female = 83.4%	NR	NR	24.9	95	33/251	Vegetarian, vegan	ORTO-15
Barthels et al. (2018), Germany	351	32	Female = 63.2%	NR	NR	23.7	NR	177/174	Vegetarian, vegan	DOS
Białek-Dratwa et al. (2024), Poland	186	> 18	Female = 94.0%; male = 5.9%	NR	NR	NR	51	84/102	Vegetarian, vegan	ORTO-15
Chard et al. (2019), USA	384	19.6	Female = 69.5%; male = 30.5%	NR	NR	23	100	30/256	Vegetarian	DOS
Çiçekoğlu and Tunçay (2018), Turkey	62	34	Female = 61.0%	NR	NR	NR	NR	31/31	Vegetarian, vegan	ORTO-11
Coimbra and Ferreira (2021), Portugal	447	32	Female = 100.0%	NR	NR	24	R	111/281	Vegetarian, vegan	DOS
Dai and Leung (2024), USA	334	> 18	Female = 58.9%; male = 38.9%; nonbinary = 0.6%; prefer not to say = 1.5%	White = 264 Black = 30 Hispanic = 18 American Indian or Alaska Native = 1 Asian = 15 Native Hawaiian or Pacific Islander = 0 Other = 6	≤ $25,000 = 15.6% $25,000–$49,999 = 26.3% $50,000–$74,999 = 25.1% $75,000–$99,999 = 12.3% $100,000–$149,999 = 9.9% ≥ $150,000 = 8.4% Prefer not to say = 2.4%	NR	NR	230/104	Vegetarian	DOS
Dell'Osso et al. (2016), Italy	2826	29	Female = 40.6%; male = 59.4%	NR	NR	22.5	75	313/2513	Vegetarian	ORTO-15

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TABLE 1 | (Continued)

Author, year, country	*N* (Total)	Age (mean years)	Sex assigned at birth and/or gender	Race/ethnicity (*n*)	SES	BMI	Education level (% university degree)	*n* (VVD/OMN)	Dietary exposition	Measure of orthorexia nervosa symptoms
Dell'Osso et al. (2022), Italy	2140	24	Female = 66.0%; male = 33.9%	NR	NR	NR	100	118/1956	Vegetarian, vegan	ORTO-R
Dittfeld et al. (2017), Italy	2611	24	NR	NR	NR	22.1	47	1346/1265	Vegetarian	BOT
Dunn et al. (2017), USA	275	22	Female = 68.0%; male = 31.0%	White = 214 Latino = 41 African American = 11 Asian American = 5 Declined to answer = 4	NR	NR	100	34/219	Vegetarian	ORTO-15
Ferreira and Coimbra (2021), Portugal	541	35	Female = 82.6%	NR	NR	24.4	NR	126/357	Vegetarian, vegan	DOS
Gwioździk et al. (2022), Poland	420	24	Female = 100.0%	NR	NR	NR	88	115/227	Vegetarian	ORTO-15
Hessler-Kaufmann et al. (2020), Germany	511	43	Female = 63.4%	NR	NR	25	51	49/364	Vegetarian	DOS
Heiss et al. (2019), USA	381	31	Female = 80.8%	White = 335	NR	25	NR	241/106	Ovo-lacto vegetarian, vegan	ORTO-15
Luck-Sikorski et al. (2019), Germany	1007	51	Female = 48.6%	NR	NR	26	NR	59/948	Vegetarian	DOS
Missbach et al. (2015), Austria	1029	31	Female = 74.6%; male = 25.4%	NR	NR	23	37	179/829	Vegetarian, vegan	ORTO-15
Novara et al. (2022), Italy	1075	21	Female = 75.0%	NR	NR	NR	NR	58/1017	Vegetarian, vegans	EHQ

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TABLE 1 | (Continued)

Author, year, country	*N* (Total)	Age (mean years)	Sex assigned at birth and/or gender	Race/ethnicity (*n*)	SES	BMI	Education level (% university degree)	*n* (VVD/OMN)	Dietary exposition	Measure of orthorexia nervosa symptoms
Oberle et al. (2021), USA	847	22	Female = 82.0%; male = 15.0%	NR	NR	NR	47	120/606	Vegetarian, vegan	DOS
Yücel et al. (2021), Turkey	965	20–65	Female = 76.0%; male = 23.7%	NR	Employed = 319 unemployed = 607; left work = 39	NR	NR	603/362	Vegetarian, vegan	ORTO-15
Reynolds et al. (2023), USA, India, Australia, UK, Canada, Others.	444	37	Female = 45.5%; male = 53.4%; other = 0.7%	Caucasian = 254 Southeast Asian = 42; other = 60; East Asian = 33; African = 19; Latino/ Hispanic = 11; South Asian = 10; mixed = 6; missing = 6; Middle Eastern = 3	NR	27	59	70/374	Vegetarian, vegan, ovo-lacto vegetarian, ovo-vegetarian, lacto-vegetarian	ORTO-15
Ruiz and Quiles (2021), Spain	534	22	Female = 79.0%; male = 21.0%	NR	NR	NR	100	86/448	Vegetarian, vegan	ORTO-11, TOS
Şentürk et al. (2022), Turkey	1165	31	Female = 81.5%; male = 17.0%; other = 1.5%	NR	NR	22.3	NR	739/426	Vegetarian, vegan	TOS
Strahler et al. (2018), Germany	713	29	Female = 58.0%	NR	Employment: student/ unemployed = 238; full time = 153; part time = 122; mini job = 134; nonregular job = 55; parental leave = 11	23	94	140/451	Vegetarian, vegan	DOS
Tarsitano et al. (2022), Italy	4107	31	Female = 95.0%	NR	NR	24	NR	1071/2931	Vegetarian, vegan	DOS

Abbreviations: BMI, body mass index; BOT, Bratman Test for Orthorexia; DOS, Duesseldorf Orthorexia Scale; EHQ, Eating Habits Questionnaire; NR, not reported; OMN, omnivorous diets; ORTO-15/11, Questionnaire for the Diagnosis of Orthorexia; ORTO-R, abbreviated version of the ORTO-11; SES, socioeconomic status; TOS, Teruel Orthorexia Scale; VVD, vegetarian and/or vegan diet.

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(vi) blinding of outcome assessors to participants' exposure status. (Table S4).

3.5 | Meta-Analysis

The meta-analyses according to continuous or categorical ON data are displayed in Figures 2 and 3, respectively. Compared with those following omnivorous diets ($n = 10{,}631$), adults following VVDs ($n = 3497$) presented higher ON symptoms (SMD = 0.46; 95% CI: 0.33, 0.60; $I^2 = 81.0\%$; $n = 20$). The meta-analysis of categorical data revealed a greater prevalence of ON symptoms (OR = 1.99; 95% CI: 1.21, 3.25; $I^2 = 92.8\%$; $n = 11$) among adults following VVDs ($n = 3555$; cases: 677) than among those following omnivorous diets ($n = 9633$; cases: 2013).

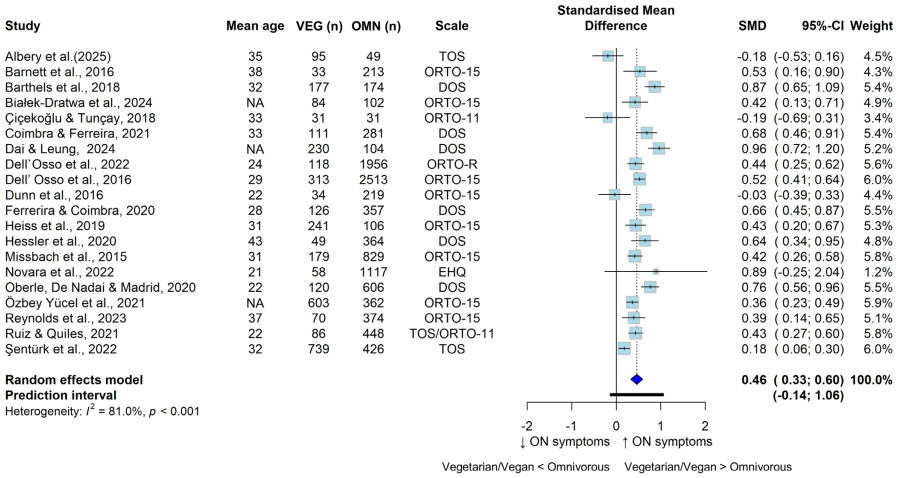


FIGURE 2 | Pooled standardized mean differences for the cross-sectional associations between vegetarian and/or vegan versus omnivorous diets and orthorexia nervosa symptoms. CI, confidence interval; DOS, Duesseldorf Orthorexia Scale; EHQ, Eating Habits Questionnaire; OMN, omnivorous; ON, orthorexia nervosa; ORTO-15/11/R, Questionnaire for the Diagnosis of Orthorexia; SMD, standardized mean difference; TOS, Teruel Orthorexia Scale; VEG, vegetarian and/or vegan.

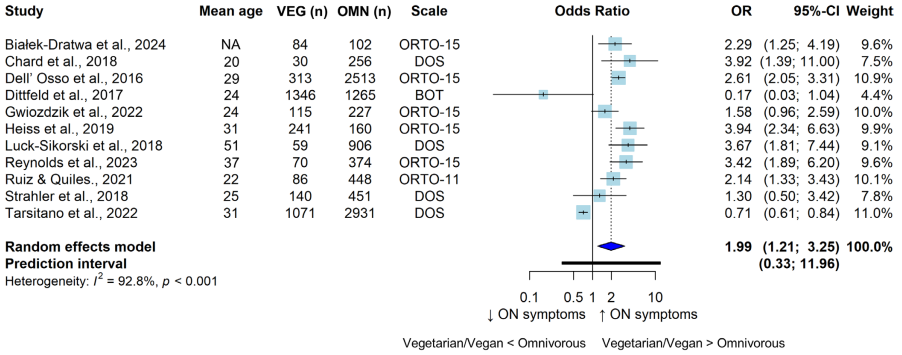


FIGURE 3 | Pooled odds ratios for the cross-sectional associations between vegetarian and/or vegan versus omnivorous diets and the likelihood of orthorexia nervosa symptoms. BOT, Bratman Test for Orthorexia; CI, confidence interval; DOS, Duesseldorf Orthorexia Scale; OMN, omnivorous; ON, orthorexia nervosa; OR, odds ratio; ORTO-15/11, Questionnaire for the Diagnosis of Orthorexia; VEG, vegetarian and/or vegan.

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3.5.1 | Subgroup Analyses and Meta-Regression Models

The results of the subgroup analyses are displayed in Figure 4 and Table S5. Compared with omnivorous diets, vegetarian (SMD = 0.46; 95% CI: 0.28, 0.63; $I^2 = 79.8\%$; $n = 12$) and vegan (SMD = 0.42; 95% CI: 0.10, 0.75; $I^2 = 87.8\%$; $n = 11$) diets were moderately associated with higher ON symptoms. No significant subgroup differences were found between vegetarians and vegans in their associations with ON symptoms ($p = 0.855$).

Compared with those following omnivorous diets, ON symptoms were significantly greater for adults following VVDs according to the self-reported scales applied. Specifically, studies employing the ORTO-15/11/R questionnaire reported a small to moderate effect size (SMD = 0.38; 95% CI: 0.26, 0.51; $I^2 = 38.4\%$; $n = 11$), and studies employing the DOS reported a large effect size (SMD = 0.76; 95% CI: 0.65, 0.88; $I^2 = 7.5\%$; $n = 6$), with significant between-group differences ($p < 0.001$). Additionally, the subgroup analysis according to geographic location revealed no significant differences ($p = 0.838$) between studies from the USA (SMD = 0.55; 95% CI: 0.22, 0.87; $I^2 = 83.8\%$; $n = 5$) and Europe (SMD = 0.51; 95% CI: 0.35, 0.67; $I^2 = 70.7\%$; $n = 11$). Owing to the small number of studies ($n < 5$) analyzing categorical outcome data in specific subgroups (i.e., USA, vegan, DOS), subgroup analyses were not performed for the meta-analysis of the prevalence of ON symptoms between VVDs and omnivorous diets.

Meta-regression analyses for participant characteristics revealed no statistically significant differences in the study associations (Table S6 and Figure S1).

3.5.2 | Sensitivity Analyses and Publication Bias

The results of the sensitivity analysis are shown in Table S7. The pooled SMDs were not modified when each study was removed one by one. According to Egger's test (Table S8) and funnel plot asymmetry, no publication bias was found for the study associations ($p = 0.762$ for continuous outcome data and $p = 0.121$ for categorical outcome data) (Figure S2).

4 | Discussion

To the best of our knowledge, this systematic review and meta-analysis is the first to synthesize observational evidence on the associations between VVDs and symptoms of ON in young and middle-aged adults. Our findings suggest that VVDs followers are more likely to exhibit ON symptoms than omnivores. Subgroup analyses revealed that both VVDs were moderately associated with greater ON symptoms than were omnivorous diets, although there was no significant difference between the two. Notably, the magnitude of the association varied depending on the self-report instrument used. Studies using the ORTO-15/11/R questionnaire showed a small-to-moderate effect size, whereas those using the DOS reported a large effect size. No significant differences were observed by geographic location or across participant characteristics assessed in the meta-regression models, including age, sex, BMI, and educational level. However, our findings should be interpreted with caution due to important limitations, including the lack of longitudinal studies–particularly prospective cohort studies– in the available literature and the generally low methodological quality of the included studies.

While previous reviews were limited to systematic syntheses (McLean et al. 2022; Mathieu et al. 2023), the present study not only confirms their main findings of a positive association between VVDs and ON symptomatology but also contributes to the field in two important ways. First, it provides the first meta-analytic estimate of this association by directly comparing individuals following VVDs with those adhering to omnivorous diets. Second, it extends the evidence through subgroup analyses and meta-regressions to explore potential moderating factors. These analyses reinforce the general finding that VVDs are moderately associated with an increased likelihood of ON symptoms compared with omnivorous diets. Interestingly, no significant differences were detected between vegetarians and vegans. These associations may be partially explained by the restrictive and selective eating patterns characteristic of certain VVDs, which align with potential behavioral markers of ON (Şentürk et al. 2022; Horovitz and Argyrides 2023). The significant heterogeneity observed, particularly regarding vegan diets, underscores the impact of methodological and contextual factors.

Some symptoms of ON, such as disordered restrictive eating, the pursuit of thinness, and weight control, are shared with other EDs (Atchison and Zickgraf 2022). These features are like the established relationships between VVDs and other EDs, particularly anorexia nervosa (Sergentanis et al. 2020). For individuals following a VVD and living with an ED, this dietary pattern may serve as a form of food restriction that either reflects or reinforces their underlying psychopathology (Lindeman et al. 2000). However, owing to the predominance of cross-sectional data, the directionality of the relationship between VVDs and ON cannot be established.

The VVD-ON association may be influenced by multiple factors, including psychological characteristics (e.g., personality traits, perfectionism, and obsessive-compulsive tendencies), sociocultural influences (e.g., excessive social media engagement, exposure to misinformation, and body stereotypes), and a history of chronic dieting and body image dissatisfaction (Horovitz and Argyrides 2023), which should be considered in future research.

In addition to individual traits and behavioral patterns, dietary motivations may influence the relationship between VVDs and ON symptoms (Szulc et al. 2025). A deeper understanding of the motivations behind adopting VVDs could provide more precise insights into the temporality of this relationship. For example, some studies have reported a decrease in ON symptoms among individuals who follow these diets due to concerns about animal welfare, environmental issues, or political beliefs (Mathieu et al. 2023). Thus, future studies must explore the reasons behind these dietary choices to further examine their associations with EDs.

Another possible explanation for the association between VVDs and ON symptoms is that, despite efforts to develop criteria for identifying risk factors and assessing appropriate treatment (Dunn and Bratman 2016; Moroze et al. 2015), a wide variety of instruments have been used to assess ON symptoms. Most of

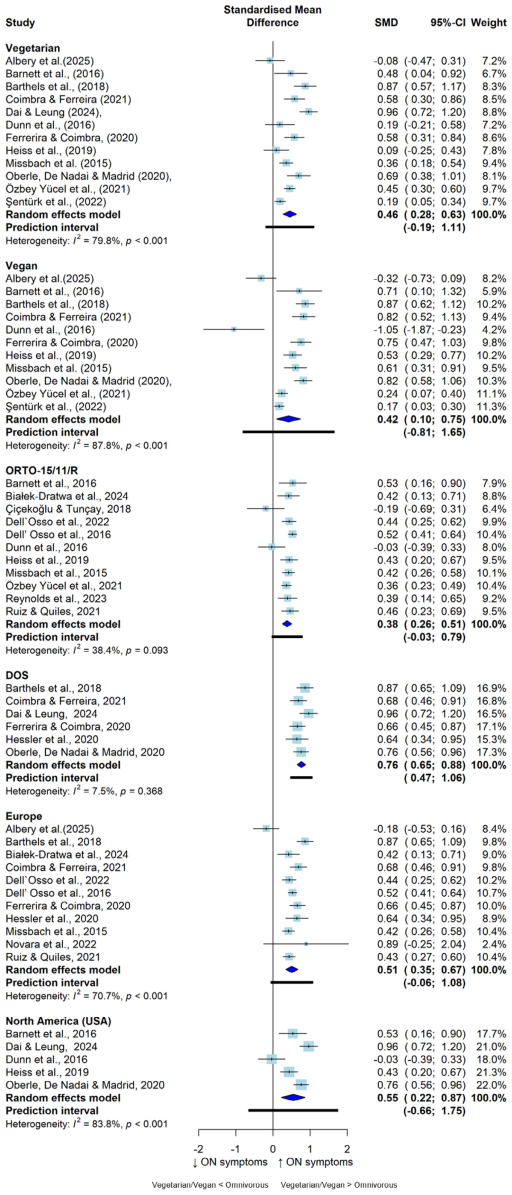


FIGURE 4 | Legend on next page.

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FIGURE 4 | Pooled standardized mean differences between vegetarian and/or vegan versus omnivorous diets and orthorexia nervosa symptoms, by subgroup. CI, confidence interval; DOS, Duesseldorf Orthorexia Scale; ON, orthorexia nervosa; ORTO-15/11/R, Questionnaire for the Diagnosis of Orthorexia; SMD, standardized mean difference.

these instruments have been criticized for their validity in detecting these features and screening for ON. For example, ORTO-15, one of the most widely used tools, has been shown to be unreliable by some authors (López-Gil et al. 2023; Ng et al. 2024; Depa et al. 2019). This suggests that the high prevalence of ON (ranging from 30% to 70%) may be due to the variety of available measurement instruments, as well as their low reliability (Dunn and Bratman 2016; Barrada and Meule 2024). Therefore, future research should prioritize the use of validated tools that are more accurate and reliable (e.g., DOS, TOS and EHQ-R) (Opitz et al. 2020). This will enable more consistent and comparable estimates to be obtained across studies. Consequently, certain behaviors may be misclassified as pathological when they may reflect a nonproblematic, health-oriented interest in eating. This underscores the necessity of further research into the etiology of this condition, with the aim of establishing standardized criteria and accurate assessment tools (Horovitz and Argyrides 2023; Donini et al. 2022).

4.1 | Strengths, Limitations, and Future Recommendations

An important strength of our study is that searching multiple databases exhaustively increased the likelihood of capturing all available evidence on the subject, thereby improving the completeness and reliability of the results. However, some limitations must also be noted. First, the inclusion of only cross-sectional studies prevented causal inferences and definitive conclusions about whether VVDs lead to the development of ON symptoms. Second, our analyses revealed substantial between-study heterogeneity in the main pooled estimates, partially attributable to differences in geographic region, the instruments used to assess ON symptoms, and the influence of specific low-quality studies (Şentürk et al. 2022; Tarsitano et al. 2022). Nevertheless, a considerable proportion of heterogeneity remained unexplained, which limits the interpretability of the findings. Third, the small number of studies with sex-stratified data prevented us from examining potential differences in the VVD–ON association. Fourth, most studies did not report sociodemographic characteristics, such as ethnicity, race, gender, and socioeconomic status. This lack of information limits the ability to evaluate the representativeness and diversity of the samples, as well as the generalizability of the findings to broader populations. Future studies should prioritize systematically reporting these characteristics to enable stratified meta-analyses and meta-regression and improve the external validity of the evidence. Finally, most studies failed to account for potentially influential covariates, such as sex, physical activity, socioeconomic status, energy intake, the reason for adhering to VVDs, the duration of adherence to these diets, and the use of social networks. This limited our ability to perform adjusted analyses for these factors. Future studies should consider key factors that may influence this relationship, such as the underlying reasons for adopting these diets (e.g., religious, ethical or environmental reasons), the duration of adherence to these diets, specific subtypes of vegetarian diets (e.g., ovo-vegetarian, lacto-vegetarian, and ovo-lacto-vegetarian diets), the nutritional quality of the diet, and the individual characteristics of the participants. The results from these analyses should also be reported by sex and BMI. It is important to distinguish between pathological behaviors, such as those associated with ON, and nonpathological behaviors that promote healthy eating. This distinction would contribute to clarifying their respective associations with dietary patterns. Research on specific age groups, particularly adolescents and older adults, who may have different vulnerabilities and motivations in relation to eating behaviors, is lacking.

5 | Conclusion

Young and middle-aged adults who follow VVDs appear to exhibit more ON symptoms than omnivores. However, these findings should be interpreted with caution because the current evidence is limited to cross-sectional studies, which preclude causal inference. Additionally, the studies are generally of low methodological quality. Future high-quality research should prioritize longitudinal designs, the use of standardized and validated assessment tools, and improved methodological rigor to better understand the nature and direction of the association between VVDs and ON symptomatology. This information could help identify individuals who could benefit from early screening and tailored interventions, particularly in clinical and nutritional counseling contexts.

Author Contributions

Valentina Díaz-Goñi: conceptualization (lead), investigation (lead), methodology (equal), formal analysis (equal), visualization (lead), writing – original draft preparation (lead), writing – review and editing (equal). **Bruno Bizzozero-Peroni:** conceptualization (supporting), investigation (supporting), methodology (equal), formal analysis (equal), writing – original draft preparation (supporting), visualization (supporting), validation (lead), project administration (equal), writing – review and editing (equal), supervision (equal). **María Eugenia Visier-Alfonso:** validation (supporting), writing – review and editing (equal). **Estela Jiménez-López:** validation (supporting), writing – review and editing (equal). **Rubén Fernández-Rodríguez:** writing – original draft preparation (supporting), writing – review and editing (equal). **José Francisco López-Gil:** writing – original draft preparation (supporting), writing – review and editing (equal). **Tomás Olivo Martins-de-Passos:** visualization (supporting), writing – review and editing (equal). **Alberto Durán González:** visualization (supporting), writing – review and editing (equal). **Vicente Martínez-Vizcaíno:** methodology (supporting), writing – review and editing (equal). **Arthur Eumann Mesas:** conceptualization (supporting), investigation (supporting), methodology (equal), writing – original draft preparation (supporting), visualization (supporting), project administration (equal), writing – review and editing (equal), supervision (equal). All the authors have read and agreed to the published version of the manuscript.

Ethics Statement

The authors have nothing to report.

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Consent

The authors have nothing to report.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

References

Agnoli, C., L. Baroni, I. Bertini, et al. 2023. "A Comprehensive Review of Healthy Effects of Vegetarian Diets." *Nutrition, Metabolism, and Cardiovascular Diseases* 33: 1308–1315.

Albery, I. P., R. Smith, D. Frings, et al. 2025. "Patterns of Implicit and Explicit Identity as a Vegan or Vegetarian in Predicting Healthy Orthorexia and Orthorexia Nervosa." *Eating and Weight Disorders* 30: 1–14.

Atchison, A. E., and H. F. Zickgraf. 2022. "Orthorexia Nervosa and Eating Disorder Behaviors: A Systematic Review of the Literature." *Appetite* 177: 106134.

Balduzzi, S., G. Rücker, and G. Schwarzer. 2019. "How to Perform a Meta-Analysis With R: A Practical Tutorial." *Evidence-Based Mental Health* 22: 153–160.

Barnett, M. J., W. R. Dripps, and K. K. Blomquist. 2016. "Organivore or Organorexic? Examining the Relationship Between Alternative Food Network Engagement, Disordered Eating, and Special Diets." *Appetite* 105: 713–720.

Barrada, J. R., and A. Meule. 2024. "Orthorexia Nervosa: Research Based on Invalid Measures Is Invalid." *Journal of Global Health* 14: 03007.

Barthels, F., F. Meyer, and R. Pietrowsky. 2018. "Orthorexic and Restrained Eating Behaviour in Vegans, Vegetarians, and Individuals on a Diet." *Eating and Weight Disorders* 23: 159–166.

Białek-Dratwa, A., W. Stoń, W. Staśkiewicz-Bartecka, M. Grajek, K. Krupa-Kotara, and O. Kowalski. 2024. "The Psychosocial Aspects of Vegetarian Diets: A Cross-Sectional Study of the Motivations, Risks, and Limitations in Daily Life." *Nutrients* 16: 2504.

Borenstein, M., L. V. Hedges, J. P. T. Higgins, and H. R. Rothstein. 2009. "Converting Among Effect Sizes." In *Introduction to Meta-Analysis*, 45–49. John Wiley & Sons.

Bratman, S. 2017. "Orthorexia vs. Theories of Healthy Eating." *Eating and Weight Disorders* 22: 381–385.

Brytek-Matera, A. 2020. "Interaction Between Vegetarian Versus Omnivorous Diet and Unhealthy Eating Patterns (Orthorexia Nervosa, Cognitive Restraint) and Body Mass Index in Adults." *Nutrients* 12: 646.

Brytek-Matera, A. 2021. "Vegetarian Diet and Orthorexia Nervosa: A Review of the Literature." *Eating and Weight Disorders* 26: 1–11.

Brytek-Matera, A., K. Czepczor-Bernat, H. Jurzak, M. Kornacka, and N. Kołodziejczyk. 2019. "Strict Health-Oriented Eating Patterns (Orthorexic Eating Behaviours) and Their Connection With a Vegetarian and Vegan Diet." *Eating and Weight Disorders* 24: 441–452.

Chard, C. A., C. Hilzendegen, F. Barthels, and N. Stroebele-Benschop. 2019. "Psychometric Evaluation of the English Version of the Düsseldorf Orthorexie Scale (DOS) and the Prevalence of Orthorexia Nervosa Among a U.S. Student Sample." *Eating and Weight Disorders* 24: 275–281.

Çiçekoğlu, P., and G. Y. Tunçay. 2018. "A Comparison of Eating Attitudes Between Vegans/Vegetarians and Nonvegans/Nonvegetarians in Terms of Orthorexia Nervosa." *Archives of Psychiatric Nursing* 32: 200–205.

Cohen, J. 1988. *Statistical Power Analysis for the Behavioral Sciences*. 2nd ed. Lawrence Erbaum Associates.

Coimbra, M., and C. Ferreira. 2021. "Understanding the Omnivore, Vegetarian, Vegan, and Paleo Dietary Patterns: How They Differ in Disordered Eating Indicators." *Revista Portuguesa de Investigação Comportamental e Social* 7: 41–51.

Cramer, H., C. S. Kessler, T. Sundberg, et al. 2017. "Characteristics of Americans Choosing Vegetarian and Vegan Diets for Health Reasons." *Journal of Nutrition Education and Behavior* 49: 561–567.e1.

Dai, X., and A. K. Y. Leung. 2024. "Motivations Matter: Moral and Health-Related Motives Indirectly Relate to Differential Psychological Health Indicators Among Vegetarians." *Journal of Health, Population, and Nutrition* 43: 1–21.

Dell'Osso, L., M. Abelli, B. Carpita, et al. 2016. "Orthorexia Nervosa in a Sample of Italian University Population." *Rivista di Psichiatria* 51: 190–196.

Dell'Osso, L., I. M. Cremone, I. Chiarantini, et al. 2022. "Investigating Orthorexia Nervosa With the ORTO-R in a Sample of University Students With or Without Subthreshold Autism Spectrum: Focus on Dietary Habits and Gender Differences." *Frontiers in Psychiatry* 13: 900880.

Depa, J., J. R. Barrada, and M. Roncero. 2019. "Are the Motives for Food Choices Different in Orthorexia Nervosa and Healthy Orthorexia?" *Nutrients* 11: 697.

Diagnostic and Statistical Manual of Mental Disorders. 2022. *Text Revision (DSM-5-TR)*. 5th ed. American Psychiatric Publishing.

Dittfeld, A., K. Gwizdek, P. Jagielski, J. Brzęk, and K. Ziora. 2017. "A Study on the Relationship Between Orthorexia and Vegetarianism Using the BOT (Bratman Test for Orthorexia)." *Psychiatria Polska* 51: 1133–1144.

Donini, L. M., J. R. Barrada, F. Barthels, et al. 2022. "A Consensus Document on Definition and Diagnostic Criteria for Orthorexia Nervosa." *Eating and Weight Disorders* 27: 3695–3711.

Dunn, T. M., and S. Bratman. 2016. "On Orthorexia Nervosa: A Review of the Literature and Proposed Diagnostic Criteria." *Eating Behaviors* 21: 11–17.

Dunn, T. M., J. Gibbs, N. Whitney, and A. Starosta. 2017. "Prevalence of Orthorexia Nervosa Is Less Than 1%: Data From a US Sample." *Eating and Weight Disorders* 22: 185–192.

Ferreira, C., and M. Coimbra. 2021. "To Further Understand Orthorexia Nervosa: DOS Validity for the Portuguese Population and Its Relationship With Psychological Indicators, Sex, BMI and Dietary Pattern." *Eating and Weight Disorders* 26: 2127–2134.

Forestell, C. A., A. M. Spaeth, and S. A. Kane. 2012. "To Eat or Not to Eat Red Meat. A Closer Look at the Relationship Between Restrained Eating and Vegetarianism in College Females." *Appetite* 58: 319–325.

Gacek, M. 2010. "Selected Lifestyle and Health Condition Indices of Adults With Varied Models of Eating." *Roczniki Panstwowego Zakladu Higieny* 61: 65–69.

Gkiouleka, M., C. Stavraki, T. N. Sergentanis, and T. Vassilakou. 2022. "Orthorexia Nervosa in Adolescents and Young Adults: A Literature Review." *Children* 9: 365.

Gortat, M., M. Samardakiewicz, and A. Perzyński. 2021. "Orthorexia Nervosa—A Distorted Approach to Healthy Eating." *Psychiatria Polska* 55: 421–433.

Gwioździk, W., K. Krupa-Kotara, B. Całyniuk, P. Helisz, M. Grajek, and J. Głogowska-Ligus. 2022. "Traditional, Vegetarian, or Low FODMAP Diets and Their Relation to Symptoms of Eating Disorders: A Cross-Sectional Study Among Young Women in Poland." *Nutrients* 14: 4125.

Hargreaves, S. M., D. L. Rosenfeld, A. V. B. Moreira, and R. P. Zandonadi. 2023. "Plant-Based and Vegetarian Diets: An Overview and

Definition of These Dietary Patterns." *European Journal of Nutrition* 62: 1109–1121.

Heiss, S., J. A. Coffino, and J. M. Hormes. 2019. "What Does the ORTO-15 Measure? Assessing the Construct Validity of a Common Orthorexia Nervosa Questionnaire in a Meat Avoiding Sample." *Appetite* 135: 93–99.

Hessler-Kaufmann, J. B., A. Meule, C. Holzapfel, et al. 2020. "Orthorexic Tendencies Moderate the Relationship Between Semi-Vegetarianism and Depressive Symptoms." *Eating and Weight Disorders* 26: 623–628.

Higgins, J., J. Thomas, J. Chandler, et al. 2024. *Cochrane Handbook for Systematic Reviews of Interventions*. Cochrane Training. https://training.cochrane.org/handbook.

Hopwood, C. J., D. Rosenfeld, S. Chen, and W. Bleidorn. 2021. "An Investigation of Plant-Based Dietary Motives Among Vegetarians and Omnivores." *Collabra: Psychology* 7: 2021.

Horovitz, O., and M. Argyrides. 2023. "Orthorexia and Orthorexia Nervosa: A Comprehensive Examination of Prevalence, Risk Factors, Diagnosis, and Treatment." *Nutrients* 15: 3851.

Iguacel, I., I. Huybrechts, L. A. Moreno, and N. Michels. 2021. "Vegetarianism and Veganism Compared With Mental Health and Cognitive Outcomes: A Systematic Review and Meta-Analysis." *Nutrition Reviews* 79: 361–381.

Jackson, D., and R. Turner. 2017. "Power Analysis for Random-Effects Meta-Analysis." *Research Synthesis Methods* 8: 290–302.

Lindeman, M., K. Stark, and K. Latvala. 2000. "Vegetarianism and Eating-Disordered Thinking." *Eating Disorders* 8: 157–165.

López-Gil, J. F., P. J. Tárraga-López, M. S. Hershey, et al. 2023. "Overall Proportion of Orthorexia Nervosa Symptoms: A Systematic Review and Meta-Analysis Including 30 476 Individuals From 18 Countries." *Journal of Global Health* 13: 4087.

Luck-Sikorski, C., F. Jung, K. Schlosser, and S. G. Riedel-Heller. 2019. "Is Orthorexic Behavior Common in the General Public? A Large Representative Study in Germany." *Eating and Weight Disorders* 24: 267–273.

Mathieu, S., E. Hanras, and G. Dorard. 2023. "Associations Between Vegetarianism, Body Mass Index, and Eating Disorders/Disordered Eating Behaviours: A Systematic Review of Literature." *International Journal of Food Sciences and Nutrition* 74: 424–462.

McLean, C. P., J. Kulkarni, and G. Sharp. 2022. "Disordered Eating and the Meat-Avoidance Spectrum: A Systematic Review and Clinical Implications." *Eating and Weight Disorders* 27: 2347–2375.

Missbach, B., B. Hinterbuchinger, V. Dreiseitl, S. Zellhofer, C. Kurz, and J. König. 2015. "When Eating Right, Is Measured Wrong! A Validation and Critical Examination of the ORTO-15 Questionnaire in German." *PLoS One* 10: e0135772.

Morgan, R. L., P. Whaley, K. A. Thayer, and H. J. Schünemann. 2018. "Identifying the PECO: A Framework for Formulating Good Questions to Explore the Association of Environmental and Other Exposures With Health Outcomes." *Environment International* 121: 1027–1031.

Moroze, R. M., T. M. Dunn, J. Craig Holland, J. Yager, and P. Weintraub. 2015. "Microthinking About Micronutrients: A Case of Transition From Obsessions About Healthy Eating to Near-Fatal "Orthorexia Nervosa" and Proposed Diagnostic Criteria." *Psychosomatics* 56: 397–403.

National Heart Lung and Blood Institute. 2021. "Study Quality Assessment Tools | NHLBI, NIH." https://www.nhlbi.nih.gov/health-topics/study-quality-assessment-tools.

Ng, Q. X., D. Y. X. Lee, C. E. Yau, et al. 2024. "On Orthorexia Nervosa: A Systematic Review of Reviews." *Psychopathology* 57: 345–358.

Niedzielski, A., and N. Kaźmierczak-Wojtaś. 2021. "Prevalence of Orthorexia Nervosa and Its Diagnostic Tools—A Literature Review." *International Journal of Environmental Research and Public Health* 18: 5488.

Novara, C., S. Pardini, F. Visioli, and N. Meda. 2022. "Orthorexia Nervosa and Dieting in a Non-Clinical Sample: A Prospective Study." *Eating and Weight Disorders* 27: 2081–2093.

Oberle, C. D., A. S. De Nadai, and A. L. Madrid. 2021. "Orthorexia Nervosa Inventory (ONI): Development and Validation of a New Measure of Orthorexic Symptomatology." *Eating and Weight Disorders* 26: 609–622.

Opitz, M. C., E. Newman, A. S. Alvarado Vázquez Mellado, M. K. D. A. Robertson, and H. Sharpe. 2020. "The Psychometric Properties of Orthorexia Nervosa Assessment Scales: A Systematic Review and Reliability Generalization." *Appetite* 155: 104797.

Oussalah, A., J. Levy, C. Berthezène, D. H. Alpers, and J. L. Guéant. 2020. "Health Outcomes Associated With Vegetarian Diets: An Umbrella Review of Systematic Reviews and Meta-Analyses." *Clinical Nutrition* 39: 3283–3307.

Ouzzani, M., H. Hammady, Z. Fedorowicz, et al. 2016. "Rayyan—A Web and Mobile App for Systematic Reviews." *Systematic Reviews* 5: 1–10.

Page, M. J., J. E. McKenzie, P. M. Bossuyt, et al. 2021. "The PRISMA 2020 Statement: An Updated Guideline for Reporting Systematic Reviews." *BMJ* 372: n71.

Parra-Fernández, M. L., M. Manzaneque-Cañadillas, M. D. Onieva-Zafra, et al. 2020. "Pathological Preoccupation With Healthy Eating (Orthorexia Nervosa) in a Spanish Sample With Vegetarian, Vegan, and Non-Vegetarian Dietary Patterns." *Nutrients* 12: 1–12.

Raj, S., N. S. Guest, M. J. Landry, A. R. Mangels, R. Pawlak, and M. Rozga. 2025. "Vegetarian Dietary Patterns for Adults: A Position Paper of the Academy of Nutrition and Dietetics." *Journal of the Academy of Nutrition and Dietetics* 125: 831–846.e2.

Rethlefsen, M. L., S. Kirtley, S. Waffenschmidt, et al. 2021. "PRISMA-S: An Extension to the PRISMA Statement for Reporting Literature Searches in Systematic Reviews." *Systematic Reviews* 10: 1–19.

Reynolds, R., A. McGowan, S. Smith, and P. Rawstorne. 2023. "Vegan and Vegetarian Males and Females Have Higher Orthorexic Traits Than Omnivores, and Are Motivated in Their Food Choice by Factors Including Ethics and Weight Control." *Nutrition and Health* 31: 439–450.

Ruby, M. B. 2012. "Vegetarianism. A Blossoming Field of Study." *Appetite* 58: 141–150.

Ruiz, Á., and Y. Quiles. 2021. "Prevalence of Orthorexia Nervosa in Spanish University Students: Relationship With Body Image and Eating Disorders." *Anales de Psicología* 37: 493–499.

Şentürk, E., B. Güler Şentürk, S. Erus, B. Geniş, and B. Coşar. 2022. "Dietary Patterns and Eating Behaviors on the Border Between Healthy and Pathological Orthorexia." *Eating and Weight Disorders* 27: 3279–3288.

Sergentanis, T. N., M. E. Chelmi, A. Liampas, et al. 2020. "Vegetarian Diets and Eating Disorders in Adolescents and Young Adults: A Systematic Review." *Children* 8: 12.

Sidik, K., and J. N. Jonkman. 2005. "Simple Heterogeneity Variance Estimation for Meta-Analysis." *Journal of the Royal Statistical Society. Series C, Applied Statistics* 54: 367–384.

Sterne, J. A. C., M. Egger, and G. D. Smith. 2001. "Systematic Reviews in Health Care: Investigating and Dealing With Publication and Other Biases in Meta-Analysis." *British Medical Journal* 323: 101–105.

Strahler, J., A. Hermann, B. Walter, and R. Stark. 2018. "Orthorexia Nervosa: A Behavioral Complex or a Psychological Condition?" *Journal of Behavioral Addictions* 7: 1143–1156.

Stroup, D. F., J. A. Berlin, S. C. Morton, et al. 2000. "Meta-Analysis of Observational Studies in Epidemiology: A Proposal for Reporting. Meta-Analysis of Observational Studies in Epidemiology (MOOSE) Group." *JAMA* 283: 2008–2012.

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Szulc, P., K. Willich, and P. Gogga. 2025. "Association Between Orthorexia and Plant-Based Diets-Is There a Vicious Cycle?" *Nutrients* 17: 1337.

Tarsitano, M. G., R. Pujia, Y. Ferro, et al. 2022. "Symptoms of Orthorexia Nervosa Are Associated With Time Spent on Social Media: A Web-Based Survey in an Italian Population Sample." *European Review for Medical and Pharmacological Sciences* 26: 9327–9335.

Wang, T., A. Masedunskas, W. C. Willett, and L. Fontana. 2023. "Vegetarian and Vegan Diets: Benefits and Drawbacks." *European Heart Journal* 44: 3423–3439.

Yücel, Ü. Ö., K. Kömbeci, G. Tuğrul, Ü. Yücel, A. Uçar, and S. Yüksel. 2021. "Changes in Diet, Lifestyle and Orthorexia Nervosa Attitudes of Vegetarian, Vegan and Omnivorous Individuals in COVID-19 Pandemic." *International Journal of Nutrition Sciences* 6: 74–80.

Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Table S1:** Detailed information on search strategies. **Table S2:** Effect sizes, main results, and covariate adjustments of included studies. **Table S3:** List of the studies fully assessed for eligibility and excluded. **Table S4:**. Methodological quality of included studies[a]. **Table S5:** Subgroup analyses for the cross-sectional associations between vegetarian and/or vegan versus omnivorous diets and orthorexia nervosa symptoms. **Table S6:** Meta-regression analyses for the cross-sectional associations between vegetarian and/or vegan versus omnivorous diets and orthorexia nervosa symptoms. [a] **Table S7:**. Sensitivity analyses excluding studies one by one. **Table S8:** Meta-bias for the cross-sectional associations between vegetarian and/or vegan versus omnivorous diets and orthorexia nervosa symptoms. **Figure S1:** Meta-regression models by age (A), sex (B), body mass index (C), and educational level (D) for the cross-sectional associations between vegetarian and/or vegan versus omnivorous diets and orthorexia nervosa symptoms. **Figure S2:** Publication bias from cross-sectional meta-analyses of standardized mean differences (A) and odds ratio (B).

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MANUSCRIPT III

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Are Vegetarian and Vegan Diets Associated With Eating Disorder Symptoms? A Systematic Review and Meta-Analysis

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ABSTRACT

Objective: To synthesize the evidence on the associations between vegetarian and vegan diets (VVDs) and eating disorder (ED) symptoms compared with omnivorous diets across the lifespan.

Method: Following the preferred reporting items for systematic reviews and meta-analyses (PRISMA) 2020 Guidelines, we searched PubMed, Scopus, Cochrane Library, PsycINFO, and Web of Science Databases up to May 1, 2026, with no language or date restrictions. Random effects models with the Hartung–Knapp–Sidik–Jonkman method were used to estimate pooled effect sizes (standardized mean difference [SMD] with 95% confidence interval [CIs]).

Results: We included 24 cross-sectional studies with a total of 25,223 participants (67.7% female; mean age range: 14.9–49.6 years). ED symptoms did not differ significantly between participants who followed VVDs and those following omnivorous diets in analyses including all eligible studies (SMD = 0.07; 95% CI: −0.04 to 0.19; $I^2 = 80.3\%$; 95% prediction interval: −0.44 to 0.59). Results were unchanged when analyses were restricted to adult populations. No significant differences in ED symptoms were observed according to diet type ($p = 0.524$), measurement scale ($p = 0.392$), or geographic region ($p = 0.633$). In analyses restricted to adults, sex significantly moderated the pooled estimates ($p = 0.028$), with studies including a higher proportion of females reporting lower ED symptom scores among individuals following VVDs compared with omnivores.

Discussion: ED symptom levels do not appear to differ significantly between individuals following VVDs and those following omnivorous diets. Longitudinal studies accounting for dietary quality, duration of adherence, dietary motivations, and psychosocial factors are also needed to clarify this association.

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Summary

- This is the first meta-analysis to quantify the association between vegetarian and vegan diets and eating disorder (ED) symptoms compared with omnivorous diets across the lifespan.
- No statistically significant differences in ED symptoms were observed between dietary groups. The available evidence was predominantly derived from young and middle-aged adults.
- Sex significantly moderated the pooled estimates in analyses restricted to adult populations, with studies including a higher proportion of females showing lower ED symptom scores among those following vegetarian or vegan diets.
- Findings should be interpreted cautiously due to substantial heterogeneity and the cross-sectional nature of the evidence. No longitudinal evidence was identified, highlighting the need for studies examining directionality of associations, particularly in adolescent and older populations.

1 | Introduction

Eating disorders (EDs) are serious psychiatric conditions characterized by persistent disturbances in eating behaviors and weight regulation, often resulting in severe physical and psychological consequences (American Psychiatric Association 2022). They represent a growing global public health concern worldwide, affecting millions of individuals and contributing to the global burden of disease (GBD 2023 Mental Disorder Collaborators. 2026; Treasure et al. 2020). Although EDs most often emerge during adolescence, they may persist, recur, or first manifest later in life, resulting in important clinical, functional, and public health consequences across the lifespan (Brandsma 2007; Khalsa et al. 2017; Södersten et al. 2006).

The etiology of EDs is multifactorial and dynamic, involving the interaction of genetic vulnerability, neurobiological mechanisms (Kaye et al. 1998, 2005), psychological traits, and environmental influences (Becker et al. 2011; Erriu et al. 2020; Hesse-Biber et al. 2006). Moreover, underdiagnosis and undertreatment remain common due to the hidden nature of symptoms and the stigma surrounding help-seeking (Treasure et al. 2020). A thorough understanding of factors associated with ED symptoms is, therefore, essential to inform effective public health, clinical, and educational strategies aimed at preventing and reducing the burden of EDs (Horovitz and Argyrides 2023).

In this context, attention has increasingly focused on socially accepted dietary patterns characterized by food restriction or exclusion, such as vegetarian and vegan diets (VVDs) (Gilbody et al. 1999). VVDs are plant-based diets that vary from the exclusion of any type of meat (i.e., ovo-vegetarian, lacto-vegetarian, and ovo-lacto-vegetarian diets) to the exclusion of all animal-derived foods or food products (i.e., vegan diets) (Hargreaves et al. 2023). The prevalence of VVDs has increased worldwide in recent decades, particularly among women and younger adults (Nezlek and Forestell 2024). Although individuals may adopt these diets for a variety of reasons, such as religious, ethical, health, or environmental concerns (Kim et al. 2022; Mazzolani et al. 2023; Rosenfeld 2018), growing attention has been directed toward their possible association with EDs. Some authors suggested that VVD patterns may provide a socially acceptable framework for restrictive eating behaviors associated with ED psychopathology, particularly when adopted for weight-control purposes (Bardone-Cone et al. 2012). Conversely, individuals with EDs may be more likely to adopt vegetarian dietary patterns, raising the possibility of reverse causality in the observed associations (Heiss, Hormes, and Timko 2017; Mathieu et al. 2023). Nevertheless, current evidence is inconsistent, and it remains unclear whether adherence to a VVD is associated with increased ED symptomatology (Heiss, Hormes, and Timko 2017; Mathieu et al. 2023).

Previous systematic reviews have reported mixed and inconclusive findings. Specifically, while in a review higher ED symptom levels were associated with higher VVD adherence among adolescents and young adults (Sergentanis et al. 2020), two other reviews reported no clear associations after examining studies in adults (Mathieu et al. 2023; McLean et al. 2022a). Furthermore, these reviews often classified dietary patterns as vegetarian even when they included occasional meat or fish consumption (e.g., pescatarian, semi-vegetarian, or flexitarian diets), which may have limited the interpretability of the findings. Since these dietary patterns differ substantially in food consumption and motivations for adherence, combining them in a single exposure category may obscure associations specific to strict VVDs. Importantly, no previous meta-analysis has comprehensively evaluated the association between adherence to strict VVDs (i.e., dietary patterns that completely exclude all types of meat, including poultry and seafood) (Hargreaves et al. 2023) and ED symptoms in community-based populations. To address this gap, the present systematic review and meta-analysis aimed to synthesize the available evidence and estimate this association across the lifespan.

2 | Method

This systematic review with meta-analysis was conducted according to the Cochrane Handbook for Systematic Reviews (Higgins et al. 2024) and the 2020 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Page et al. 2021). The protocol of the systematic review was registered in PROSPERO (reference number: CRD42024527351). During the review process, a protocol amendment was made to remove the age restriction originally specified in the PROSPERO registration (participant age $\geq$ 18 years), thereby allowing the inclusion of studies across all age groups. Two researchers (VD-G and BB-P) independently performed the literature search, screening, study selection, data extraction, and methodological quality assessment. Discrepancies were resolved by consensus with a third researcher (AEM).

2.1 | Search Strategy

A systematic search was conducted in the following electronic databases, from their inception to October 9, 2025: PubMed, Scopus, Cochrane Library, PsycINFO, and Web of Science. The

search was subsequently updated to include the period from October 10, 2025, to May 1, 2026. Gray literature searches were also conducted using Google Scholar to identify potentially relevant peer-reviewed studies not captured in the primary databases. Additionally, backward citation searches were performed by reviewing the reference lists of relevant systematic reviews (Mathieu et al. 2023; McLean et al. 2022a; Sergentanis et al. 2020) and all included studies. The search strategy included terms related to the study objective, such as "vegetarian", "vegan", "plant-based", and "eating disorder". The complete search strategy for all databases is provided in Table S1.

2.2 | Eligibility Criteria

To be included, studies had to meet the following criteria: (i) population: nonclinical populations (i.e., participants not recruited or selected on the basis of a diagnosed physical or mental health condition); (ii) exposure: strict vegetarian (i.e., lacto-vegetarian, ovo-vegetarian, lacto-ovo-vegetarian) and/or vegan (i.e., exclusively plant-derived foods) diets, according to the Academy of Nutrition and Dietetics (Melina et al. 2016) and other commonly used definitions in the literature (Hargreaves et al. 2023); (iii) comparison: omnivorous diets that encompassed the consumption of any type of meat; (iv) outcome: ED psychopathology assessed using validated observer-rated or self-report instruments providing a global measure of ED symptoms. Eligible outcomes also included categorical outcomes based on established cut-off points and ED diagnoses identified through self-report or clinical assessment within community-based populations; and (v) study design: observational studies (i.e., cross-sectional and longitudinal) published in peer-reviewed academic journals.

Studies were excluded if they focused on clinical or special populations (e.g., anorexia, depression, athletes, pregnant individuals), misclassified VVDs (i.e., not explicitly defined or included meat eaters such as pescatarians or flexitarians), or compared VVDs with other special diets (e.g., gluten free, paleo). No language, publication date or other restrictions were applied.

2.3 | Study Selection

All identified studies were uploaded to the Rayyan online review platform (Ouzzani et al. 2016) and deduplicated. Titles and abstracts were screened, and potentially eligible studies were subsequently retrieved to full-text review to verify compliance with the predefined eligibility criteria.

2.4 | Data Extraction

The following data were extracted from each study: (i) first author surname, publication year and country; (ii) sample characteristics, including total sample size, mean age, sex assigned at birth and/or gender, race and/or ethnicity, socioeconomic status, body mass index (BMI), educational level (percentage of any university degree) and subsamples according to diet type; (iii) dietary exposure, including vegetarian, vegan, or mixed (vegetarian plus vegan); (iv) measure of ED symptoms, including validated observer-rated or self-report instruments providing a global score of ED psychopathology, categorical outcomes based on established cut-off points from these instruments, and ED diagnoses identified through self-report or clinical assessment; and (v) outcome data, including global scores and measures of variability (e.g., standard deviations [SD], standard errors), frequencies, effect estimates, or other information required to calculate effect size.

2.5 | Methodological Quality Assessment

The methodological quality of the included studies was assessed using the National Institutes of Health (NIH) Quality Assessment Tool for Observational Cohorts and Cross-Sectional Studies (National Heart Lung and Blood Institute 2021). This instrument includes 14 items covering domains such as study population, timeframe for study associations, exposure and outcome measures, and statistical analysis adjustments. Each item was rated as yes, no, not reported, not applicable, and cannot be determined. Based on these ratings, overall quality was judged according to the NIH quality rating guide (National Heart Lung and Blood Institute 2021), classifying each cross-sectional study as good, fair, or poor.

2.6 | Effect Size

Standardized mean difference (SMD) using Cohen's *d* index (Cohen 1988) was applied as the main effect size. The means, SDs, and sample sizes for each diet group were extracted from the included studies to estimate SMDs. Global scores from validated ED instruments were extracted to maximize comparability across studies. When outcome data were reported as standard errors (Zickgraf et al. 2020), frequencies (Gwioździk et al. 2022; Köse et al. 2021; Perry et al. 2001), beta coefficients (Collins and Quinton 2020), or medians with interquartile ranges (Białek-Dratwa et al. 2024), the appropriate conversion formulas were applied to estimate SMDs (Higgins et al. 2024; McGrath et al. 2020). Negative SMD values indicate that individuals adhering to VVDs reported lower overall levels of ED symptoms than those following omnivorous diets. The criteria proposed by Cohen were used to interpret the effect size as small (SMD = 0.2), moderate (SMD = 0.5), or large (SMD = 0.8) (Cohen 1988).

2.7 | Data Synthesis

A meta-analysis of cross-sectional studies comparing ED symptoms of VVDs with those of omnivorous diets was conducted via a random effects model with the Hartung–Knapp–Sidik–Jonkman method (Inthout et al. 2014). The analyses were performed when more than two studies analyzed the outcome (Jackson and Turner 2017). Heterogeneity across studies was assessed using the I^2 statistic, with values of 0%–40% indicating not important, 30%–60% moderate, 50%–90% substantial, and 75%–100% considerable (Higgins et al. 2024). The corresponding *p* values were also considered. In addition, 95% prediction intervals were estimated to reflect the expected range of SMDs in future studies. Primary analyses included all eligible studies, encompassing both adolescent and adult populations. Given

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that most included studies were conducted in adults, all analyses were repeated in studies restricted to adult populations (i.e., excluding studies with participants younger than 18 years).

Subgroup analyses were conducted according to diet type (vegetarian or vegan diets), the self-reported scales applied and geographic region. Univariate meta-regression models were conducted to examine whether participant and study characteristics (age [years], sex [% female], total sample size, BMI [kg/m^2], underweight status [% with BMI $< 18\,kg/m^2$], educational level [% with any university degree], and publication year) influenced the pooled SMD and between-study heterogeneity. Sensitivity analyses were performed to assess the robustness of the summary estimates using the leave-one-out method (Higgins et al. 2024). Publication bias was evaluated through Egger's regression test for funnel plot asymmetry and visual inspection of funnel plots (Sterne et al. 2001). Statistical significance was set at $p < 0.05$. All analyses were conducted using R (version 4.2.3; R Foundation for Statistical Computing, Vienna, Austria) with the meta (Balduzzi et al. 2019) package.

2.8 | Additional Methodological Considerations

If a study reported data from different scales (McLean et al. 2021, 2022, 2023) or from different motivations for following a vegetarian diet (Zickgraf et al. 2020), the corresponding SMDs were pooled into a single estimate for the main analysis. When studies provided separate data for vegetarians and vegans (Barnett et al. 2016; Coimbra and Ferreira 2021; Collins and Quinton 2020; Hanras et al. 2022; McLean et al. 2022, 2023; Norwood et al. 2019; Timko et al. 2012), these results were included in their respective subgroup analyses. In such cases, data on ED symptoms were also combined to calculate a single pooled SMD for inclusion of each study in the main meta-analysis (VVDs vs. omnivorous diets). For one study that did not report SD, the SD was assumed to be equal to the reported mean to enable calculation of the effect size (Norwood et al. 2019).

3 | Results

3.1 | Study Selection

A total of 780 records were identified, of which 47 were assessed in full text for eligibility and 24 were ultimately excluded for various reasons (Table S2). In the search update, 105 additional records were identified; after removal of duplicates, 62 records were screened by title and abstract, 7 articles were assessed in full text, and 1 additional study met the inclusion criteria. Finally, a total of 24 cross-sectional studies (Barnett et al. 2016; Białek-Dratwa et al. 2024; Çiçekoğlu and Tunçay 2018; Coimbra and Ferreira 2021; Collins and Quinton 2020; Dorard and Mathieu 2021; Forestell et al. 2012; Gorgoni et al. 2026; Gwioździk et al. 2022; Hanras et al. 2022; Heiss, Coffino, and Hormes 2017; Heiss et al. 2019; Köse et al. 2021; Lindeman 2002; Lindeman et al. 2000; McLean et al. 2021, 2022, 2023; Norwood et al. 2019; Paslakis et al. 2020; Sieke et al. 2021; Timko et al. 2012; Zickgraf et al. 2020) were included in the systematic review and meta-analysis (Figure 1).

3.2 | Characteristics of Studies and Participants

Table 1 shows the main characteristics of the studies included, published between 2000 (Lindeman et al. 2000) and 2026 (Gorgoni et al. 2026). The total sample included 25,223 individuals (67.7% females), with mean ages ranging from 14.9 (Perry et al. 2001) to 49.6 (Paslakis et al. 2020) years and mean BMIs from 22.0 (Köse et al. 2021) to 25.9 (Paslakis et al. 2020) kg/m^2. Four studies included both adolescent (< 18 years) and adult (≥ 18 years) participants (Collins and Quinton 2020; Lindeman 2002; Lindeman et al. 2000; Perry et al. 2001), whereas the remaining studies were conducted exclusively in adults. Underweight status varies from 3.6% (Collins and Quinton 2020) to 15.6% (Białek-Dratwa et al. 2024). The participants were recruited from different countries, including Australia (Collins and Quinton 2020; McLean et al. 2021, 2022, 2023; Norwood et al. 2019), Belgium (Dorard and Mathieu 2021), Canada (Dorard and Mathieu 2021; McLean et al. 2021), Finland (Lindeman 2002; Lindeman et al. 2000), France (Dorard and Mathieu 2021; Hanras et al. 2022), Germany (Paslakis et al. 2020), Italy (Gorgoni et al. 2026), Poland (Białek-Dratwa et al. 2024; Gwioździk et al. 2022), Portugal (Coimbra and Ferreira 2021), Turkey (Çiçekoğlu and Tunçay 2018; Köse et al. 2021), United Kingdom (UK) (McLean et al. 2021) and United States of America (USA) (Barnett et al. 2016; Forestell et al. 2012; Heiss, Coffino, and Hormes 2017; Heiss et al. 2019; McLean et al. 2021; Perry et al. 2001; Sieke et al. 2021; Timko et al. 2012; Zickgraf et al. 2020).

Regarding dietary exposure, studies included data from vegetarians (Gwioździk et al. 2022), vegans (Heiss, Coffino, and Hormes 2017; McLean et al. 2021), vegetarians and vegans combined (Białek-Dratwa et al. 2024; Çiçekoğlu and Tunçay 2018; Dorard and Mathieu 2021; Forestell et al. 2012; Gorgoni et al. 2026; Köse et al. 2021; Lindeman 2002; Lindeman et al. 2000; Paslakis et al. 2020; Perry et al. 2001; Sieke et al. 2021; Zickgraf et al. 2020), and vegetarians and vegans separately (Barnett et al. 2016; Coimbra and Ferreira 2021; Collins and Quinton 2020; Hanras et al. 2022; Heiss et al. 2019; McLean et al. 2022, 2023; Norwood et al. 2019; Timko et al. 2012). Only four studies (Dorard and Mathieu 2021; Forestell et al. 2012; McLean et al. 2022; Timko et al. 2012) reported the mean duration of adherence to VVD, which ranged from 5 to 10 years. Two studies analyzed ED symptoms according to the motivation for following such diets (Sieke et al. 2021; Zickgraf et al. 2020), and one study provided sex-stratified results (McLean et al. 2021).

Regarding the instruments to assess ED symptoms, 10 studies employed the Eating Attitudes Test (EAT) (Białek-Dratwa et al. 2024; Çiçekoğlu and Tunçay 2018; Collins and Quinton 2020; Dorard and Mathieu 2021; Forestell et al. 2012; Hanras et al. 2022; Köse et al. 2021; Lindeman 2002; Lindeman et al. 2000; McLean et al. 2021, 2023; Timko et al. 2012), nine studies used the ED Examination Questionnaire (EDE-Q) (Barnett et al. 2016; Coimbra and Ferreira 2021; Gorgoni et al. 2026; Heiss, Coffino, and Hormes 2017; Heiss et al. 2019; McLean et al. 2021, 2022; Paslakis et al. 2020; Sieke et al. 2021; Zickgraf et al. 2020), one study employed the Eating Disorder Inventory (EDI) (Norwood et al. 2019), one study applied the Eating Disorder Diagnostic Scale (Barnett et al. 2016), one study

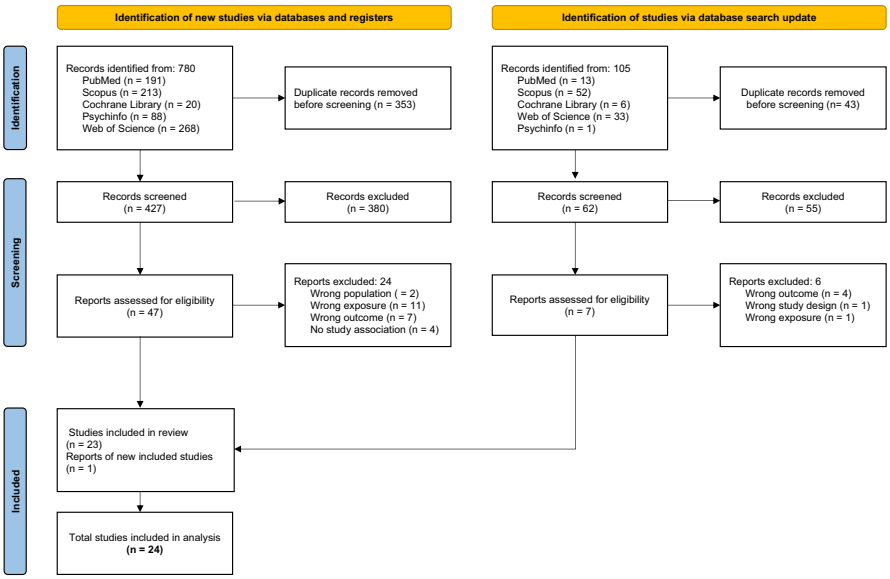


FIGURE 1 | PRISMA flow diagram of study selection.

used the Sick-Control-One-Fat-Food questionnaire (SCOFF) (Gwioździk et al. 2022), and one study assessed ED status through self-reported diagnosis (McLean et al. 2021; Perry et al. 2001). No studies employed observer-rated instruments.

3.3 | Narrative Synthesis of Study Findings

Overall, findings across studies were heterogeneous (Table S3). Ten studies reported higher ED symptom scores among individuals following VVDs compared with omnivorous diets (Köse et al. 2021; Lindeman 2002; Lindeman et al. 2000; McLean et al. 2021, 2022, 2023; Paslakis et al. 2020; Sieke et al. 2021; Timko et al. 2012; Zickgraf et al. 2020), 10 found no significant differences between dietary groups (Barnett et al. 2016; Białek-Dratwa et al. 2024; Çiçekoğlu and Tunçay 2018; Coimbra and Ferreira 2021; Dorard and Mathieu 2021; Forestell et al. 2012; Gwioździk et al. 2022; Heiss et al. 2019; Norwood et al. 2019; Perry et al. 2001), and four reported lower ED symptom scores among individuals following VVDs (Collins and Quinton 2020; Gorgoni et al. 2026; Hanras et al. 2022; Heiss, Coffino, and Hormes 2017). In some studies, associations varied in magnitude and, occasionally, in direction according to the dietary pattern examined as exposure (i.e., vegetarian or vegan diets) (Barnett et al. 2016; Coimbra and Ferreira 2021; Collins and Quinton 2020; Hanras et al. 2022; Heiss, Coffino, and Hormes 2017; Heiss et al. 2019; Norwood et al. 2019; Timko et al. 2012) and the instrument used to assess ED symptoms (McLean et al. 2021). The limited number of studies examining motivations for dietary adherence also suggested that associations may differ according to the reasons underlying VVD adoption (Sieke et al. 2021; Zickgraf et al. 2020). One study found higher ED symptom levels among individuals following VVDs for weight-related reasons (Zickgraf et al. 2020), whereas another found that weight- and health-related motivations were not associated with higher ED symptom levels among vegetarians and vegans (Sieke et al. 2021; Zickgraf et al. 2020). Findings from studies reporting categorical data were also heterogeneous (Table S3). Two studies reported a higher proportion of participants exceeding ED screening thresholds among individuals following VVDs compared with omnivorous diets (Köse et al. 2021; McLean et al. 2022), one reported a lower proportion (Hanras et al. 2022), and six found no significant differences between dietary groups (Barnett et al. 2016; Białek-Dratwa et al. 2024; Dorard and Mathieu 2021; Gwioździk et al. 2022; Perry et al. 2001; Sieke et al. 2021). A meta-analysis of categorical outcomes was not conducted because outcome definitions varied substantially across studies, including self-reported diagnoses and different instrument-specific screening thresholds, precluding the standardization of effect estimates.

3.4 | Methodological Quality of the Included Studies

According to the NIH Quality Assessment Tool, study scores ranged from four to seven points. The most frequently unmet criteria included formal sample size justification or power calculations, exposure assessed prior to outcome, sufficient timeframe,

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TABLE 1 | Characteristics of the included studies.

Author, year, country	*N* (Total)	Age (mean years)	Sex assigned at birth and/or gender (%)	Race/ethnicity (*n*)	SES	BMI (mean)	Education level (% with any university education)	Dietary exposure (*n*)	Measure of ED symptoms
Barnett et al. (2016), USA	284	38.0	Female = 83.4 male = 16.6	NR	NR	24.9	26.6	Vegetarians: 22 vegans: 11 omnivores:213	EDE-Q
Białek-Dratwa et al. (2024), Poland	186	NR	Female = 94.0 male = 5.9	NR	NR	NR	51.1	Vegetarians/vegans: 84 omnivores: 102	EAT-26
Çiçekoğlu and Tunçay (2018), Turkey	62	34.0	Female = 61.0	NR	NR	NR	96.7	Vegetarians/ vegans: 31 omnivores: 31	EAT-40
Coimbra and Ferreira (2021), Portugal	447	32.7	Female = 100	NR	NR	23.8	NR	Vegetarians: 61 vegans: 50 omnivores: 281	EDE-Q
Collins and Quinton (2020), Australia	634	28.8	Female = 100	Caucasian non-Hispanic (578) Hispanic (6) Asian (18) Aboriginal/Torres Strait Islander (11) Middle Eastern (6) Pacific Islander (2) Black or African American (2) other (11)	NR	24.9	NR	Vegetarians: 103 vegans: 280 omnivores: 212	EAT-26
Dorard and Mathieu (2021), France, Belgium, and Canada	101	29.5	Female = 74.3 male = 25.7	NR	NR	22.9	50.0	Vegetarians/ vegans: 49 omnivores: 52	EAT-26

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TABLE 1 | (Continued)

Author, year, country	*N* (Total)	Age (mean years)	Sex assigned at birth and/or gender (%)	Race/ethnicity (*n*)	SES	BMI (mean)	Education level (% with any university education)	Dietary exposure (*n*)	Measure of ED symptoms
Forestell et al. (2012), USA	240	19.2	Female = 100	Caucasian (115) Asian (18) African American (9) mixed (more than one race) (4)	Family income, > $75,000. *n* = 95	22.0	100	Vegetarians/ vegans: 55 omnivores: 91	EAT-26
Gorgoni et al. (2026), Italy	747	36.4	Female = 73.8 male = 26.2	NR	NR	23.2	NR	Vegetarian/vegan: 215 omnivores: 532	EDE-Q
Gwioździk et al. (2022), Poland	420	24.0	Female = 100	NR	NR	NR	88.1	Vegetarians: 115 omnivores: 227	SCOFF
Hanras et al. (2022), France	589	31.8	Female = 83.4	NR	Student (27.7%) employed (56.4%) unemployed (14.1%) retirement (1.9%)	24.7	74.0	Vegetarians: 112 vegans: 127 omnivores: 212	EAT-26
Heiss, Coffino, and Hormes (2017), USA[a]	577	30.6	Female = 80.4	White (498) American Indian/ Alaska Native (11) Asian/Pacific Islander (33) Black or African American (12) Other (5)	NR	24.3	NR	Vegans: 357 omnivores: 220	EDE-Q
Heiss et al. (2019), USA[a]	381	31.1	Female = 80.8	White (308)	NR	25.2	NR	Vegetarians: 50 omnivores: 106	EDE-Q
Köse et al. (2021), Turkey	318	21.6	Female = 77.4 male = 22.6	NR	NR	22.0	100	Vegetarians/ vegans: 47 omnivores: 242	EAT-40
Lindeman et al. (2000), Finland[b]	118	16.3	Female = 100	NR	NR	NR	NR	Vegetarians/ vegans: 15 Omnivores: 103	EAT-26

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TABLE 1 | (Continued)

Author, year, country	*N* (Total)	Age (mean years)	Sex assigned at birth and/or gender (%)	Race/ethnicity (*n*)	SES	BMI (mean)	Education level (% with any university education)	Dietary exposure (*n*)	Measure of ED symptoms
Lindeman (2002), Finland[b]	239	29.0	Female = 100	NR	NR	NR	NR	Vegetarians/ vegans: 42 omnivores: 197	EAT-26
McLean et al. (2021), Australia, Canada, UK, USA	228	NR	Female = 51.8 male = 48.2	NR	NR	25.3	NR	Vegans: 110 omnivores: 118	EAT-26, EDE-Q
McLean et al. (2022), Australia[c]	1271	29.9	Female = 82.0	Australian (494)	Least SES disadvantage (58.9%)	24.7	63.6	Vegetarians: 278 vegans: 580 omnivores: 413	EDE-Q
McLean et al. (2023), Australia[c]	1271	29.9	Female = 82.0	Australian (494)	Least SES disadvantage (58.9%)	24.7	63.6	Vegetarians: 278 vegans: 580 omnivores: 413	EAT-26
Norwood et al. (2019), Australia	393	29.4	Female = 83.0 male = 17.0	Caucasian (310) Asian (43) Other (39)	NR	23.0	28.3	Vegetarians: 48 vegans: 128 omnivores: 101	EDI-3
Paslakis et al. (2020), Germany	2449	49.6	Female = 53.5 male = 46.5	NR	Income groups Euro/month: 0 to < 1000 (23.9%) 1000 to < 2500 (62.2%) ≥ 2500 (10.7%)	25.9	23.4	Vegetarians/ vegans: 133 omnivores: 2316	EDE-Q8
Perry et al. (2001), USA	4510	14.9	Female = 49.8 male = 50.2	Caucasian (2302) African American (902) Aian American (911) Hispanic (275) native American (166) mixed/other (185)	NR	NR	0	Vegetarians/ vegans: 94 omnivores: 4416	Self-reported diagnosis

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TABLE 1 | (Continued)

Author, year, country	*N* (Total)	Age (mean years)	Sex assigned at birth and/or gender (%)	Race/ethnicity (*n*)	SES	BMI (mean)	Education level (% with any university education)	Dietary exposure (*n*)	Measure of ED symptoms
Sieke et al. (2021), USA	1585	20.9	Female = 60.0	Caucasian (1173) Asian (156) Hispanic (89) African American (77) other (90)	NR	NR	100	Vegetarians/ vegans:136 omnivores: 1398	EDE-Q
Timko et al. (2012), USA	486	25.1	Female = 77.0	Caucasian (388) Asian/Pacific Islanders (40) African American (23) Hispanic/ Latino (15) Biracial (11) other (7)	NR	24.0	NR	Vegetarians: 111 vegans: 35 omnivores: 265	EAT-26
Zickgraf et al. (2020), USA	9910	23.4	Cisgender women = 54.3 cisgender men = 44.4 transgender men = 0.2 transgender women = 0.2 genderqueer/gender nonconforming = 0.7 other = 0.2	Non-Hispanic White (6639) Non-Hispanic Black/African American (535) Hispanic/ Latinx (931) Asian (1318) other (505)	NR	23.2	100	Vegetarians/ vegans: 968 omnivores: 8926	S-EDE-Q

Note: All studies are cross-sectional.
Abbreviations: BMI, body mass index; EAT, Eating Attitudes Test; ED, eating disorder; EDE-Q, Eating Disorder Examination-Questionnaire; EDI, Eating Disorder Inventory; NR, not reported; SCOFF, Sick-Control-Fat-Food questionnaire; S-EDE-Q, Short-Eating Disorder Examination-Questionnaire; SES, socioeconomic status.
[a]Vegan participants in Heiss et al. (2019) overlapped with those included in Heiss, Hormes, and Timko (2017); therefore, only vegetarian participants from the 2019 study were retained to prevent double counting.
[b]To avoid double counting, only the adolescent sample from Lindeman et al. (2000) was included, as the adult participants were subsequently reported in Lindeman (2002).
[c]These studies analyzed different scales measuring eating disorder symptoms within the same study sample.

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repeated exposure assessment, and blinding of outcome assessors (Table S4). However, some unmet criteria reflected limitations inherent to cross-sectional designs (e.g., exposure assessed prior to outcome, sufficient timeframe, repeated exposure assessment) or the use of self-reported outcomes (e.g., blinding of outcome assessors), rather than necessarily indicating poor overall methodological rigor.

3.5 | Meta-Analysis

The main meta-analysis is displayed in Figure 2. No significant differences in ED symptom scores were observed between individuals following VVDs ($n = 4448$) and those following omnivorous diets ($n = 20{,}775$), with a pooled SMD of 0.07 (95% CI: −0.04 to 0.19; $I^2 = 80.3\%$; prediction interval: −0.44 to 0.59; $n = 23$) in analyses including both adolescent and adult populations. Results were similar in analyses restricted to adult populations (SMD = 0.05; 95% CI: −0.07 to 0.16; $I^2 = 79.7\%$; prediction interval: −0.41 to 0.50; $n = 19$; Figure S1).

The results of the subgroup analyses are displayed in Figure 3 and Table S5. No significant differences in ED symptoms were observed according to diet type ($p = 0.524$), measurement scale ($p = 0.392$), or geographic region ($p = 0.633$). Compared with omnivorous individuals, the pooled SMDs were 0.02 (95% CI: −0.09 to 0.14; $I^2 = 40.3\%$; $n = 10$) for vegetarians, and −0.05 (95% CI: −0.29 to 0.20; $I^2 = 86.7\%$; $n = 10$) for vegans. By measurement scale, the pooled SMDs were 0.15 (95% CI:−0.06 to 0.37; $I^2 = 83.2\%$; $n = 12$) for the EAT, and 0.06 (95% CI: −0.09 to 0.20; $I^2 = 80.1\%$; $n = 10$) for the EDE-Q. Across geographic regions, pooled SMDs were 0.11 (95% CI: −0.17 to 0.38; $I^2 = 82.1\%$; $n = 8$) for European countries, 0.04 (95% CI: −0.16 to 0.24; $I^2 = 80.5\%$; $n = 8$) for North America (USA only), and −0.05 (95% CI: −0.56 to 0.45; $I^2 = 89.5\%$; $n = 4$) for Oceania (Australia only). No substantial differences were observed in subgroup analyses restricted to adult populations (Table S5). Due to the small number of studies examining ED symptoms within specific subgroups (i.e., Asia, EDI, SCOFF), stratified analyses were not conducted. In addition, only one study reported sex-stratified results, and none examined age-specific results.

Meta-regression analyses according to participant and study characteristics are displayed in (Table S6) and (Figure S2,S3). The proportion of female participants was significantly associated with the pooled SMD in analyses restricted to adult populations ($\beta = -0.008$, $p = 0.028$; $R^2 = 20.6\%$). Specifically, studies including a higher proportion of female participants tended to report lower ED symptom scores among individuals following VVDs compared with omnivorous diets (Figure S3B). No other participant or study characteristics (age, total sample size, BMI, underweight status, educational level, and publication year) were significantly related to the pooled effect size ($p > 0.05$). However, underweight status explained a proportion of the between-study heterogeneity ($R^2 = 28.9\%$) and showed a nonsignificant positive association with the pooled effect estimate ($\beta = 0.062$, $p = 0.095$), suggesting a tendency toward higher ED symptom scores among adults following VVDs in studies with a greater proportion of underweight participants (Figure S3E). A trend was also observed for publication year, which explained a modest proportion of the between-study heterogeneity ($R^2 = 13.4\%$) and showed a nonsignificant inverse association with the pooled effect estimate ($\beta = -0.017$, $p = 0.057$), suggesting a tendency for more recently published

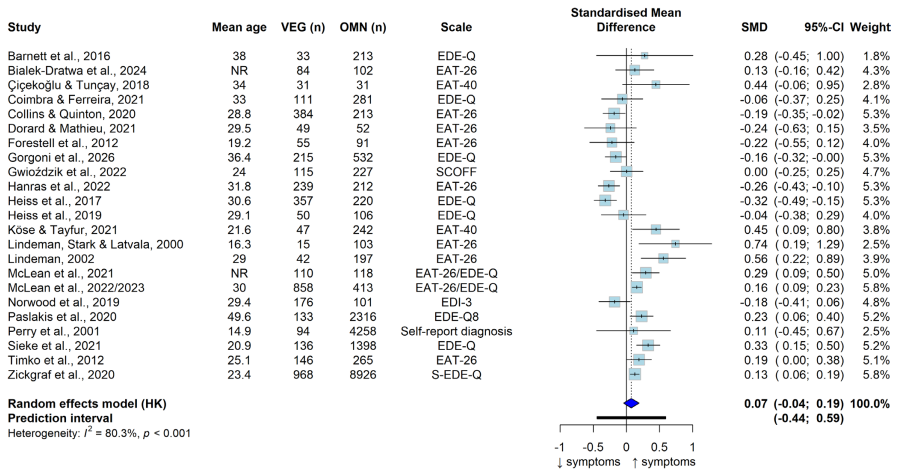


FIGURE 2 | Pooled standardized mean differences in eating disorder symptoms comparing vegetarian and vegan with omnivorous diets in studies including adolescent and adult populations. CI, confidence interval; EAT, Eating Attitudes Test; EDE-Q, Eating Disorder Examination-Questionnaire; EDI, Eating Disorder Inventory; HK, Hartung-Knapp; OMN, omnivorous; SCOFF, Sick-Control-Fat-Food questionnaire; S-EDE-Q, Short-Eating Disorder Examination-Questionnaire; SMD, standardized mean difference; VEG, vegetarians and vegans.

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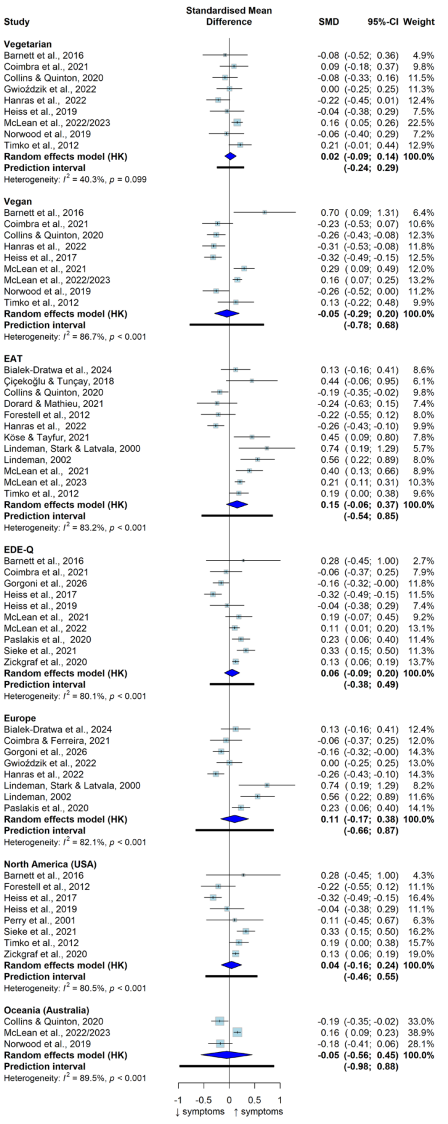


FIGURE 3 | Pooled standardized mean differences in eating disorder symptoms comparing vegetarian and vegan with omnivorous diets by subgroups in studies including adolescent and adult populations. CI, confidence interval; EAT, Eating Attitudes Test; EDE-Q, Eating Disorder Examination-Questionnaire; HK, Hartung-Knapp; OMN, omnivorous; SMD, standardized mean difference; VEG, vegetarians and vegans.

studies to report smaller effect sizes than earlier studies (Figure S2F).

The results of the sensitivity analysis are presented in Table S7. The pooled SMDs remained stable when each study was removed sequentially, and no substantial variations in between-study heterogeneity were observed. According to Egger's regression test and visual inspection of the funnel plot, no evidence of publication bias was detected ($p = 0.758$; Figure S4).

4 | Discussion

To the best of our knowledge, this is the first meta-analysis is the first to quantify the associations between ED symptoms and VVDs in relation to omnivorous diets. Our findings suggest that individuals adhering to VVDs do not report significantly higher levels of ED symptoms than those following omnivorous diets. These results are based on study samples predominantly composed by female sex and by young and middle-aged adults. Subgroup analyses revealed no significant differences according to dietary pattern type (vegetarian or vegan), geographic region (Europe, North America, or Oceania), or scale used to assess ED symptoms (EAT or EDE-Q). In addition, no significant associations were found between the pooled effect size and some participant and study characteristics assessed in meta-regressions, including age, total sample size, BMI, educational level, and publication year. However, the pooled effect was moderated by sex in analyses restricted to adult populations. Studies with a higher proportion of females showed lower ED symptom scores among vegetarian or vegan adults compared to omnivores. Findings should be interpreted with caution given the high heterogeneity and lack of longitudinal data.

Previous reviews were limited to qualitative syntheses and yielded heterogeneous, inconclusive findings regarding the association between vegetarian diets and EDs (Mathieu et al. 2023; McLean et al. 2022a; Sergentanis et al. 2020). The discrepancies with previous findings may be partly explained by important methodological and conceptual differences between studies, as well as differences in the age range of the populations examined. Definitions of vegetarian dietary patterns have varied substantially, with several studies grouping heterogeneous dietary regimens under vegetarian categories, including semi-vegetarian, flexitarian, or pescatarian diets that allow occasional meat or fish consumption (Mathieu et al. 2023; Sergentanis et al. 2020). This distinction may be relevant, as semi-vegetarian patterns have been associated with greater eating-related psychopathology than strict VVDs (Heiss, Hormes, and Timko 2017). In addition, previous reviews have examined a broad range of outcomes, including clinical diagnosis of EDs, ED symptoms, disordered eating behaviors, and orthorexia nervosa (Mathieu et al. 2023; McLean et al. 2022a; Sergentanis et al. 2020). As these outcomes represent related but distinct constructs, direct comparisons across reviews may be challenging. Notably, some reviews have reported more consistent associations between VVDs and orthorexia tendencies than with global ED psychopathology or ED symptoms (Mathieu et al. 2023; McLean

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et al. 2022a), while a recent meta-analysis also reported a positive association between VVDs and symptoms of orthorexia nervosa (Díaz-Goñi et al. 2025). Together, these considerations suggest that differences in exposure definitions and outcome assessment should be carefully considered when interpreting the available evidence.

In this context, the present meta-analysis provides quantitative evidence indicating that adherence to strict VVDs is not associated with higher levels of ED symptoms compared with omnivorous diets. The absence of an overall association may partly reflect the heterogeneity of motivations underlying adherence to VVDs. In some populations, these dietary patterns are primarily adopted for health, ethical, environmental, or animal welfare concerns (Kim et al. 2022; Miki et al. 2020; Rosenfeld 2018; Rosenfeld and Burrow 2017; Ruby 2012) rather than weight-control motives, which may be more strongly linked to ED psychopathology (Bardone-Cone et al. 2012). However, the potential influence of these motivations on ED symptomatology remains unclear because they were not consistently assessed across studies. From a public health and clinical perspective, these findings suggest that adherence to VVDs should not be uniformly interpreted as an indicator of increased ED risk. Considering the growing popularity of these dietary patterns, clinicians and researchers should consider the broader context underlying dietary choices rather than focusing exclusively on the dietary pattern itself. Greater attention may be warranted when restrictive dietary practices coexist with weight-control motivations or clinically relevant ED symptoms.

This systematic review further extends the available evidence through subgroup analyses and meta-regressions exploring potential sources of heterogeneity. The higher heterogeneity observed in studies including vegan participants compared with vegetarian participants may partly reflect the smaller number of participants in the vegan subgroup and could also be related to variability in motivations for dietary adherence. In addition, meta-regression analyses indicated that differences in the proportion of female participants and individuals classified as underweight across studies may contribute to the observed between-study heterogeneity. Specifically, studies including a higher proportion of females tended to report lower ED symptom scores among individuals adhering to VVDs compared with omnivorous diets. The finding should be interpreted cautiously and viewed as a gradual trend across studies rather than a distinct association among studies with predominantly female samples. It may suggest that the meaning and motivations underlying adherence to VVDs differ across populations. In samples with a higher proportion of female, VVDs may be more frequently adopted for ethical, environmental, or health-related reasons rather than weight-control purposes (MacInnis and Hodson 2017; Rosenfeld 2020), potentially weakening their association with ED symptoms. Alternatively, this finding may reflect other unmeasured sociocultural characteristics of the included samples. Future studies should examine whether motivations for dietary adherence explain sex-related differences in the association between VVDs and ED symptoms. From a public health perspective, these findings suggest that the assessment of ED risk among individuals adhering to VVDs should consider the motivations underlying dietary choices rather than focusing exclusively on the dietary pattern itself.

A nonsignificant trend was also observed for the proportion of underweight participants, with studies including a higher proportion of these individuals tending to report higher ED symptom scores among those adhering to VVDs compared with omnivorous diets. Although these findings should be interpreted cautiously, they may suggest that VVDs can, in some individuals, provide a socially acceptable framework for dietary restrictions, particularly among those with greater weight concerns or pre-existing disordered eating behaviors (Gilbody et al. 1999). A further trend was observed for publication year, with more recently published studies tending to report smaller effect sizes than earlier studies. Although this association did not reach statistical significance, it may reflect temporal and sociocultural changes in the acceptance and motivations underlying VVDs. However, this finding should be interpreted cautiously because publication year may also capture differences in study populations and methodologies.

The substantial between-study heterogeneity also suggests the influence of methodological variability. One possible explanation relates to the questionnaires used to assess ED symptoms, as most instruments were developed for the general population and may not fully capture eating-related behaviors among individuals following specific dietary patterns such as VVDs. Concerns have been raised regarding the psychometric performance of some commonly used ED instruments in vegetarian and vegan populations, as certain items may capture normative dietary practices rather than ED psychopathology (Mathieu et al. 2023; McLean et al. 2022a). For example, instruments such as the EDE-Q include restraint-related items that may not clearly distinguish between psychopathological eating restraint and food restrictions arising from ethical, environmental, or health-related dietary choices. Consequently, widely used tools may not adequately reflect the experiences of individuals adhering to VVDs (McLean et al. 2022a). In response to these limitations, assessment instruments specifically tailored to vegetarian and vegan populations are currently being developed and validated (McLean et al. 2024).

Contextual and cultural factors may also contribute to the observed heterogeneity. Although no statistically significant geographical differences were detected in the present study, the analyses were restricted to studies conducted in North America (USA), Europe (France, Germany, Poland, and Portugal), and Oceania (Australia), limiting the representation of other world regions. Previous research has documented substantial cross-cultural variation in the occurrence and clinical presentation of EDs (Nobakht and Dezhkam 2000; Song et al. 2023). In some non-Western contexts, restrictive eating behaviors may be framed in culturally sanctioned terms and may not be accompanied by an explicit fear of weight gain, despite underlying weight-related concerns (Rieger et al. 2001). Cultural differences may also influence the social meaning and motivations underlying adherence to VVDs. Given that most included studies were conducted in Western populations, our findings may not be generalizable to cultural contexts in which plant-based diets are more prevalent, socially normative, or rooted in long-standing religious

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and cultural traditions. Future studies from underrepresented regions, including parts of Asia, Africa, and Latin America, are needed to better understand whether the association between VVDs and ED symptoms differs across cultural contexts.

4.1 | Limitations and Strengths

Some limitations should be noted. First, the available evidence reported only cross-sectional studies and prevented consistent conclusions about whether VVDs lead to the development of ED symptoms. Second, our analyses revealed substantial between-study heterogeneity in the main pooled estimate, partially attributable to differences in diet type, geographic region, the instruments used to assess ED symptoms, and characteristics of study samples (percentages of females and underweight status). Third, the small number of studies with age- and sex-stratified data prevented us from examining potential differences in these population characteristics. Fourth, data and analyses of VVD adherence, specifically regarding duration, motivation, and quality, are lacking in all or most studies, preventing key analyses that could help explain the observed associations. Moreover, most studies classified VVDs based on self-reported adherence rather than objectively assessed dietary intake, which may have resulted in exposure misclassification. Fifth, most studies did not report sociodemographic characteristics, such as ethnicity, race, gender, and socioeconomic status. This lack of information limits the ability to evaluate the representativeness and diversity of the samples, as well as the generalizability of the findings to broader populations. Sixth, all included studies were conducted in nonclinical populations. Therefore, our findings are primarily relevant to prevention, screening, and public health contexts and should not be extrapolated to individuals with diagnosed EDs or those undergoing treatment or recovery. Consequently, the present review cannot determine whether adherence to vegetarian or vegan diets may influence the course, treatment, or recovery of EDs. Finally, most studies did not provide information on potentially influential covariates, such as physical activity, socioeconomic status, weight loss, and the use of social networks. This limited our ability to perform adjusted analyses for these factors.

However, several important strengths distinguish our work. First, to the best of our knowledge, this is the first meta-analysis to quantify the association between VVDs and omnivorous diets. Second, this approach enabled the implementation of a random-effects meta-analytic model using the Hartung–Knapp–Sidik–Jonkman method, which has been shown to yield more conservative and robust CIs in comparison to traditional methods, particularly in the presence of heterogeneity and a limited number of studies (Inthout et al. 2014). Third, subgroup analyses were conducted to explore potential sources of heterogeneity and to assess variations in effect size according to key variables relevant to the study association. Fourth, meta-regression analyses were performed to evaluate the potential influence of relevant confounders on the observed associations. Fifth, prediction intervals were calculated to estimate the range of actual effects that could be expected in future studies, providing a more realistic assessment of the variability between studies and the certainty of the results. Finally, only studies that explicitly defined vegetarian diets as strict—excluding any type of meat—were included (e.g., excluding semi-vegetarians, flexitarians, and pescatarians), to ensure clarity in the research question and to provide more accurate and interpretable results.

4.2 | Future Recommendations

Longitudinal research remains essential to clarify the directionality and causal mechanisms linking diet with ED. In our study, individuals adhering to VVDs are not more likely to report ED symptoms than those following omnivorous diets. However, the underlying motivations for adopting VVDs may play a crucial role in this relationship. Across the included evidence, one study (Zickgraf et al. 2020) reported that adopting VVDs for weight-related reasons was linked to greater symptom levels compared with non–weight-related reasons. In turn, adjusted models from a recent study found that motives such as liking and health were negatively associated with disordered eating attitudes, whereas other motives such as visual appeal, social image, weight control, and affect regulation were positively associated with higher levels of these attitudes (Mazzolani et al. 2023). Among the general population, motivations driven by ethical or health considerations could differ in psychological meaning and behavioral implications from those influenced by perceived social expectations or body image concerns (Mazzolani et al. 2023; Sharpe et al. 2018). This highlights the importance of distinguishing the reasons why individuals adopt VVDs rather than assuming these dietary patterns are inherently linked to psychopathology.

Discouraging VVDs among individuals whose dietary choices are closely tied to their personal identity or values may therefore be counterproductive, potentially reinforcing distress rather than supporting healthier relationships with food (McLean et al. 2022b). In this context, previous evidence from qualitative research has proposed five key indicators to help identify potentially pathological forms of VVDs adherence, including the timing of dietary change relative to the onset of disordered eating, the motivations for dietary adherence, fear-driven reactions, flexibility within vegetarian or vegan practices, and the potential use of dietary choices to conceal ED behaviors (McLean et al. 2025).

Future research should adopt longitudinal designs and include a broader range of age groups. Given that most available evidence is derived from young and middle-aged adults, further research in adolescent and older populations is warranted. Research should also prioritize populations from understudied geographical regions, cultural contexts, and ethnic and racial backgrounds. In addition, studies conducted in clinical populations, including individuals with diagnosed EDs and those undergoing treatment or recovery, are needed to determine whether adherence to VVDs influences treatment outcomes, symptom progression, or recovery trajectories. It will also be essential to examine whether diet quality within vegetarian and vegan patterns—ranging from highly processed to whole-food plant-based approaches—modifies associations with ED outcomes, given that nutritional adequacy and food quality may be key determinants of mental health trajectories (Bizzozero-Peroni et al. 2025). In addition, the duration and flexibility for VVD adherence should be considered, as these factors may further influence psychological outcomes. Finally, future studies should

assess the role of additional factors such as gender, weight loss, social media exposure, physical activity, tobacco smoking, and alcohol consumption, which may influence both dietary motivations and eating-related vulnerability.

5 | Conclusion

Across the available evidence, no significant differences in ED symptoms were observed between individuals following VVDs and those following omnivorous diets. These findings suggest that dietary patterns alone may not necessarily be associated with an increased risk of ED. However, the results should be interpreted with caution given the substantial between-study heterogeneity and the exclusively cross-sectional nature of the available evidence, which precludes conclusions regarding causality and may affect the robustness of the findings. Moreover, the available evidence was predominantly derived from young and middle-aged adults, highlighting the need for additional research in adolescent and older populations. Future longitudinal studies across diverse geographical and cultural contexts—and reporting stratified analyses by age, sex, ethnicity/race, diet quality, and flexibility, motivation, and duration of VVD adherence—are essential to clarify the directionality and underlying mechanisms of these associations. Such evidence could inform early screening and the development of personalized prevention strategies in public health and community settings.

Author Contributions

Arthur Eumann Mesas: conceptualization, investigation, methodology, writing – original draft, visualization, project administration, writing – review and editing, supervision. **Valentina Díaz-Goñi:** conceptualization, investigation, methodology, formal analysis, visualization, writing – original draft, writing – review and editing. **Estela Jiménez-López:** writing – original draft, writing – review and editing. **Bruno Bizzozero-Peroni:** writing – review and editing, conceptualization, investigation, methodology, formal analysis, writing – original draft, visualization, validation, project administration, supervision. **Ana María Peraile-Huerta:** validation, writing – review and editing. **Miriam Garrido-Miguel:** validation, writing – review and editing. **Tomás Olivo-Martins-de-Passos:** validation, writing – review and editing. **María Eugenia Visier-Alfonso:** writing – original draft, writing – review and editing. **Fernando Peral-Martínez:** validation, writing – review and editing.

Lived Experience Involvement Statement

No specific efforts were undertaken to involve persons with lived experience in the study design or execution, or in the preparation of this manuscript.

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Disclosure

No generative AI tools were used in the preparation of this manuscript.

Ethics Statement

The authors have nothing to report.

Consent

The authors have nothing to report.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

References

American Psychiatric Association. 2022. *Diagnostic and Statistical Manual of Mental Disorders*. American Psychiatric Association (APA). https://doi.org/10.1176/APPI.BOOKS.9780890425787.

Balduzzi, S., G. Rücker, and G. Schwarzer. 2019. "How to Perform a Meta-Analysis With R: A Practical Tutorial." *Evidence-Based Mental Health* 22, no. 4: 153–160. https://doi.org/10.1136/EBMENTAL-2019-300117.

Bardone-Cone, A. M., E. E. Fitzsimmons-Craft, M. B. Harney, et al. 2012. "The Inter-Relationships Between Vegetarianism and Eating Disorders Among Females." *Journal of the Academy of Nutrition and Dietetics* 112, no. 8: 1247–1252. https://doi.org/10.1016/J.JAND.2012.05.007.

Barnett, M. J., W. R. Dripps, and K. K. Blomquist. 2016. "Organivore or Organorexic? Examining the Relationship Between Alternative Food Network Engagement, Disordered Eating, and Special Diets." *Appetite* 105: 713–720. https://doi.org/10.1016/J.APPET.2016.07.008.

Becker, A. E., K. E. Fay, J. Agnew-Blais, A. N. Khan, R. H. Striegel-Moore, and S. E. Gilman. 2011. "Social Network Media Exposure and Adolescent Eating Pathology in Fiji." *British Journal of Psychiatry* 198, no. 1: 43–50. https://doi.org/10.1192/bjp.bp.110.078675.

Białek-Dratwa, A., W. Stoń, W. Staśkiewicz-Bartecka, M. Grajek, K. Krupa-Kotara, and O. Kowalski. 2024. "The Psychosocial Aspects of Vegetarian Diets: A Cross-Sectional Study of the Motivations, Risks, and Limitations in Daily Life." *Nutrients* 16, no. 15: 2504. https://doi.org/10.3390/NU16152504.

Bizzozero-Peroni, B., V. Díaz-Goñi, R. Fernández-Rodríguez, et al. 2025. "Plant-Based Diets and Mental and Neurocognitive Health Outcomes: A Systematic Review With Meta-Analysis." *Nutrition Reviews* 83, no. 12: 2282–2295. https://doi.org/10.1093/NUTRIT/NUAF080.

Brandsma, L. 2007. "Eating Disorders Across the Lifespan." *Journal of Women and Aging* 19, no. 1–2: 155–172. https://doi.org/10.1300/J074v19n01_10.

10981108, 0, Downloaded from https://onlinelibrary.wiley.com/doi/10.1002/eat.70158 by Valentina Diaz Goni. - Universidad Castilla La Mancha , Wiley Online Library on [08/07/2026]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Çiçekoğlu, P., and G. Y. Tunçay. 2018. "A Comparison of Eating Attitudes Between Vegans/Vegetarians and Nonvegans/Nonvegetarians in Terms of Orthorexia Nervosa." *Archives of Psychiatric Nursing* 32, no. 2: 200–205. https://doi.org/10.1016/j.apnu.2017.11.002.

Cohen, J. 1988. *Statistical Power Analysis for the Behavioral Sciences*. 2nd ed. Lawrence Erbaum Associates.

Coimbra, M., and C. Ferreira. 2021. "Understanding the Omnivore, Vegetarian, Vegan, and Paleo Dietary Patterns: How They Differ in Disordered Eating Indicators." *Revista Portuguesa de Investigação Comportamental e Social* 7, no. 1: 41–51. https://doi.org/10.31211/rpics.2021.7.1.205.

Collins, M., and S. Quinton. 2020. "The Inter-Relationship Between Diet, Selflessness, and Disordered Eating in Australian Women." *Brain and Behavior* 10, no. 9: e01774. https://doi.org/10.1002/BRB3.1774.

Díaz-Goñi, V., B. Bizzozero-Peroni, M. E. Visier-Alfonso, et al. 2025. "The Associations Between Vegetarian and Vegan Diets and Orthorexia Nervosa Symptoms in Adults: A Systematic Review and Meta-Analysis." *International Journal of Eating Disorders* 59, no. 3: 409–423. https://doi.org/10.1002/EAT.24596.

Dorard, G., and S. Mathieu. 2021. "Vegetarian and Omnivorous Diets: A Cross-Sectional Study of Motivation, Eating Disorders, and Body Shape Perception." *Appetite* 156: 104972. https://doi.org/10.1016/J.APPET.2020.104972.

Erriu, M., S. Cimino, and L. Cerniglia. 2020. "The Role of Family Relationships in Eating Disorders in Adolescents: A Narrative Review." *Behavioral Science* 10, no. 4: 71. https://doi.org/10.3390/bs10040071.

Forestell, C. A., A. M. Spaeth, and S. A. Kane. 2012. "To Eat or Not to Eat Red Meat. A Closer Look at the Relationship Between Restrained Eating and Vegetarianism in College Females." *Appetite* 58, no. 1: 319–325. https://doi.org/10.1016/j.appet.2011.10.015.

GBD 2023 Mental Disorder Collaborators. 2026. "Updated Trends in the Global Prevalence and Burden of Mental Disorders, 1990-2023: A Systematic Analysis for the Global Burden of Disease Study 2023." *Lancet (London, England)* 407, no. 10543: 2040–2064. https://doi.org/10.1016/S0140-6736(26)00519-2.

Gilbody, S. M., S. F. L. Kirk, and A. J. Hill. 1999. "Vegetarianism in Young Women: Another Means of Weight Control?" *International Journal of Eating Disorders* 26: 87–90. https://doi.org/10.1002/(SICI)1098-108X(199907)26:1<87::AID-EAT11>3.0.CO;2-M.

Gorgoni, M., A. Comparelli, S. Frappetta, et al. 2026. "Sleeping Green: An Italian Survey for the Assessment of the Relationship Between Sleep and Vegetarian Diet." *Sleep and Breathing* 30, no. 1: 85. https://doi.org/10.1007/S11325-026-03593-3.

Gwioździk, W., K. Krupa-Kotara, B. Całyniuk, P. Helisz, M. Grajek, and J. Głogowska-Ligus. 2022. "Traditional, Vegetarian, or Low FODMAP Diets and Their Relation to Symptoms of Eating Disorders: A Cross-Sectional Study Among Young Women in Poland." *Nutrients* 14, no. 19: 4125. https://doi.org/10.3390/NU14194125.

Hanras, E., S. Mathieu, B. Chevrier, E. Boujut, and G. Dorard. 2022. "Vegans, Strict Vegetarians, Partial Vegetarians, Omnivores: Do They Differ in Food Choice Motives, Coping, and Quality of Life?" *La Presse Médicale Open* 3: 100033. https://doi.org/10.1016/J.LPMOPE.2022.100033.

Hargreaves, S. M., D. L. Rosenfeld, A. V. B. Moreira, and R. P. Zandonadi. 2023. "Plant-Based and Vegetarian Diets: An Overview and Definition of These Dietary Patterns." *European Journal of Nutrition* 62, no. 3: 1109–1121. https://doi.org/10.1007/S00394-023-03086-Z.

Heiss, S., J. A. Coffino, and J. M. Hormes. 2017. "Eating and Health Behaviors in Vegans Compared to Omnivores: Dispelling Common Myths." *Appetite* 118: 129–135. https://doi.org/10.1016/J.APPET.2017.08.001.

Heiss, S., J. A. Coffino, and J. M. Hormes. 2019. "What Does the ORTO-15 Measure? Assessing the Construct Validity of a Common Orthorexia Nervosa Questionnaire in a Meat Avoiding Sample." *Appetite* 135: 93–99. https://doi.org/10.1016/J.APPET.2018.12.042.

Heiss, S., J. M. Hormes, and C. A. Timko. 2017. "Vegetarianism and Eating Disorders." In *Vegetarian and Plant-Based Diets in Health and Disease Prevention*, 51–69. Elsevier. https://doi.org/10.1016/B978-0-12-803968-7.00004-6.

Hesse-Biber, S., P. Leavy, C. E. Quinn, and J. Zoino. 2006. "The Mass Marketing of Disordered Eating and Eating Disorders: The Social Psychology of Women, Thinness and Culture." *Women's Studies International Forum* 29, no. 2: 208–224. https://doi.org/10.1016/j.wsif.2006.03.007.

Higgins, J., J. Thomas, J. Chandler, et al. 2024. "Cochrane Handbook For Systematic Reviews of Interventions version 6.5 Cochrane Training." https://training.cochrane.org/handbook.

Horovitz, O., and M. Argyrides. 2023. "Orthorexia and Orthorexia Nervosa: A Comprehensive Examination of Prevalence, Risk Factors, Diagnosis, and Treatment." *Nutrients* 15, no. 17: 3851. https://doi.org/10.3390/NU15173851.

Inthout, J., J. P. Ioannidis, and G. F. Borm. 2014. "The Hartung-Knapp-Sidik-Jonkman Method for Random Effects Meta-Analysis Is Straightforward and Considerably Outperforms the Standard DerSimonian-Laird Method." *BMC Medical Research Methodology* 14, no. 1: 1–12. https://doi.org/10.1186/1471-2288-14-25.

Jackson, D., and R. Turner. 2017. "Power Analysis for Random-Effects Meta-Analysis." *Research Synthesis Methods* 8, no. 3: 290–302. https://doi.org/10.1002/JRSM.1240.

Kaye, W. H., G. K. Frank, U. F. Bailer, and S. E. Henry. 2005. "Neurobiology of Anorexia Nervosa: Clinical Implications of Alterations of the Function of Serotonin and Other Neuronal Systems." *International Journal of Eating Disorders* 37, no. S1: S15–S19. https://doi.org/10.1002/eat.20109.

Kaye, W. H., C. G. Greeno, H. Moss, et al. 1998. "Alterations in Serotonin Activity and Psychiatric Symptoms After Recovery From Bulimia Nervosa." *Archives of General Psychiatry* 55, no. 10: 927–935. https://doi.org/10.1001/archpsyc.55.10.927.

Khalsa, S. S., L. C. Portnoff, D. McCurdy-McKinnon, and J. D. Feusner. 2017. "What Happens After Treatment? A Systematic Review of Relapse, Remission, and Recovery in Anorexia Nervosa." *Journal of Eating Disorders* 5, no. 1: 20. https://doi.org/10.1186/s40337-017-0145-3.

Kim, G., J. Oh, and M. Cho. 2022. "Differences Between Vegetarians and Omnivores in Food Choice Motivation and Dietarian Identity." *Food* 11, no. 4: 539. https://doi.org/10.3390/FOODS11040539.

Köse, G., M. Tayfur, and R. Karayigit. 2021. "BMI, Physical Activity, Sleep Quality, Eating Attitudes, Emotions: Which One Is Affected by Mindful Eating?" *Progress in Nutrition* 23, no. 1: e2021002. https://doi.org/10.23751/PN.V23I1.9194.

Lindeman, M. 2002. "The State of Mind of Vegetarians: Psychological Well-Being or Distress?" *Ecology of Food and Nutrition* 41, no. 1: 75–86. https://doi.org/10.1080/03670240212533.

Lindeman, M., K. Stark, and K. Latvala. 2000. "Vegetarianism and Eating-Disordered Thinking." *Eating Disorders* 8, no. 2: 157–165. https://doi.org/10.1080/10640260008251222.

MacInnis, C. C., and G. Hodson. 2017. "It Ain't Easy Eating Greens: Evidence of Bias Toward Vegetarians and Vegans From Both Source and Target." *Group Processes and Intergroup Relations* 20, no. 6: 721–744. https://doi.org/10.1177/1368430215618253.

Mathieu, S., E. Hanras, and G. Dorard. 2023. "Associations Between Vegetarianism, Body Mass Index, and Eating Disorders/Disordered Eating Behaviours: A Systematic Review of Literature." *International Journal of Food Sciences and Nutrition* 74, no. 4: 424–462. https://doi.org/10.1080/09637486.2023.2232953.

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Mazzolani, B. C., F. I. Smaira, G. P. Esteves, et al. 2023. "Disordered Eating Attitudes and Food Choice Motives Among Individuals Who Follow a Vegan Diet in Brazil." *JAMA Network Open* 6, no. 6: E2321065. https://doi.org/10.1001/JAMANETWORKOPEN.2023.21065.

McGrath, S., X. F. Zhao, R. Steele, et al. 2020. "Estimating the Sample Mean and Standard Deviation From Commonly Reported Quantiles in Meta-Analysis." *Statistical Methods in Medical Research* 29, no. 9: 2520–2537. https://doi.org/10.1177/0962280219889080.

McLean, C. P., Z. Chen, R. Song, J. Le, J. Fielding, and G. Sharp. 2024. "Development and Preliminary Validation of a Novel Eating Disorder Screening Tool for Vegetarians and Vegans: The V-EDS." *Journal of Eating Disorders* 12, no. 1: 4. https://doi.org/10.1186/S40337-024-00964-7.

McLean, C. P., K. de Boer, and M. Bray. 2025. "'If There Are Restrictions Within the Restrictions, That's When You Can Probably Get Concerned': Key Indicators for Untying Vegetarianism and Veganism From Eating Disorder Pathology." *International Journal of Eating Disorders* 58, no. 9: 1723–1731. https://doi.org/10.1002/EAT.24475.

McLean, C. P., J. Kulkarni, and G. Sharp. 2022a. "Disordered Eating and the Meat-Avoidance Spectrum: A Systematic Review and Clinical Implications." *Eating and Weight Disorders* 27, no. 7: 2347–2375. https://doi.org/10.1007/S40519-022-01428-0.

McLean, C. P., J. Kulkarni, and G. Sharp. 2022b. "Eating Disorders and Meat Avoidance: A Call to Understand the 'Why' Instead of the 'What'." *Australian and New Zealand Journal of Psychiatry* 56, no. 6: 731–732. https://doi.org/10.1177/00048674211037889.

McLean, C. P., J. Kulkarni, and G. Sharp. 2023. "The 26-Item Eating Attitudes Test (EAT-26): Psychometric Properties and Factor Structure in Vegetarians and Vegans." *Nutrients* 15, no. 2: 297. https://doi.org/10.3390/NU15020297/S1.

McLean, C. P., A. Lavale, J. Kulkarni, and G. Sharp. 2022. "Psychometric Properties and Factor Structure of the Eating Disorder Examination-Questionnaire in Omnivores, Vegetarians, and Vegans." *Body Image* 43: 374–384. https://doi.org/10.1016/J.BODYIM.2022.10.006.

McLean, C. P., E. K. Moeck, G. Sharp, and N. A. Thomas. 2021. "Characteristics and Clinical Implications of the Relationship Between Veganism and Pathological Eating Behaviours." *Eating and Weight Disorders* 27, no. 5: 1881–1886. https://doi.org/10.1007/S40519-021-01330-s1.

Melina, V., W. Craig, and S. Levin. 2016. "Position of the Academy of Nutrition and Dietetics: Vegetarian Diets." *Journal of the Academy of Nutrition and Dietetics* 116, no. 12: 1970–1980. https://doi.org/10.1016/j.jand.2016.09.025.

Miki, A. J., K. A. Livingston, M. C. Karlsen, S. C. Folta, and N. M. McKeown. 2020. "Using Evidence Mapping to Examine Motivations for Following Plant-Based Diets." *Current Developments in Nutrition* 4, no. 3: nzaa013. https://doi.org/10.1093/CDN/NZAA013.

National Heart Lung and Blood Institute. 2021. "Study Quality Assessment Tools|NHLBI, NIH." https://www.nhlbi.nih.gov/health-topics/study-quality-assessment-tools.

Nezlek, J. B., and C. A. Forestell. 2024. "Recent Increases in Vegetarianism May Be Limited to Women: A 15-Year Study of Young Adults at an American University." *Sex Roles* 90, no. 9: 1234–1243. https://doi.org/10.1007/S11199-024-01504-Y.

Nobakht, M., and M. Dezhkam. 2000. "An Epidemiological Study of Eating Disorders in Iran." *International Journal of Eating Disorders* 28: 265–271. https://doi.org/10.1002/1098-108X(200011)28:3.

Norwood, R., T. Cruwys, V. S. Chachay, and J. Sheffield. 2019. "The Psychological Characteristics of People Consuming Vegetarian, Vegan, Paleo, Gluten Free and Weight Loss Dietary Patterns." *Obesity Science and Practice* 5, no. 2: 148–158. https://doi.org/10.1002/OSP4.325.

Ouzzani, M., H. Hammady, Z. Fedorowicz, and A. Elmagarmid. 2016. "Rayyan-a Web and Mobile App for Systematic Reviews." *Systematic Reviews* 5, no. 1: 1–10. https://doi.org/10.1186/S13643-016-0384-4/FIGURES/6.

Page, M. J., J. E. McKenzie, P. M. Bossuyt, et al. 2021. "The PRISMA 2020 Statement: An Updated Guideline for Reporting Systematic Reviews." *BMJ* 372: n71. https://doi.org/10.1136/BMJ.N71.

Paslakis, G., C. Richardson, M. Nöhre, et al. 2020. "Prevalence and Psychopathology of Vegetarians and Vegans – Results From a Representative Survey in Germany." *Scientific Reports* 10, no. 1: 1–10. https://doi.org/10.1038/s41598-020-63910-y.

Perry, C. L., M. T. Mcguire, D. Neumark-Sztainer, and M. Story. 2001. "Characteristics of Vegetarian Adolescents in a Multiethnic Urban Population." *Journal of Adolescent Health* 29, no. 6: 406–416. https://doi.org/10.1016/S1054-139X(01)00258-0.

Rieger, E., S. W. Touyz, T. Swain, and P. J. V. Beumont. 2001. "Cross-Cultural Research on Anorexia Nervosa: Assumptions Regarding the Role of Body Weight." *International Journal of Eating Disorders* 29, no. 2: 205–215. https://doi.org/10.1002/1098-108x(200103)29:2<205::aid-eat1010>3.0.co;2-1.

Rosenfeld, D. L. 2018. "Why Some Choose the Vegetarian Option: Are All Ethical Motivations the Same?" *Motivation and Emotion* 43, no. 3: 400–411. https://doi.org/10.1007/S11031-018-9747-6.

Rosenfeld, D. L. 2020. "Gender Differences in Vegetarian Identity: How Men and Women Construe Meatless Dieting." *Food Quality and Preference* 81: 103859. https://doi.org/10.1016/J.FOODQUAL.2019.103859.

Rosenfeld, D. L., and A. L. Burrow. 2017. "Vegetarian on Purpose: Understanding the Motivations of Plant-Based Dieters." *Appetite* 116: 456–463. https://doi.org/10.1016/J.APPET.2017.05.039.

Ruby, M. B. 2012. "Vegetarianism. A Blossoming Field of Study." *Appetite* 58, no. 1: 141–150. https://doi.org/10.1016/J.APPET.2011.09.019.

Sergentanis, T. N., M. E. Chelmi, A. Liampas, et al. 2020. "Vegetarian Diets and Eating Disorders in Adolescents and Young Adults: A Systematic Review." *Children* 8, no. 1: 12. https://doi.org/10.3390/CHILDREN8010012.

Sharpe, H., S. Griffiths, T. H. Choo, et al. 2018. "The Relative Importance of Dissatisfaction, Overvaluation and Preoccupation With Weight and Shape for Predicting Onset of Disordered Eating Behaviors and Depressive Symptoms Over 15 Years." *International Journal of Eating Disorders* 51, no. 10: 1168–1175. https://doi.org/10.1002/EAT.22936.

Sieke, E. H., J. L. Carlson, J. Lock, C. A. Timko, D. Neumark-Sztainer, and R. Peebles. 2021. "To Meat or Not to Meat: Disordered Eating and Vegetarian Status in University Students." *Eating and Weight Disorders - Studies on Anorexia, Bulimia and Obesity* 27, no. 2: 831–837. https://doi.org/10.1007/S40519-021-01202-8.

Södersten, P., C. Bergh, and M. Zandian. 2006. "Understanding eating disorders." *Hormones and Behavior* 50, no. 4: 572–578. https://doi.org/10.1016/j.yhbeh.2006.06.030.

Song, S., C. M. Stern, T. Deitsch, and M. Sala. 2023. "Acculturation and Eating Disorders: A Systematic Review." *Eating and Weight Disorders - Studies on Anorexia, Bulimia and Obesity* 28, no. 1: 39. https://doi.org/10.1007/S40519-023-01563-2.

Sterne, J. A. C., M. Egger, and G. D. Smith. 2001. "Systematic Reviews in Health Care: Investigating and Dealing With Publication and Other Biases in Meta-Analysis." *British Medical Journal* 323, no. 7304: 101–105. https://doi.org/10.1136/BMJ.323.7304.101.

Timko, C. A., J. M. Hormes, and J. Chubski. 2012. "Will the Real Vegetarian Please Stand Up? An Investigation of Dietary Restraint and Eating Disorder Symptoms in Vegetarians Versus Non-Vegetarians." *Appetite* 58, no. 3: 982–990. https://doi.org/10.1016/J.APPET.2012.02.005.

Treasure, J., T. A. Duarte, and U. Schmidt. 2020. "Eating disorders." *Lancet* 395, no. 10227: 899–911. https://doi.org/10.1016/S0140-6736(20)30059-3.

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Zickgraf, H. F., V. M. Hazzard, S. M. O'Connor, et al. 2020. "Examining Vegetarianism, Weight Motivations, and Eating Disorder Psychopathology Among College Students." *International Journal of Eating Disorders* 53, no. 9: 1506–1514. https://doi.org/10.1002/EAT.23335.

Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Table S1:** Detailed information on search strategies. **Table S2:** Studies excluded after full-text assessment. **Table S3:** Effect sizes, main results, and covariate adjustments of included studies. **Table S4:** Methodological quality of included studies. **Table S5:** Subgroup analyses for the cross-sectional associations between vegetarian and vegan versus omnivorous diets and eating disorder symptoms. **Table S6:** Meta-regression analyses for the cross-sectional associations between vegetarian and vegan versus omnivorous diets and eating disorder symptoms. **Table S7:** Sensitivity analyses excluding studies one by one. **Figure S1:** Pooled standardized mean differences in eating disorder symptoms comparing vegetarian and vegan with omnivorous diets in studies including adult populations. **Figure S2:** Meta-regression models by age (A), females (B), total sample size (C), Body Mass Index (D), underweight status (E), and publication year (F) for studies including both adolescent and adult populations. **Figure S3:** Meta-regression models by age (A), females (B), total sample size (C), Body Mass Index (D), underweight status (E), educational level (F) and publication year (G) for studies restricted to adult populations. Notes: (A) Mean age (years); (B) Percentage of females; (C) total sample size; (D) Body Mass Index (mean, kg/m2); (E) Percentage of underweight status (BMI < 18 kg/m2); (F) Percentage of high educational level (university degree); and (G) Publication year. **Figure S4:** Funnel plot of publication bias.

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MANUSCRIPT IV

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Plant-Based Diet Indices and Depression in University Students: The Nuts4Brain-Z Study

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Abstract

Background/Objectives: Evidence on the associations between adherence to different plant-based diet indices and depression in young adults remains limited. This study aimed to analyze the associations of overall, healthy, and unhealthy plant-based diet indices with depressive symptoms in university students. **Methods**: A cross-sectional study was conducted in 2023 with self-reported data from university students in Cuenca, Spain. Adherence to the overall plant-based diet index (PDI) and to the healthy (hPDI) and unhealthy (uPDI) plant-based diet indices were calculated using data from a 137-item food-frequency questionnaire. Mild-to-severe depression was defined as a Beck Depression Inventory II score > 13 points. Linear and logistic regression models were adjusted for sociodemographic and lifestyle-related confounders. **Results**: A total of 392 students (mean age: 20.9 ± 2.4 years; 70.4% female) were included. The prevalence of mild-to-severe depression was 36.0%. Higher hPDI and overall PDI scores were associated with lower depressive symptom scores, whereas uPDI scores showed a positive but non-significant association after full adjustment. In logistic regression analyses, high adherence to the hPDI was associated with lower odds of mild-to-severe depression (OR = 0.51; 95% CI: 0.28–0.95; *p*-for-trend = 0.030). In contrast, higher uPDI adherence was associated with greater odds of depression, although the association was attenuated after adjustment for lifestyle-related variables. **Conclusions**: Greater adherence to a healthy plant-based diet was associated with lower depressive symptoms and lower odds of mild-to-severe depression among university students. These findings highlight the importance of plant food quality, rather than plant-based diets per se, in relation to depression in young adults.

Keywords: diet; lifestyle; depressive symptoms; college students; young adult

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1. Introduction

Depression is a major global public health concern, affecting an estimated 4% of the world's population [1,2] and 6.5% of the European population [3]. In 2021, major

depressive disorder ranked among the most prevalent mental health conditions worldwide [2]. Notably, approximately three-quarters of depression cases have their onset during youth [4], which corresponds with the high prevalence observed among young adults aged 18–25 years [5]. For those pursuing higher education, the transition to university represents a critical developmental period [6] marked by academic, social, and personal challenges that may adversely affect mental health [7–9]. Accordingly, a meta-analysis of 59 studies estimated a pooled depression prevalence of 33.6% among university students [10], highlighting the importance of addressing mental health during this life stage as a key strategy for prevention and early intervention [11].

Adherence to a healthy lifestyle has been consistently associated with better mental health [12–14] and reduced depressive symptoms [15]. Among lifestyle behaviors, diet has been widely recognized as a modifiable determinant of mental health promotion [14,16] and depression prevention [17,18]. In this sense, plant-based diets, characterized by higher consumption of plant-derived foods and lower consumption of animal-derived foods [19–21], have been suggested to confer beneficial effects on mental health outcomes [22] and depressive symptoms [23]. However, plant-based diet quality may vary according to the predominant plant food subgroups, and this may impact their health effects. This is particularly relevant when examining the association between plant-based diets and populations with suboptimal dietary habits, such as Spanish youth [24] and university students [25,26]. While a healthy plant-based diet includes mainly fresh and minimally processed plant foods (e.g., fruits, vegetables, whole grains, nuts), a less healthy plant-based diet includes high consumption of processed and ultra-processed foods (e.g., refined grains, sweetened carbonated beverages, salty snacks, sweets), characterized by its elevated levels of saturated fats, trans fats, sugars, sodium, and refined starches [27], and alcohol [28]. In this context, the plant-based diet index (PDI) makes it possible to assess the degree of adherence to dietary patterns characterized by a high consumption of plant-based foods. Furthermore, this index allows for a distinction to be made between the quality of such diets, differentiating between the healthy plant-based diet index (hPDI) and the unhealthy plant-based diet index (uPDI) [21,29].

The association between these three indices and depression has been previously explored. In a meta-analysis of 23 studies conducted on adult populations, the authors reported that greater adherence to the hPDI was associated with a lower likelihood and risk of depression [30]. However, evidence in young adults remains limited, as only two of these studies included participants under 35 years of age, and both focused exclusively on Iranian women [31,32]. Furthermore, only one of them examined outcomes related to depression [32]. For this reason, it is important to expand the empirical evidence on European young populations, especially regarding depression-related outcomes. Therefore, the objective of this study was to examine the associations between adherence to plant-based diets, differentiating between healthy and unhealthy patterns, and depression among Spanish university students.

2. Materials and Methods

This cross-sectional study is based on data obtained from a sample of students in various degree programs, including nursing, social work, audiovisual communication, tourism, business administration, law, education, and engineering, at the *Universidad de Castilla-La Mancha* (UCLM) in Cuenca, Spain, during the 2023–2024 academic year. The data analyzed are drawn from the Nuts4Brain-Z study, which was designed to estimate the associations between nut consumption and mental health outcomes in the target population. The sample size was calculated with GRANMO software (version 7.12) [33], which estimated a minimum sample size of 454 students to detect a mean difference

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of 0.3 units (standard deviation [SD] 2.04) on the Center for Epidemiological Studies Depression Scale-Revised [34], with an alpha error of 0.05 and a statistical power of 0.8. Considering a nonresponse rate of 20%, the total sample size was calculated at 544 students. Taking as a sampling frame the list of students enrolled in the UCLM courses (academic degrees in education, engineering, social sciences and nursing), 463 agreed to participate and met the following inclusion criterion: being regular university students at the Cuenca campus of UCLM. After excluding individuals with missing data on key variables and with implausible energy intake values, a total of 392 university students were included in this analysis (84.7%).

The data collection process was conducted between September and December of 2023. All participants were required to attend scheduled visits at the MOVI Fitness Laboratory, which is located within the Faculty of Nursing of Cuenca, Spain. Assessments were conducted between 8:00 a.m. and 11:30 a.m., Monday to Friday. The study protocol was approved by the Clinical Research Ethics Committee of the *Hospital Virgen de la Luz* of Cuenca (2023/PI1323) and conducted in accordance with the principles of the Declaration of Helsinki [35]. Written informed consent was obtained from all participants. This cross-sectional study was reported according to the Strengthening the Reporting of Observational Studies in Epidemiology guidelines [36].

2.1. Study Variables

2.1.1. Exposure

A 137-item food frequency questionnaire (FFQ) was used to estimate food consumption [37]. The FFQ comprised 137 food items grouped into nine major categories: dairy products; eggs, meat, and fish; vegetables and leafy greens; fruits; legumes and cereals; oils and fats; pastries and baked goods; miscellaneous foods; and beverages. For each item, participants reported their usual intake using one of nine frequency categories, ranging from "never or almost never" to "more than six times per day". Dietary intake was quantified by combining the reported consumption frequency with the standard portion size assigned to each food item in the questionnaire, based on data from the Spanish Food Composition Database [38]. The plant-based diet indices were calculated in accordance with the method originally proposed by Satija et al. [21] which comprises three indices: the overall PDI, the hPDI, and the uPDI. Prior to the creation of the indices, the foods in the FFQ were divided into 18 food groups, which were in turn subdivided into three categories: (i) healthy plant food groups, including fruits, vegetables, whole grains, nuts, legumes, vegetable oils and tea/coffee; (ii) less healthy plant food groups, encompassing fruit juices, refined grains, potatoes, sugar-sweetened beverages and sweets/desserts; and (iii) animal food groups, containing animal fats, dairy, eggs, fish/seafood, meat (red and white meat) and miscellaneous animal-based foods. The specific foods included in each food group are presented in Table S1.

For the creation of the three indices, the 18 food groups were classified into quintiles based on daily intake in grams. Depending on the index and the food category, a standard or inverse scoring method was applied. For positively scored components, the lowest quintile received 1 point and the highest, 5 points; for inversely scored components, this scoring was reversed (quintile 1 scored 5 and quintile 5 scored 1). In the PDI, plant-based food groups were scored positively, while animal-based food groups were scored inversely. In the hPDI, healthy plant-based foods received positive scores, while less healthy plant-based foods and animal-based foods were scored inversely. In the uPDI, less healthy plant-based foods were scored positively, while healthy plant-based foods and animal-based foods were scored inversely. To calculate each index, the score for each food group was summed, with a range of 18 to 90 points.

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Higher scores on all PDIs indicate lower consumption of animal-based foods. Additionally, higher scores on the overall PDI indicate higher consumption of both healthy and less healthy plant-based food groups. Higher scores on the hPDI indicate higher consumption of healthy plant-based foods and lower consumption of less healthy plant-based foods. Higher scores on the uPDI indicate higher consumption of less healthy plant-based foods and lower consumption of healthy plant-based foods.

Once the indices were calculated, they were classified into tertiles to categorize participants according to their level of adherence (tertile 1: low adherence; tertile 2: moderate adherence; tertile 3: high adherence).

2.1.2. Outcome

Depressive symptom severity was evaluated with the Spanish version [39] of the Beck Depression Inventory II (BDI-II) [40], a widely self-reported measure used in both scientific research and clinical practice. It has strong construct and criterion validity among university students [41]. The BDI-II includes 21 items that assess a broad range of cognitive, emotional, behavioral, and somatic symptoms of depression including feelings of sadness, pessimism, guilt, worthlessness, and self-dislike; self-critical thoughts and perceived failure; diminished pleasure, interest, and sexual desire; indecisiveness, agitation, irritability, crying, and concentration difficulties; as well as physical symptoms such as fatigue, low energy, sleep and appetite disturbances, and suicidal thoughts or wishes. Each item has four response options and is measured on a scale of 0–3, with total scores ranging from 0 to 63. Higher scores indicate greater severity of depressive symptoms, and the BDI-II total score can be classified as absent or minimal (0–13), mild (14–19), moderate (20–28), or severe (29–63) [40]. For the present analysis, mild-to-severe depression was defined as a binary outcome, with a cut-off score of greater than 13 points on the BDI-II [42,43].

2.1.3. Covariates

Sociodemographic and lifestyle-related variables were included as potential confounders given the established evidence supporting their relationships with both diet and depression [44–47]. The sociodemographic data were self-reported and included age (years), sex (female, male), and socioeconomic status based on parental educational level and occupation (medium-high, low). The participants' weight (kg) and height (cm) were objectively measured in accordance with standardized procedures, and their body mass index (BMI) was calculated (kg/m^2) to classify the students as overweight or obese ($\geq$25 kg/m^2) or not overweight or obese (<25 kg/m^2).

For lifestyle behaviors, participants were first asked about their tobacco and alcohol use over the past 30 days. Those who answered "daily" for smoking and "weekly" or "daily" for drinking alcohol were considered as tobacco smokers and alcohol drinkers, respectively. Physical activity levels were assessed via the International Physical Activity Questionnaire [48], with participants classified as moderate to high (i.e., energy expenditure $\geq$ 600 MET-min/week) or low physical activity (i.e., energy expenditure < 600 MET-min/week) [49]. Sleep quality over the last month was assessed using the Pittsburgh Sleep Quality Index (PSQI) [50]. Scores can range from 0 to 21, and increasing scores are indicative of lower overall sleep quality. The PSQI score was utilized to categorize the participants as having either good (score $\leq$ 5) or poor (score > 5) sleep quality [50,51].

Finally, the total energy intake of participants was estimated based on the responses to the 137-item FFQ and calculated in total calories per day using the updated values from the Spanish Food Composition Database [37,38]. We excluded participants with implausible

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total energy intake values (<500 or >5000 kcal/day) [52] and those with missing data for any covariate included in the multivariable models.

2.2. Statistical Analysis

First, baseline characteristics of the study participants were examined overall and according to depression status (i.e., absent or minimal vs. mild-to-severe). Categorical data were presented as frequencies and percentages. For continuous variables, means and SD were reported for normally distributed data, whereas medians and interquartile ranges (Q1–Q3) were used when distributional assumptions were not met. Normality was assessed using visual and analytical methods, including normal probability plots and the Kolmogorov–Smirnov test. Variables with a nonnormal distribution were analyzed using the Mann–Whitney U test. Categorical variables were compared using the chi-square test. In addition, the characteristics of the study sample and the mean consumption of food groups were examined according to tertiles of adherence (i.e., low, moderate, and high) to the plant-based diet indices.

Second, linear regression analyses were conducted to estimate B coefficients and their 95% confidence intervals (95% CIs) for depressive symptom scores associated with a 1-point increase in the plant-based diet indices. Scatter plots with fitted regression lines were generated to further illustrate the associations observed in the regression analyses. Binary logistic regression models were employed to estimate the odds ratios (ORs) and their 95% CIs for mild-to-severe depression (vs. absent or minimal depression) according to plant-based diet adherence tertiles (2nd or moderate and 3rd or high vs. 1st tertile or low adherence [reference category]). For both analyses, four models were estimated to assess the influence of potential confounders: Model 0: unadjusted; Model 1: adjusted for age, sex, and socioeconomic status; Model 2: Model 1 plus BMI; Model 3: Model 2 plus tobacco smoking, alcohol drinking, physical activity level, sleep quality, and total energy intake. To evaluate potential multicollinearity among covariates included in the fully adjusted model, variance inflation factors (VIFs) were calculated. Multicollinearity diagnostics indicated low VIF values for all covariates included in Model 3 (range: 1.05–1.20).

For the statistical analyses, covariates were categorized as follows: age (as a continuous variable in years), sex (female or male), socioeconomic status (low or medium/high), tobacco smoking (yes/no), alcohol drinking (yes/no), physical activity level (low or moderate/high), sleep quality (poor [PSQI score > 5] vs. good [PSQI score $\leq$ 5]), total energy intake (tertiles of the sample distribution) and BMI ($\geq$25 kg/m^2 vs. <25 kg/m^2). Tests for linear trends (*p*-for-trend) across tertiles were conducted by modeling the median value of each category as a continuous variable in logistic regression models. To address potential concerns regarding statistical power, post hoc power analyses were conducted using the final analytical sample (n = 392). The statistical power of the linear and logistic regression analyses involving the plant-based diet indices was estimated separately.

Third, potential interactions between plant-based diet indices and all covariates included in Model 3 were assessed by adding interaction terms to the linear regression models. Significant interactions ($p < 0.05$) were further explored through stratified analyses.

Finally, sensitivity analyses were conducted by excluding (i) participants with moderate-to-severe depression (BDI-II score $\geq$ 20) and/or self-reported treatment of depression, to minimize the potential influence of more severe depression on dietary behaviors and assess the robustness of the observed associations; and (ii) participants adhering to a vegetarian diet (i.e., without consumption of red meat, white meat, or fish), to evaluate whether the study associations were driven by individuals at the extreme end of plant-based diet adherence.

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All the statistical analyses were performed using IBM SPSS Statistics, version 24.0 (IBM Corp., Armonk, NY, USA). A p-value < 0.05 was considered statistically significant.

3. Results

After excluding 51 individuals with missing data on key variables and 20 with implausible energy intake values, a total of 392 university students aged 17 to 32 years were included in the analyses (mean age 20.9 ± 2.4, 70.4% female). Table 1 presents the baseline characteristics of the study participants overall and according to depression status. The prevalence of mild-to-severe depression was 36.0% (n = 141), including 68 participants with mild depression and 73 with moderate-to-severe depression. Mild-to-severe depression was significantly more prevalent among females than males (41.3% vs. 23.3%), tobacco smokers than non-smokers (55.4% vs. 32.1%), participants with low physical activity levels than those with moderate-to-high levels (49.1% vs. 33.7%), individuals with poor compared to good sleep quality (52.4% vs. 17.0%), and participants with BMI ≥ 25 kg/m^2 compared with those with BMI < 25 kg/m^2 (46.5% vs. 32.4%; all p-values < 0.05).

Table 1. Characteristics of the sample according to depression status.

Characteristic	Total	Depression Status		*p*-Value
		Absent or Minimal	Mild-to-Severe [1]	
Total sample, n (%)	392 (100.0)	251 (64.0)	141 (36.0)	
Age (years), median (Q1–Q3)	21 (19–22)	21 (19–22)	20 (19–22)	0.806
Sex, n (%)				**<0.001**
Female	276 (70.4)	162 (58.7)	114 (41.3)	
Male	116 (29.6)	89 (76.7)	27 (23.3)	
Socioeconomic status, n (%)				0.914
Low	65 (16.6)	42 (64.6)	23 (35.4)	
Medium/high	327 (83.4)	209 (63.9)	118 (36.1)	
BMI status (kg/m^2), n (%)				**0.012**
BMI < 25	293 (74.7)	198 (67.6)	95 (32.4)	
BMI ≥ 25	99 (25.3)	53 (53.5)	46 (46.5)	
Tobacco smokers, n (%)				**<0.001**
Yes	65 (16.6)	29 (44.6)	36 (55.4)	
No	327 (83.4)	222 (67.9)	105 (32.1)	
Alcohol drinkers, n (%)				0.839
Yes	136 (34.7)	88 (64.7)	48 (35.3)	
No	256 (65.3)	163 (63.7)	93 (36.3)	
Physical activity levels, n (%)				**0.025**
Low	57 (14.5)	29 (50.9)	28 (49.1)	
Moderate/high	335 (85.5)	222 (66.3)	113 (33.7)	
Sleep quality, n (%)				**<0.001**
Poor	210 (53.6)	100 (47.6)	110 (52.4)	
Good	182 (46.4)	151 (83.0)	31 (17.0)	
Total energy intake (kcal/d), Median (Q1–Q3)	2412 (1910–3052)	2455 (1892–3014)	2367 (1918–3122)	0.914

Notes: The values are expressed as absolute frequency (n) and percentages (%) for categorical variables, and median (Q1–Q3) for continuous variables. The Mann–Whitney U test was used to compare the medians of total energy intake and age by the depression status, while the chi-square test was used accordingly for categorical variables. Bold values indicate statistical significance at a p-value < 0.05. [1] Mild-to-severe depression was defined as a BDI-II score > 13 [42,43]. A BMI of ≥25 kg/m^2 indicates overweight or obesity. Abbreviation: BMI, body mass index.

The sample characteristics are available separately for categories of adherence to plant-based diets in Table S2. Overall, participants with higher adherence to the hPDI tended to exhibit healthier lifestyle behaviors, including higher physical activity levels, lower tobacco and alcohol use, and better sleep quality, whereas higher adherence to the uPDI was generally associated with less favorable lifestyle profiles. In addition, the

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mean consumption of food groups included in plant-based diets according to categories of adherence is available in Table S3. The relationships between PDI, hPDI, and uPDI scores and BDI-II scores are illustrated in Supplementary Figure S1A–C.

3.1. Adherence to the PDI

The PDI score ranged from 34 to 70 points. In the fully adjusted linear regression model, higher PDI scores were associated with lower depressive symptom scores (B = −0.12; 95% CI: −0.30 to −0.02; Table 2). In logistic regression analyses, adherence to the PDI was not significantly associated with mild-to-severe depression. In the fully adjusted model (Model 3), students with moderate (OR = 0.63; 95% CI: 0.36–1.12) and high (OR = 0.66; 95% CI: 0.35–1.22) adherence to the PDI showed similar odds of mild-to-severe depression compared with those with low adherence (*p*-for-trend = 0.166; Table 3).

Table 2. Linear regression analysis of the association between plant-based diet index scores and mild-to-severe depressive symptoms.

Plant-Based Diet Indices (Score Range)	Model 0	Model 1	Model 2	Model 3
PDI (34–70)	**−0.10 (−0.28, −0.01)**	**−0.11 (−0.28, −0.01)**	**−0.11 (−0.29, −0.02)**	**−0.12 (−0.30, −0.02)**
hPDI (36–80)	**−0.11 (−0.25, −0.02)**	**−0.11 (−0.24, −0.01)**	**−0.13 (−0.26, −0.03)**	**−0.11 (−0.24, −0.02)**
uPDI (36–76)	**0.10 (0.00, 0.24)**	0.09 (−0.01, 0.23)	0.08 (−0.02, 0.22)	0.05 (−0.06, 0.18)

Notes: The values correspond to B coefficients (95% confidence intervals) from linear regression models. B coefficients represent the change in BDI-II score associated with a one-point increase in the corresponding plant-based diet index score (PDI, hPDI, or uPDI). Models were adjusted as follows: Model 0, unadjusted; Model 1, adjusted for age, sex and socioeconomic status; Model 2, Model 1 adjusted by BMI; Model 3, Model 2 adjusted by tobacco smoking, alcohol drinking, physical activity level, sleep quality and total energy intake. Bold values indicate statistical significance at *p*-value < 0.05. Abbreviations: hPDI, healthy plant-based diet index; PDI, plant-based diet index; uPDI, unhealthy plant-based diet index.

Table 3. Logistic regression of mild-to-severe depression according to the adherence to plant-based diets.

Adherence to Plant-Based Diet Indices	Total (n Cases)	Model 0	Model 1	Model 2	Model 3
PDI					
Low, T1	144 (58)	1.00	1.00	1.00	1.00
Moderate, T2	130 (41)	0.68 (0.42–1.12)	0.65 (0.39–1.08)	0.67 (0.40–1.12)	0.63 (0.36–1.12)
High, T3	118 (42)	0.82 (0.50–1.36)	0.79 (0.47–1.33)	0.78 (0.47–1.32)	0.66 (0.35–1.22)
p-for-trend	392 (141)	0.391	0.326	0.319	0.166
hPDI					
Low, T1	142 (64)	1.00	1.00	1.00	1.00
Moderate, T2	125 (35)	**0.47 (0.28–0.79)**	**0.45 (0.27–0.76)**	**0.41 (0.24–0.70)**	**0.43 (0.23–0.80)**
High, T3	125 (42)	0.62 (0.38–1.01)	**0.58 (0.34–0.98)**	**0.52 (0.31–0.89)**	**0.51 (0.28–0.95)**
p-for-trend	392 (141)	**0.043**	**0.032**	**0.014**	**0.030**
uPDI					
Low, T1	138 (38)	1.00	1.00	1.00	1.00

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Table 3. *Cont.*

Adherence to Plant-Based Diet Indices	Total (n Cases)	Model 0	Model 1	Model 2	Model 3
Moderate, T2	124 (50)	**1.78 (1.06–2.99)**	1.67 (0.98–2.81)	**1.76 (1.03–2.99)**	1.54 (0.85–2.79)
High, T3	130 (53)	**1.81 (1.09–3.02)**	**1.78 (1.06–3.00)**	**1.72 (1.01–2.91)**	1.63 (0.86–3.10)
p-for-trend	392 (141)	**0.023**	**0.031**	**0.044**	0.138

Notes: The values correspond to odds ratios (95% confidence intervals) from logistic regression models: Model 0, unadjusted; Model 1, adjusted for age, sex and socioeconomic status; Model 2, Model 1 adjusted by BMI; Model 3, Model 2 adjusted by tobacco smoking, alcohol drinking, physical activity level, sleep quality and total energy intake. *p*-for-trend was calculated by entering the PDI, hPDI, and uPDI tertiles as ordinal continuous variables in the models. Bold values indicate statistical significance at p-value < 0.05. Abbreviations: hPDI, healthy plant-based diet index; PDI, plant-based diet index; T, tertile; uPDI, unhealthy plant-based diet index.

3.2. Adherence to the hPDI

The hPDI score ranged from 36 to 80 points. In linear regression analyses, higher hPDI scores were associated with lower depressive symptom scores (B = −0.11; 95% CI: −0.24 to −0.02; Table 2). In logistic regression analyses, Model 1 revealed that participants with moderate and high adherence to the hPDI had lower odds of mild-to-severe depression than those with low adherence (Table 3). In the fully adjusted model (Model 3), moderate (OR = 0.43; 95% CI: 0.23–0.80) and high (OR = 0.51; 95% CI: 0.28–0.95) adherence to the hPDI were significantly associated with lower odds of mild-to-severe depression, with evidence of a significant linear trend across tertiles (*p*-for-trend = 0.030).

3.3. Adherence to the uPDI

The uPDI score ranged from 36 to 76 points. In linear regression analyses, higher uPDI scores were associated with higher depressive symptom scores, although this association was not statistically significant (B = 0.05; 95% CI: −0.06, 0.18; Table 2). In logistic regression analyses, high adherence to the uPDI was associated with greater odds of mild-to-severe depression in the unadjusted model (Model 0; OR = 1.81, 95% CI: 1.09–3.02), the sociodemographic adjusted model (Model 1; OR = 1.78, 95% CI: 1.06–3.00) and the model additionally adjusted for BMI (Model 2; OR = 1.72, 95% CI: 1.01–2.91). However, the association was attenuated and no longer significant after further adjustment for lifestyle-related covariates in the fully adjusted model (Model 3; OR = 1.63, 95% CI: 0.86–3.10; Table 3).

3.4. Post Hoc Power Analyses

Post hoc power analyses indicated variable statistical power across analyses. For the linear regression models, statistical power ranged from 24% to 35% for PDI, from 47% to 89% for hPDI, and from 37% to 50% for uPDI. For the logistic regression models, statistical power ranged from 30% to 32% for PDI, from 48% to 83% for hPDI and from 59% to 63% for uPDI, depending on the tertile comparison.

3.5. Interaction and Subgroup Analyses

A significant interaction was observed between the hPDI and alcohol drinking (*p*-for-interaction = 0.002). Conversely, no statistically significant interactions were identified between the plant-based diet index scores and the remaining covariates (Table S4). In exploratory stratified analyses according to alcohol drinking status, the direction of the association between hPDI and depressive symptoms was inverse in both groups. However, the association was only statistically significant among drinkers. Specifically, in the fully adjusted linear regression models, higher hPDI scores were significantly associated with lower

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depressive symptom scores among drinkers (B = −0.31; 95% CI: −0.48, −0.14), whereas no significant association was observed among non-drinkers (B = −0.03; 95% CI: −0.18, 0.11; Table S5). Consistently, in the fully adjusted logistic regression models, participants in the highest adherence of hPDI exhibited significantly lower odds of mild-to-severe depression among drinkers (OR = 0.18; 95% CI: 0.05–0.59), but not among non-drinkers (OR = 0.80; 95% CI: 0.37–1.72; Table S5).

3.6. Sensitivity Analyses

The results of the sensitivity analyses were largely consistent with the main analyses. The relationships between PDI, hPDI, and uPDI scores and BDI-II scores after excluding participants with moderate-to-severe depression and those receiving treatment for depression (n = 73) are illustrated in Supplementary Figure S2A–C. Notably, both moderate (OR = 2.54; 95% CI: 1.15–5.60) and high (OR = 3.50; 95% CI: 1.49–8.24) adherence to the uPDI remained significantly associated with greater odds of mild-to-severe depression in the fully adjusted model (p-for-trend = 0.004; Table S6).

4. Discussion

This study examined the cross-sectional associations between plant-based diet indices and depression among Spanish university students. One of the main findings was that the associations between plant-based dietary patterns and depression differed according to the quality of plant foods consumed. Linear regression analyses showed that higher hPDI and overall PDI scores were associated with lower depressive symptom scores, whereas uPDI scores showed a positive but non-significant association after full adjustment. Logistic regression analyses were generally consistent with these findings. Participants with the highest adherence to the hPDI showed lower odds of mild-to-severe depression, whereas higher adherence to the uPDI was associated with greater odds of mild-to-severe depression, although this association was attenuated after adjustment for lifestyle-related behaviors. Taken together, these findings highlight the importance of plant-based food quality, rather than plant-based diets per se, in relation to depressive symptoms.

Consistent with these findings, previous studies conducted in young and middle-aged Iranian women (20–50 years) have reported inverse associations between the PDI and hPDI and depressive symptoms, whereas higher adherence to the uPDI was associated with greater severity of depressive symptoms [31,32]. Similarly, our study extends these observations to a population of Spanish university students, suggesting that the quality of plant-based diets may play an important role in depression-related outcomes. Higher hPDI and overall PDI scores were associated with lower depressive symptom scores; however, only the hPDI was associated with lower odds of mild-to-severe depression. Previous prospective studies further support these observations. A cohort study of Spanish middle-aged adults reported that greater adherence to the hPDI was associated with lower depressive symptom scores [53]. Similarly, a large population-based study involving middle-aged and older adults in the United Kingdom showed that greater adherence to the hPDI was associated with lower risk of depression [54]. These findings are further supported by recent meta-analyses conducted in adult populations, predominantly including middle-aged and older adults [55].

Lifestyle-related factors may partly explain our findings. Previous evidence has shown that unhealthy lifestyle behaviors, including smoking, excessive alcohol consumption, sleep deprivation, and insufficient physical activity, are associated with poorer mental health outcomes in young adults [56]. In the present study, the association between the uPDI and depression was attenuated after adjustment for lifestyle-related factors, which suggests that behaviors such as physical activity, smoking, alcohol consumption, and

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sleep quality may partly influence this relationship [53]. Conversely, healthier lifestyle behaviors have been associated with lower likelihood of depressive symptoms [15]. In our study, greater adherence to the hPDI was associated with healthier lifestyle behaviors, including higher physical activity levels, better sleep quality, and lower tobacco and alcohol use. Importantly, the association between the hPDI and depression remained significant after adjustment for these variables, suggesting a potential complementary role of healthy dietary patterns and other favorable lifestyle behaviors in relation to mental health outcomes. Additionally, healthier plant-based dietary patterns have been associated with better physical fitness [57], whereas higher levels of cardiorespiratory fitness and muscular strength have consistently been associated with lower risk of depression across different adult populations [58,59]. Subgroup analyses also revealed that the inverse association between the hPDI and depressive symptoms was stronger among alcohol drinkers than among non-drinkers. One possible explanation is that non-drinkers may already exhibit a healthier overall lifestyle profile, thereby reducing the relative contribution of diet quality to mental health outcomes. In contrast, diets rich in fruits, vegetables, whole grains, and dietary fiber provide antioxidants and anti-inflammatory compounds [60] that may help mitigate the oxidative stress and inflammation associated with alcohol use [61,62], both of which have been linked to depressive symptoms [63].

Several biological mechanisms may also underlie the associations between hPDI and depression. Dietary patterns rich in healthy plant foods may modulate pathways associated with inflammation, oxidative stress, neuroplasticity, and the gut microbiota [17,60]. In this context, previous research has indicated that higher adherence to the PDI and hPDI is associated with lower inflammatory profiles, whereas greater adherence to the uPDI has been linked to increased inflammation [31]. A more mechanistic explanation for the observed associations may involve the synergistic effects of specific bioactive compounds commonly found in plant-based dietary patterns. Fruits, vegetables, legumes, nuts, whole grains, and extra-virgin olive oil provide abundant polyphenols and fermentable fibers, which can modulate the gut microbiota and enhance the production of short-chain fatty acids, particularly butyrate, propionate, and acetate [64,65]. These microbial metabolites contribute to the maintenance of intestinal barrier integrity, regulate immune responses, and attenuate systemic low-grade inflammation, including reductions in inflammatory biomarkers such as C-reactive protein, interleukin-6, and tumor necrosis factor-alpha [66]. Polyphenols may further influence the gut–brain axis through antioxidant and anti-inflammatory mechanisms, promoting a more favorable neurochemical environment and supporting the expression of brain-derived neurotrophic factor (BDNF), a key mediator of neuroplasticity, learning, and emotional regulation [64]. In addition, healthy plant-based dietary patterns may be characterized by a higher intake of omega-3-rich foods, such as nuts, seeds, and certain vegetable oils, potentially contributing to a more favorable omega-6/omega-3 fatty acid balance. Omega-3 fatty acids play important roles in neuronal membrane function, neurotransmission, and the modulation of neuro-inflammatory pathways, and have also been linked to BDNF-related signaling [67]. Similarly, other plant foods such as nuts and whole grains, which are rich in fiber, antioxidants, and bioactive compounds, have been associated with a lower likelihood of depression [68,69].

These biological mechanisms may be particularly relevant among university students, a population frequently exposed to academic stress, sleep disturbances, and unhealthy lifestyle behaviors that are associated with poorer mental health outcomes [70,71]. Such dietary exposures may contribute to alterations in gut microbiota composition and increased low-grade inflammation, potentially affecting gut–brain axis signaling and neurobiological processes involved in psychological well-being [72]. Furthermore, a systematic review suggests that plant-based dietary patterns, particularly the Mediterranean diet, exhibit

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high antioxidant potential, as reflected by inverse associations with biomarkers of oxidative stress, including F2-isoprostanes and malondialdehyde [73,74]. Inadequate intake of antioxidants and vitamins has also been associated with a greater risk of depression [75].

Conversely, a higher consumption of ultra-processed foods such as processed meats, sugar-sweetened beverages, packaged snacks, and ready-to-eat meals has been associated with an increased likelihood of depressive symptoms [27]. These associations may not be fully explained by nutritional composition or energy density alone, but also by additives and compounds generated during industrial processing, which can impair nutrient absorption and contribute to harmful metabolic and inflammatory processes [76]. Therefore, adherence to dietary patterns characterized by greater consumption of plant-based foods such as fruits, vegetables, whole grains, and nuts, along with lower consumption of ultra-processed foods, may represent a complementary strategy for promoting mental well-being and reducing depressive symptoms [23,30,53,77].

From a public health and epidemiological perspective, our findings do not support a general recommendation for plant-based diets per se, but rather highlight the importance of diet quality within plant-based dietary patterns. Accordingly, improving adherence to healthy plant-based diets may represent a potentially modifiable approach for promoting mental health and preventing depression among young adults, although causal relationships cannot be established from the present study.

This study has several limitations that should be acknowledged. First, due to the cross-sectional design, causal relationships cannot be established. Longitudinal cohort studies with repeated measures of both diet and depressive symptoms are needed to better evaluate the proposed associations over time. To our knowledge, no prospective studies have specifically examined the relationship between plant-based diet indices and depression among university students or young adults, although this being a critical stage for mental health prevention. Furthermore, reverse causality represents an important limitation of the present study and cannot be ruled out, as depressive symptoms may influence eating behaviors and dietary habits, potentially affecting adherence to healthy and unhealthy plant-based dietary patterns. Although sensitivity analyses excluding participants with moderate-to-severe depression and those receiving treatment for depression yielded largely similar findings, the temporal direction of the observed associations remains uncertain. Nevertheless, these findings should be interpreted within the broader body of evidence, including prospective cohort studies [53] and randomized controlled trials [78], which have suggested that higher-quality dietary patterns may contribute to better mental health outcomes and a lower risk of depression. In addition, some lifestyle-related variables included in the fully adjusted models may have acted as mediators rather than confounders. However, the cross-sectional design precluded assessment of these potential pathways. Second, dietary intake and depressive symptoms were self-reported, which may have introduced recall and social desirability bias. Participants may have under-reported foods perceived as unhealthy and over-reported foods perceived as healthy, potentially influencing the estimation of the plant-based diet indices. Although dietary intake was assessed using a previously validated FFQ and participants with implausible energy intakes were excluded to improve data quality, some degree of dietary mis-reporting and measurement error is likely unavoidable. Consequently, the observed associations may have been underestimated or otherwise affected by exposure misclassification. Furthermore, although plant-based diet indices classify foods into predefined food groups, some foods and beverages are commonly consumed together (e.g., coffee or tea with sugar or other additives). Consequently, the classification of individual food groups may not fully reflect how foods are consumed in real-life settings, which could have introduced a degree of exposure misclassification. Third, post hoc power analyses indicated limited statistical

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power for some comparisons. Consequently, the interpretation of null findings should be undertaken with caution. Future studies with larger sample sizes are warranted to confirm these findings and to examine potential effect modifiers with greater precision. Fourth, plant-based diet indices such as the PDI, hPDI, and uPDI are constructed differently across studies, including differences in the number of food groups and scoring criteria used, which further limits direct comparisons between findings. Finally, most participants in our study consumed some type of meat, and only five participants identified as vegetarians. Although the results remained consistent after excluding these individuals, future studies should evaluate these associations in strictly vegetarian populations to better understand the role of plant-based diet quality in relation to depressive symptoms among young adults.

5. Conclusions

Our findings suggest that university students with greater adherence to healthy plant-based diets were less likely to have mild-to-severe depression than those with lower adherence. In contrast, higher adherence to an unhealthy plant-based diet was associated with greater odds of mild-to-severe depression, although this association was attenuated after adjustment for lifestyle-related factors. These findings highlight the importance of plant food quality, rather than plant-based diets per se, in relation to depressive symptoms in young adults. However, given the cross-sectional design, reliance on self-reported data, and relatively small sample size, the results should be interpreted with caution. Future longitudinal studies using standardized definitions of plant-based diets and larger samples are needed to confirm these associations and better inform preventive strategies in young populations.

Supplementary Materials: The following supporting information can be downloaded at https://www.mdpi.com/article/10.3390/nu18122018/s1, Table S1: Food components included in the 18 food groups used to construct the plant-based diet indices; Table S2: Characteristics of the sample according to categories of adherence to plant-based diet indices; Table S3: Mean consumption of food groups across tertiles of adherence to plant-based diet indices; Table S4: Interaction analyses between plant-based diet indices and covariates in relation to depressive symptoms; Table S5: Stratified linear and logistic regression analyses of the association between hPDI adherence and depressive symptoms according to alcohol drinking status; Table S6: Sensitivity analyses excluding participants with moderate-to-severe depression or receiving treatment, and those adhering to a strictly vegetarian diet; Supplementary Figure S1; Scatter plots illustrating the relationships between PDI, hPDI, and uPDI scores and BDI-II depressive symptom scores; Supplementary Figure S2; Scatter plots illustrating the relationships between PDI, hPDI, and uPDI scores and depressive symptom scores after excluding participants with moderate-to-severe depression and those receiving treatment for depression.

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Abbreviations

BDI-II	Beck depression inventory II
BDNF	Brain-derived neurotrophic factor
BMI	Body mass index
CIs	Confidence intervals
FFQ	Food frequency questionnaire
hPDI	Healthy plant-based diet index
ORs	Odds ratios
PDI	Plant-Based diet index
PSQI	Pittsburgh sleep quality index
SD	Standard deviation
UCLM	*Universidad de Castilla-La Mancha*
uPDI	Unhealthy plant-based diet index
VIF	Variance inflation factor

References

1. World Health Organization (WHO). Depressive Disorder (Depression). Available online: https://www.who.int/news-room/fact-sheets/detail/depression (accessed on 21 August 2025).
2. Fan, Y.; Fan, A.; Yang, Z.; Fan, D. Global burden of mental disorders in 204 countries and territories, 1990–2021: Results from the global burden of disease study 2021. *BMC Psychiatry* **2025**, *25*, 486. [CrossRef] [PubMed]
3. Arias-de la Torre, J.; Vilagut, G.; Ronaldson, A.; Bakolis, I.; Dregan, A.; Martín, V.; Martínez-Alés, G.; Molina, A.J.; Serrano-Blanco, A.; Valderas, J.M.; et al. Prevalence and variability of depressive symptoms in Europe: Update using representative data from the second and third waves of the European Health Interview Survey (EHIS-2 and EHIS-3). *Lancet Public Health* **2023**, *8*, e889–898. [CrossRef] [PubMed]
4. Lipson, S.K.; Zhou, S.; Abelson, S.; Heinze, J.; Jirsa, M.; Morigney, J.; Patterson, A.; Singh, M.; Eisenberg, D. Trends in college student mental health and help-seeking by race/ethnicity: Findings from the national healthy minds study, 2013–2021. *J. Affect. Disord.* **2022**, *306*, 138–147. [CrossRef] [PubMed]
5. Goodwin, R.D.; Dierker, L.C.; Wu, M.; Galea, S.; Hoven, C.W.; Weinberger, A.H. Trends in U.S. Depression Prevalence from 2015 to 2020: The Widening Treatment Gap. *Am. J. Prev. Med.* **2022**, *63*, 726–733. [CrossRef] [PubMed]
6. Lenz, B. The transition from adolescence to young adulthood: A theoretical perspective. *J. Sch. Nurs.* **2001**, *17*, 300–306. [CrossRef] [PubMed]
7. Campbell, F.; Blank, L.; Cantrell, A.; Baxter, S.; Blackmore, C.; Dixon, J.; Goyder, E. Factors that influence mental health of university and college students in the UK: A systematic review. *BMC Public Health* **2022**, *22*, 1778. [CrossRef] [PubMed]
8. Liu, X.; Ping, S.; Gao, W. Changes in Undergraduate Students' Psychological Well-Being as They Experience University Life. *Int. J. Environ. Res. Public Health* **2019**, *16*, 2864. [CrossRef] [PubMed]

https://doi.org/10.3390/nu18122018

9. Dyson, R.; Renk, K. Freshmen adaptation to university life: Depressive symptoms, stress, and coping. *J. Clin. Psychol.* **2006**, *62*, 1231–1244. [CrossRef] [PubMed]
10. Li, W.; Zhao, Z.; Chen, D.; Peng, Y.; Lu, Z. Prevalence and associated factors of depression and anxiety symptoms among college students: A systematic review and meta-analysis. *J. Child. Psychol. Psychiatry* **2022**, *63*, 1222–1230. [CrossRef] [PubMed]
11. Uhlhaas, P.J.; Davey, C.G.; Mehta, U.M.; Shah, J.; Torous, J.; Allen, N.B.; Avenevoli, S.; Bella-Awusah, T.; Chanen, A.; Chen, E.Y.H.; et al. Towards a youth mental health paradigm: A perspective and roadmap. *Mol. Psychiatry* **2023**, *28*, 3171–3181. [CrossRef] [PubMed]
12. Velten, J.; Lavallee, K.L.; Scholten, S.; Meyer, A.H.; Zhang, X.C.; Schneider, S.; Margraf, J. Lifestyle choices and mental health: A representative population survey. *BMC Psychol.* **2014**, *2*, 58. [CrossRef] [PubMed]
13. Hautekiet, P.; Saenen, N.D.; Martens, D.S.; Debay, M.; Van der Heyden, J.; Nawrot, T.S.; De Clercq, E.M. A healthy lifestyle is positively associated with mental health and well-being and core markers in ageing. *BMC Med.* **2022**, *20*, 328. [CrossRef] [PubMed]
14. Abascal, L.; Vela, A.; Sugden, S.; Kohlenberg, S.; Hirschberg, A.; Young, A.; Lane, K.; Merlo, G. Incorporating Mental Health Into Lifestyle Medicine. *Am. J. Lifestyle Med.* **2022**, *16*, 570–576. [CrossRef] [PubMed]
15. Wang, X.; Arafa, A.; Liu, K.; Eshak, E.S.; Hu, Y.; Dong, J.Y. Combined healthy lifestyle and depressive symptoms: A meta-analysis of observational studies. *J. Affect. Disord.* **2021**, *289*, 144–150. [CrossRef] [PubMed]
16. Warren, M.; O'Connor, C.; Lee, J.E.; Burton, J.; Walton, D.; Keathley, J.; Wammes, M.; Osuch, E. Predispose, precipitate, perpetuate, and protect: How diet and the gut influence mental health in emerging adulthood. *Front. Nutr.* **2024**, *11*, 1339269. [CrossRef] [PubMed]
17. Marx, W.; Moseley, G.; Berk, M.; Jacka, F. Nutritional psychiatry: The present state of the evidence. *Proc. Nutr. Soc.* **2017**, *76*, 427–436. [CrossRef] [PubMed]
18. Opie, R.S.; O'Neil, A.; Itsiopoulos, C.; Jacka, F.N. The impact of whole-of-diet interventions on depression and anxiety: A systematic review of randomised controlled trials. *Public Health Nutr.* **2015**, *18*, 2074. [CrossRef] [PubMed]
19. Rajaram, S.; Jones, J.; Lee, G.J. Plant-Based Dietary Patterns, Plant Foods, and Age-Related Cognitive Decline. *Adv. Nutr.* **2019**, *10*, S422. [CrossRef] [PubMed]
20. Tuso, P.J.; Ismail, M.H.; Ha, B.P.; Bartolotto, C. Nutritional update for physicians: Plant-based diets. *Perm. J.* **2013**, *17*, 61–66. [CrossRef] [PubMed]
21. Satija, A.; Bhupathiraju, S.N.; Rimm, E.B.; Spiegelman, D.; Chiuve, S.E.; Borgi, L.; Willett, W.C.; Manson, J.E.; Sun, Q.; Hu, F.B. Plant-Based Dietary Patterns and Incidence of Type 2 Diabetes in US Men and Women: Results from Three Prospective Cohort Studies. *PLoS Med.* **2016**, *13*, e1002039. [CrossRef] [PubMed]
22. Rosenfeld, R.M.; Juszczak, H.M.; Wong, M.A. Scoping review of the association of plant-based diet quality with health outcomes. *Front. Nutr.* **2023**, *10*, 1211535. [CrossRef] [PubMed]
23. Bizzozero-Peroni, B.; Martínez-Vizcaíno, V.; Fernández-Rodríguez, R.; Jiménez-López, E.; Núñez de Arenas-Arroyo, S.; Saz-Lara, A.; Díaz-Goñi, V.; Mesas, A.E. The impact of the Mediterranean diet on alleviating depressive symptoms in adults: A systematic review and meta-analysis of randomized controlled trials. *Nutr. Rev.* **2024**, *83*, 29–39. [CrossRef] [PubMed]
24. Alfaro-González, S.; Garrido-Miguel, M.; Fernández-Rodríguez, R.; Sequí-Domínguez, I.; Mesas, A.E.; Bizzozero-Peroni, B.; Jiménez-López, E.; Martínez-Vizcaíno, V. Adherence trends to the Mediterranean Diet in Spanish youth: A systematic review and meta-analysis. *Nutr. Metab. Cardiovasc. Dis.* **2025**, *35*, 104220. [CrossRef] [PubMed]
25. Bernardo, G.L.; Jomori, M.M.; Fernandes, A.C.; Proença RPda, C. Food intake of university students. *Rev. Nutr.* **2017**, *30*, 847–865. [CrossRef]
26. Ramón-Arbués, E.; Granada-López, J.M.; Martínez-Abadía, B.; Echániz-Serrano, E.; Antón-Solanas, I.; Jerue, B.A. Factors related to diet quality: A cross-sectional study of 1055 university students. *Nutrients* **2021**, *13*, 3512. [CrossRef] [PubMed]
27. Lane, M.M.; Gamage, E.; Travica, N.; Dissanayaka, T.; Ashtree, D.N.; Gauci, S.; Lotfaliany, M.; O'Neil, A.; Jacka, F.N.; Marx, W. Ultra-Processed Food Consumption and Mental Health: A Systematic Review and Meta-Analysis of Observational Studies. *Nutrients* **2022**, *14*, 2568. [CrossRef] [PubMed]
28. Vázquez-Aguilar, A.; Ballesteros-Torres, J.M.; Escalante-Aburto, A.; Huerta-Canseco, C.; Jiménez-López, K.L.; Caballero-Prado, C.J. Dietary Trends and Lifestyle Habits Among University Students: Analysis of Consumption Patterns and Nutritional Risks. *Nutrients* **2026**, *18*, 532. [CrossRef] [PubMed]
29. Satija, A.; Hu, F.B. Plant-based diets and cardiovascular health. *Trends Cardiovasc. Med.* **2018**, *28*, 437. [CrossRef] [PubMed]
30. Bizzozero-Peroni, B.; Díaz-Goñi, V.; Fernández-Rodríguez, R.; Martínez-Vizcaíno, V.; Jiménez-López, E.; Visier-Alfonso, M.E.; Garrido-Miguel, M.; Mesas, A.E. Plant-Based Diets and Mental and Neurocognitive Health Outcomes: A Systematic Review with Meta-Analysis. *Nutr. Rev.* **2025**, *83*, 2282–2295. [CrossRef] [PubMed]

https://doi.org/10.3390/nu18122018

31. Aljuraiban, G.S. Plant-based dietary indices and stress in female college students: A cross-sectional study. *Br. J. Nutr.* **2022**, *127*, 123–132. [CrossRef] [PubMed]
32. Zamani, B.; Daneshzad, E.; Siassi, F.; Guilani, B.; Bellissimo, N.; Azadbakht, L. Association of plant-based dietary patterns with psychological profile and obesity in Iranian women. *Clin. Nutr.* **2020**, *39*, 1799–1808. [CrossRef] [PubMed]
33. GRANMO—DATARUS. Available online: https://www.datarus.eu/aplicaciones/granmo/ (accessed on 30 August 2025).
34. Francis, H.M.; Stevenson, R.J.; Chambers, J.R.; Gupta, D.; Newey, B.; Lim, C.K. A brief diet intervention can reduce symptoms of depression in young adults—A randomised controlled trial. *PLoS ONE* **2019**, *14*, e0222768. [CrossRef] [PubMed]
35. World Medical Association. World Medical Association declaration of Helsinki: Ethical principles for medical research involving human subjects. *JAMA* **2013**, *310*, 2191–2194. [CrossRef] [PubMed]
36. von Elm, E.; Altman, D.G.; Egger, M.; Pocock, S.J.; Gøtzsche, P.C.; Vandenbroucke, J.P. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: Guidelines for reporting observational studies. *J. Clin. Epidemiol.* **2008**, *61*, 344–349. [CrossRef] [PubMed]
37. Fernández-Ballart, J.D.; Piñol, J.L.; Zazpe, I.; Corella, D.; Carrasco, P.; Toledo, E.; Perez-Bauer, M.; Martínez-González, M.A.; Salas-Salvadó, J.; Martín-Moreno, J.M. Relative validity of a semi-quantitative food-frequency questionnaire in an elderly Mediterranean population of Spain. *Br. J. Nutr.* **2010**, *103*, 1808–1816. [CrossRef] [PubMed]
38. Ministerio de Ciencia e Innovación AE de SA y N (AESAN). BEDCA: Base de Datos Española de Composición de Alimentos. Available online: https://www.bedca.net/bdpub/ (accessed on 30 August 2025).
39. Sanz, J.; Perdigón, A.L.; Vázquez, C. The Spanish adaptation of Beck's Depression Inventory-ll (BDI-II): 2. Psychometric properties in the general population. *Clin. Salud.* **2003**, *14*, 249–280.
40. Beck, A.T.; Steer, R.A.; Brown, G. *Beck Depression Inventory–II*; PsycTESTS Dataset; American Psychological Corporation: San Antonio, TX, USA, 1996. [CrossRef]
41. Fernández, J.S.; Navarro, M.E.; Valverde, C.V. Adaptación Española del Inventario para la Depresión de Beck-II (BDI-II): Propiedades Psicométricas en Estudiantes Universitarios. *Análisis Modif. Conducta* **2003**, *29*, 239–288. Available online: https://dialnet.unirioja.es/servlet/articulo?codigo=761288&info=resumen&idioma=SPA (accessed on 6 April 2026).
42. Whisman, M.A.; Richardson, E.D. Normative Data on the Beck Depression Inventory--Second Edition (BDI-II) in College Students. *J. Clin. Psychol.* **2015**, *71*, 898–907. [CrossRef] [PubMed]
43. Ignjatović-Ristić, D.; Hinić, D.; Jović, J. Evaluation of the Beck Depression Inventory in a nonclinical student sample. *West Indian Med. J.* **2012**, *61*, 489–493. [CrossRef] [PubMed]
44. Marx, W.; Manger, S.H.; Blencowe, M.; Murray, G.; Ho, F.Y.Y.; Lawn, S.; Blumenthal, J.A.; Schuch, F.; Stubbs, B.; Ruusunen, A.; et al. Clinical guidelines for the use of lifestyle-based mental health care in major depressive disorder: World Federation of Societies for Biological Psychiatry (WFSBP) and Australasian Society of Lifestyle Medicine (ASLM) taskforce. *World J. Biol. Psychiatry* **2023**, *24*, 333–386. [CrossRef] [PubMed]
45. Kandola, A.A.; del Pozo Cruz, B.; Osborn, D.P.J.; Stubbs, B.; Choi, K.W.; Hayes, J.F. Impact of replacing sedentary behaviour with other movement behaviours on depression and anxiety symptoms: A prospective cohort study in the UK Biobank. *BMC Med.* **2021**, *19*, 133. [CrossRef] [PubMed]
46. Freeman, A.; Tyrovolas, S.; Koyanagi, A.; Chatterji, S.; Leonardi, M.; Ayuso-Mateos, J.L.; Tobiasz-Adamczyk, B.; Koskinen, S.; Rummel-Kluge, C.; Haro, J.A. The role of socio-economic status in depression: Results from the COURAGE (aging survey in Europe). *BMC Public Health* **2016**, *16*, 1098. [CrossRef] [PubMed]
47. Buckman, J.E.J.; Saunders, R.; Stott, J.; Arundell, L.L.; O'Driscoll, C.; Davies, M.R.; Eley, T.C.; Hollon, S.D.; Kendrick, T.; Amblet, G.; et al. Role of age, gender and marital status in prognosis for adults with depression: An individual patient data meta-analysis. *Epidemiol. Psychiatr. Sci.* **2021**, *30*, e42. [CrossRef] [PubMed]
48. IPAQ-Group. Guidelines for Data Processing and Analysis of the International Physical Activity Questionnaire (IPAQ)—Short. 2005. Available online: https://sites.google.com/view/ipaq/home (accessed on 26 July 2025).
49. Chudasama, Y.V.; Khunti, K.K.; Zaccardi, F.; Rowlands, A.V.; Yates, T.; Gillies, C.L.; Davies, M.J.; Dhalwani, N.N. Physical activity, multimorbidity, and life expectancy: A UK Biobank longitudinal study. *BMC Med.* **2019**, *17*, 108. [CrossRef] [PubMed]
50. Buysse, D.J.; Reynolds, C.F.; Monk, T.H.; Berman, S.R.; Kupfer, D.J. The Pittsburgh sleep quality index: A new instrument for psychiatric practice and research [Índice de calidad del sueño de Pittsburgh: Un nuevo instrumento para la práctica y la investigación psiquiátrica]. *Psychiatry Res.* **1989**, *28*, 193–213. [CrossRef] [PubMed]
51. de la Vega, R.; Tomé-Pires, C.; Solé, E.; Racine, M.; Castarlenas, E.; Jensen, M.P.; Miró, J. The Pittsburgh Sleep Quality Index: Validity and factor structure in young people. *Psychol. Assess.* **2015**, *27*, e22–e27. [CrossRef] [PubMed]
52. Wang, S.; Fan, C.; Zhu, Y.; Tang, X.; Ling, L. The Obesity-Related Dietary Pattern Is Associated with Higher Risk of Sleep Disorders: A Cross-Sectional Study from NHANES. *Nutrients* **2022**, *14*, 3987. [CrossRef] [PubMed]

https://doi.org/10.3390/nu18122018

53. Lugon, G.; Hernáez, Á.; Jacka, F.N.; Marrugat, J.; Ramos, R.; Garre-Olmo, J.; Elosua, R.; Lassale, C. Association between different diet quality scores and depression risk: The REGICOR population-based cohort study. *Eur. J. Nutr.* **2024**, *63*, 2885–2895. [CrossRef] [PubMed]
54. Wu, H.; Gu, Y.; Meng, G.; Wu, H.; Zhang, S.; Wang, X.; Zhang, J.; Huang, T.; Niu, K. Quality of plant-based diet and the risk of dementia and depression among middle-aged and older population. *Age Ageing* **2023**, *52*, afad070. [CrossRef] [PubMed]
55. Fernández-Rodríguez, R.; Bizzozero-Peroni, B.; Díaz-Goñi, V.; Garrido-Miguel, M.; Boronat, A.; Jacka, F.; McGuinness, A.J.; Marx, W.; Fresán, U. The association of environmentally sustainable healthy dietary patterns and risk of neurological and psychiatric disorders: A systematic review and meta-analysis of 28 cohorts. *Nutr. Psychiatry* **2026**, *2*, 100008. [CrossRef]
56. Massetti, G.M.; Thomas, C.C.; King, J.; Ragan, K.; Lunsford, N.B. Mental Health Problems and Cancer Risk Factors Among Young Adults. *Am. J. Prev. Med.* **2017**, *53*, S30–S39. [CrossRef] [PubMed]
57. Bizzozero-Peroni, B.; Brazo-Sayavera, J.; Martínez-Vizcaíno, V.; Fernández-Rodríguez, R.; López-Gil, J.F.; Díaz-Goñi, V.; Cavero-Redondo, I.; Mesas, A.E. High Adherence to the Mediterranean Diet is Associated with Higher Physical Fitness in Adults: A Systematic Review and Meta-Analysis. *Adv. Nutr.* **2022**, *13*, 2195–2206. [CrossRef] [PubMed]
58. Díaz-Goñi, V.; López-Gil, J.F.; Rodríguez-Gutiérrez, E.; Visier-Alfonso, M.E.; Jiménez-López, E.; Sequí-Domínguez, I.; Ortega, F.B.; Castro-Piñero, J.; Mesas, A.E.; Sánchez-López, M.; et al. Cardiorespiratory fitness and risk of mental disorders and dementia: A systematic review and meta-analysis. *Nat. Ment. Health* **2026**, *4*, 653–663. [CrossRef]
59. Marín-Jiménez, N.; Bizzozero-Peroni, B.; Molina-Garcia, P.; Ortega, F.B.; Chaput, J.P.; Zhang, K.; Lang, J.J.; McGrath, R.; Tomkinson, G.R.; Martínez-Vizcaíno, V.; et al. Clinical importance of simple muscular fitness tests to predict long-term health conditions: A systematic review and meta-analysis of 94 cohort studies. *Br. J. Sports Med.* **2026**, *60*, 465–483. [CrossRef] [PubMed]
60. Marx, W.; Lane, M.; Hockey, M.; Aslam, H.; Berk, M.; Walder, K.; Borsini, A.; Firth, J.; Pariante, C.M.; Berding, K.; et al. Diet and depression: Exploring the biological mechanisms of action. *Mol. Psychiatry* **2021**, *26*, 134–150. [CrossRef] [PubMed]
61. Das, S.K.; Vasudevan, D.M. Alcohol-induced oxidative stress. *Life Sci.* **2007**, *81*, 177–187. [CrossRef] [PubMed]
62. Ambade, A.; Mandrekar, P. Oxidative Stress and Inflammation: Essential Partners in Alcoholic Liver Disease. *Int. J. Hepatol.* **2012**, *2012*, 853175. [CrossRef] [PubMed]
63. Li, H.; Song, L.; Cen, M.; Fu, X.; Gao, X.; Zuo, Q.; Wu, J. Oxidative balance scores and depressive symptoms: Mediating effects of oxidative stress and inflammatory factors. *J. Affect. Disord.* **2023**, *334*, 205–212. [CrossRef] [PubMed]
64. Han, X.; Liu, Y.; Wei, Y.; Ma, L.; Lim, S.S.; Wang, Z. The mechanism of natural dietary polyphenols on inhibiting inflammation and modulating gut-brain axis: An effective way to prevent depression. *Agric. Prod. Process. Storage* **2026**, *2*, 16. [CrossRef]
65. Valdes, A.M.; Walter, J.; Segal, E.; Spector, T.D. Role of the gut microbiota in nutrition and health. *BMJ* **2018**, *361*, 36–44. [CrossRef] [PubMed]
66. Mann, E.R.; Lam, Y.K.; Uhlig, H.H. Short-chain fatty acids: Linking diet, the microbiome and immunity. *Nat. Rev. Immunol.* **2024**, *24*, 577–595. [CrossRef] [PubMed]
67. Tian, J.; Zhang, Y.; Zhao, X. The Effects and Mechanisms of n-3 and n-6 Polyunsaturated Fatty Acids in the Central Nervous System. *Cell. Mol. Neurobiol.* **2025**, *45*, 25. [CrossRef] [PubMed]
68. Bizzozero-Peroni, B.; Fernández-Rodríguez, R.; Martínez-Vizcaíno, V.; Garrido-Miguel, M.; Medrano, M.; Jiménez-López, E.; Mesas, A.E. Nut consumption is associated with a lower risk of depression in adults: A prospective analysis with data from the UK Biobank cohort. *Clin. Nutr.* **2023**, *42*, 1728–1736. [CrossRef] [PubMed]
69. Gibson-Smith, D.; Bot, M.; Brouwer, I.A.; Visser, M.; Giltay, E.J.; Penninx, B.W.J.H. Association of food groups with depression and anxiety disorders. *Eur. J. Nutr.* **2019**, *59*, 767. [CrossRef] [PubMed]
70. Tomás-Gallego, G.; Boraita, R.J.; Sierra, J.O.; Ibort, E.G.; Torres, J.M.D. Emotional and Behavioural Problems in Spanish University Students: Association with Lifestyle Habits and Mental Well-Being. *Healthcare* **2024**, *12*, 1482. [CrossRef] [PubMed]
71. Gardani, M.; Bradford, D.R.R.; Russell, K.; Allan, S.; Beattie, L.; Ellis, J.G.; Akran, U. A systematic review and meta-analysis of poor sleep, insomnia symptoms and stress in undergraduate students. *Sleep Med. Rev.* **2022**, *61*, 101565. [CrossRef] [PubMed]
72. Morais, L.H.; Schreiber, H.L.; Mazmanian, S.K. The gut microbiota-brain axis in behaviour and brain disorders. *Nat. Rev. Microbiol.* **2021**, *19*, 241–255. [CrossRef] [PubMed]
73. Aleksandrova, K.; Koelman, L.; Rodrigues, C.E. Dietary patterns and biomarkers of oxidative stress and inflammation: A systematic review of observational and intervention studies. *Redox Biol.* **2021**, *42*, 101869. [CrossRef] [PubMed]
74. Grune, T.; Berger, M.M. Markers of oxidative stress in ICU clinical settings: Present and future. *Curr. Opin. Clin. Nutr. Metab. Care* **2007**, *10*, 712–717. [CrossRef] [PubMed]
75. Ferriani, L.O.; Silva, D.A.; Molina Mdel, C.B.; Mill, J.G.; Brunoni, A.R.; da Fonseca Mde, J.M.; Moreno, A.B.; Benseñor, I.M.; Barbosa de Aguiar, O.; Barreto, S.M.; et al. Associations of depression and intake of antioxidants and vitamin B complex: Results of the Brazilian Longitudinal Study of Adult Health (ELSA-Brasil). *J. Affect. Disord.* **2022**, *297*, 259–268. [CrossRef] [PubMed]
76. Lane, M.M.; Gamage, E.; Du, S.; Ashtree, D.N.; McGuinness, A.J.; Gauci, S.; Baker, P.; Lawrence, M.; Rebholz, C.M.; Srour, B.; et al. Ultra-processed food exposure and adverse health outcomes: Umbrella review of epidemiological meta-analyses. *BMJ* **2024**, *384*, e077310. [CrossRef] [PubMed]

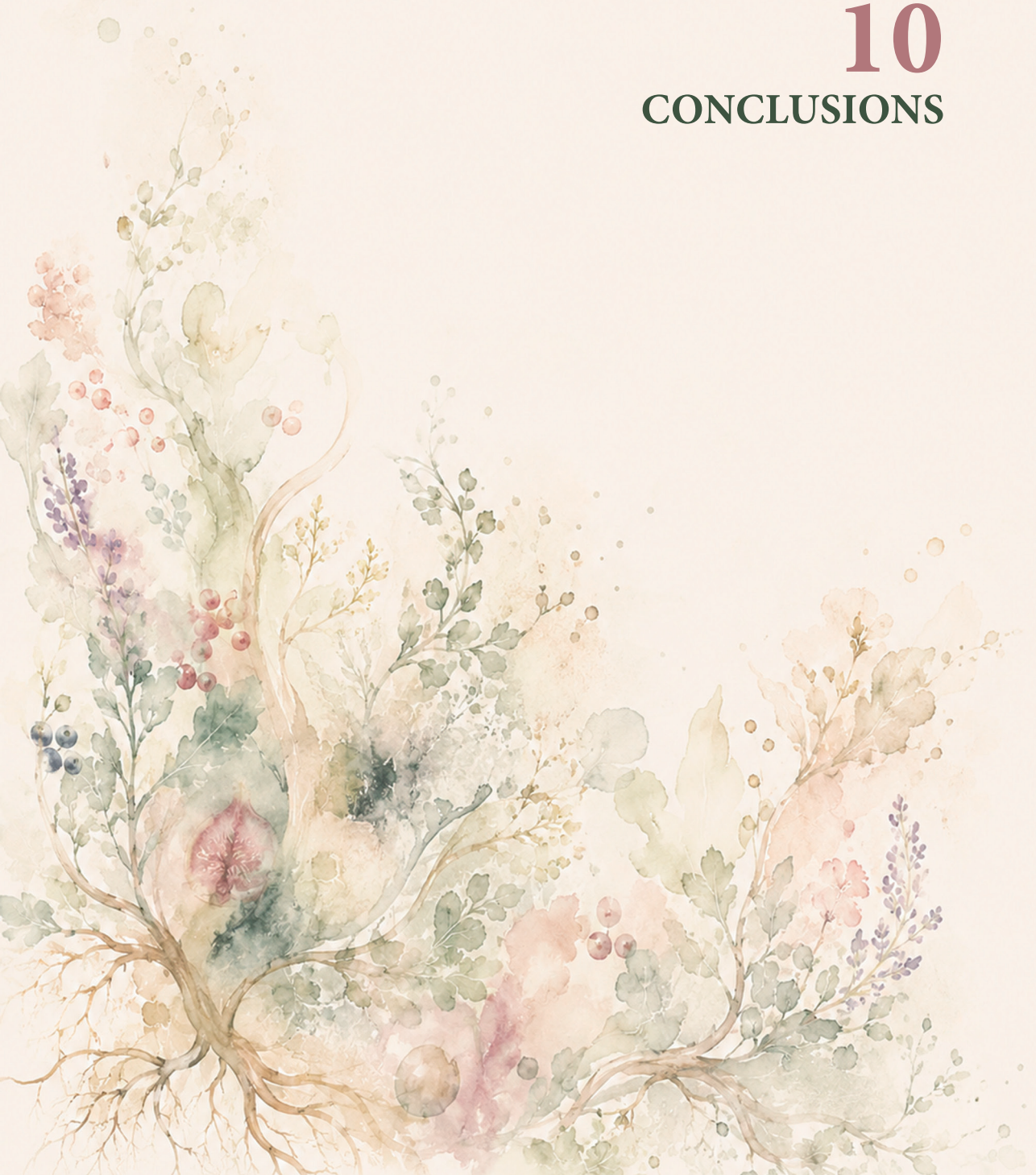
https://doi.org/10.3390/nu18122018

77. Bizzozero-Peroni, B.; Ortolá, R.; Martínez-Vizcaíno, V.; Rodríguez-Artalejo, F.; Fernández-Rodríguez, R.; Banegas, J.R.; Lopez-Garcia, E.; Mesas, A.E. Proinflammatory dietary pattern and depression risk in older adults: Prospective analyses from the Seniors-ENRICA studies. *Clin. Nutr.* **2022**, *41*, 2614–2620. [CrossRef] [PubMed]
78. Firth, J.; Marx, W.; Dash, S.; Carney, R.; Teasdale, S.B.; Solmi, M.; Stubbs, B.; Schuch, F.B.; Carvalho, A.F.; Jacka, F.; et al. The Effects of Dietary Improvement on Symptoms of Depression and Anxiety: A Meta-Analysis of Randomized Controlled Trials. *Psychosom. Med.* **2019**, *81*, 265. [CrossRef] [PubMed]

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10
CONCLUSIONS



MANUSCRIPT I

Cardiorespiratory fitness and risk of mental disorders and dementia: a systematic review and meta-analysis

Objective: Synthesize the available evidence from cohort studies on the associations between cardiorespiratory fitness levels and the risk of mental and neurocognitive disorders at all ages in the general population.

This systematic review and meta-analysis provide a comprehensive synthesis of the evidence on the associations between cardiorespiratory fitness and the incidence of mental and neurocognitive disorders in the general population across all age groups. The findings suggest that higher CRF is associated with lower risks of depression, dementia and psychotic disorders (male-only evidence) in adults. Cardiorespiratory fitness may be considered a candidate marker for risk stratification. However, additional cohort studies are needed to clarify its preventive potential, particularly for anxiety, depression and psychotic disorders, where evidence remains of very low certainty. Other mental disorders have only been examined in single studies, limiting the ability to draw firm conclusions. Evidence across specific age groups, including children, adolescents and older adults, should be examined for all mental disorders to ensure comprehensive coverage across the lifespan.

MANUSCRIPT II

The Associations Between Vegetarian and Vegan Diets and Orthorexia Nervosa Symptoms in Adults: A Systematic Review and Meta-Analysis

Objective: Synthesize the evidence on the associations of vegetarian and vegan diets with orthorexia nervosa symptoms compared with omnivorous diets in the adult population.

Young and middle-aged adults who follow vegetarian and vegan diets appear to exhibit more orthorexia nervosa symptoms than omnivores. However, these findings should be interpreted with caution because the current evidence is limited to cross-sectional studies, which preclude causal inference. Additionally, the studies are generally of low methodological quality. Future high-quality research should prioritize longitudinal designs, the use of standardized and validated assessment tools, and improved methodological rigor to better understand the nature and direction of the association between vegetarian and vegan diets and orthorexia nervosa symptomatology. This information could help identify individuals who could benefit from early screening and tailored interventions, particularly in clinical and nutritional counseling contexts.

MANUSCRIPT III

Are vegetarian and vegan diets associated with eating disorder symptoms? A systematic review and meta-analysis

Objective: To synthesize the evidence on the associations between vegetarian/vegan diets and eating disorder symptoms compared with omnivorous diets across the lifespan.

Across the available evidence, no significant differences in eating disorder symptoms were observed between individuals following vegetarian and vegan diets and those following omnivorous diets. These findings suggest that dietary patterns alone may not necessarily be associated with an increased risk of eating disorder. However, the results should be interpreted with caution given the substantial between- study heterogeneity and the exclusively cross-sectional nature of the available evidence, which precludes conclusions regarding causality and may affect the robustness of the findings. Moreover, the available evidence was predominantly derived from young and middle-aged adults, highlighting the need for additional research in adolescent and older populations. Future longitudinal studies across diverse geographical and cultural contexts—and reporting stratified analyses by age, sex, ethnicity/race, diet quality, flexibility, motivation, and duration of vegetarian and vegan diets adherence—are essential to clarify the directionality and underlying mechanisms of these associations. Such evidence could inform early screening and the development of personalized prevention strategies in public health and community settings.

MANUSCRIPT IV

Plant-Based Diet Indices and Depression in University Students: The Nuts4Brain-Z Study

Objective: To examine the associations between adherence to plant-based diets, differentiating between healthy and unhealthy patterns, and depression among Spanish university students.

Our findings suggest that university students with greater adherence to healthy plant-based diets were less likely to have mild-to-severe depression than those with lower adherence. In contrast, higher adherence to an unhealthy plant-based diet was associated with greater odds of mild-to-severe depression, although this association was attenuated after adjustment for lifestyle-related factors. These findings highlight the importance of plant food quality, rather than plant-based diets per se, in relation to depressive symptoms in young adults. However, given the cross-sectional design, reliance on self-reported data, and relatively small sample size, the results should be interpreted with caution. Future longitudinal studies using standardized definitions of plant-based diets and larger samples are needed to confirm these associations and better inform preventive strategies in young populations.

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CONCLUSIONES



MANUSCRITO I

Condición física cardiorrespiratoria y riesgo de trastornos mentales y demencia: una revisión sistemática y metaanálisis

Objetivo: Sintetizar la evidencia disponible procedente de estudios de cohortes sobre las asociaciones entre los niveles de condición física cardiorrespiratoria y el riesgo de trastornos mentales y neurocognitivos en la población general de todas las edades.

Esta revisión sistemática y metaanálisis proporciona una síntesis exhaustiva de la evidencia sobre las asociaciones entre la condición física cardiorrespiratoria y la incidencia de trastornos mentales y neurocognitivos en la población general a lo largo de todas las etapas de la vida. Los hallazgos sugieren que una mayor condición física cardiorrespiratoria se asocia con un menor riesgo de depresión, demencia y trastornos psicóticos (evidencia disponible únicamente en hombres) en adultos. La condición física cardiorrespiratoria podría considerarse un marcador potencial para la estratificación del riesgo. No obstante, son necesarios estudios de cohortes adicionales para esclarecer su potencial preventivo, especialmente en relación con la ansiedad, la depresión y los trastornos psicóticos, donde la evidencia continúa siendo de muy baja certeza. Otros trastornos mentales solo han sido evaluados en estudios aislados, lo que limita la posibilidad de extraer conclusiones sólidas. Asimismo, es necesario generar evidencia en grupos de edad específicos, incluidos niños, adolescentes y personas mayores, para garantizar una comprensión integral de estas asociaciones a lo largo del curso de vida.

MANUSCRITO II

Asociaciones entre las dietas vegetarianas y veganas y los síntomas de ortorexia nerviosa en adultos: una revisión sistemática y metaanálisis

Objetivo: Sintetizar la evidencia sobre las asociaciones entre las dietas vegetarianas y veganas y los síntomas de ortorexia nerviosa, en comparación con las dietas omnívoras, en la población adulta.

Los adultos jóvenes y de mediana edad que siguen dietas vegetarianas y veganas parecen presentar mayores niveles de síntomas de ortorexia nerviosa que los individuos con dietas omnívoras. Sin embargo, estos hallazgos deben interpretarse con cautela, ya que la evidencia disponible se limita a estudios transversales, lo que impide establecer relaciones causales. Además, los estudios presentan, en general, una baja calidad metodológica. Las futuras investigaciones de alta calidad deberían priorizar diseños longitudinales, el uso de instrumentos de evaluación estandarizados y validados, y un mayor rigor metodológico para comprender mejor la naturaleza y la dirección de la asociación entre las dietas vegetarianas y veganas y la sintomatología de ortorexia nerviosa. Esta información podría contribuir a identificar personas que podrían beneficiarse de un cribado precoz y de intervenciones individualizadas, especialmente en contextos clínicos y de asesoramiento nutricional.

MANUSCRITO III

¿Se asocian las dietas vegetarianas y veganas con los síntomas de trastornos de la conducta alimentaria? Una revisión sistemática y metaanálisis

Objetivo: Sintetizar la evidencia sobre las asociaciones entre las dietas vegetarianas y veganas y los síntomas de trastornos de la conducta alimentaria, en comparación con las dietas omnívoras, a lo largo del curso de vida.

La evidencia disponible no mostró diferencias significativas en los síntomas de trastornos de la conducta alimentaria entre las personas que seguían dietas vegetarianas y veganas y aquellas con dietas omnívoras. Estos hallazgos sugieren que los patrones dietéticos, por sí solos, no estarían necesariamente asociados con un mayor riesgo de trastornos de la conducta alimentaria. No obstante, los resultados deben interpretarse con cautela debido a la elevada heterogeneidad entre estudios y al carácter exclusivamente transversal de la evidencia disponible, lo que impide establecer relaciones causales y puede afectar a la solidez de los hallazgos. Además, la evidencia procede mayoritariamente de adultos jóvenes y de mediana edad, lo que pone de manifiesto la necesidad de realizar investigaciones adicionales en poblaciones adolescentes y de personas mayores. Futuros estudios longitudinales realizados en diversos contextos geográficos y culturales, que además informen análisis estratificados por edad, sexo, etnia/raza, calidad de la dieta, grado de flexibilidad, motivación y duración de la adherencia a las dietas vegetarianas y veganas, serán fundamentales para esclarecer la direccionalidad y los mecanismos subyacentes de estas asociaciones. Esta evidencia podría contribuir al desarrollo de estrategias de cribado precoz y de prevención personalizada en el ámbito de la salud pública y comunitaria.

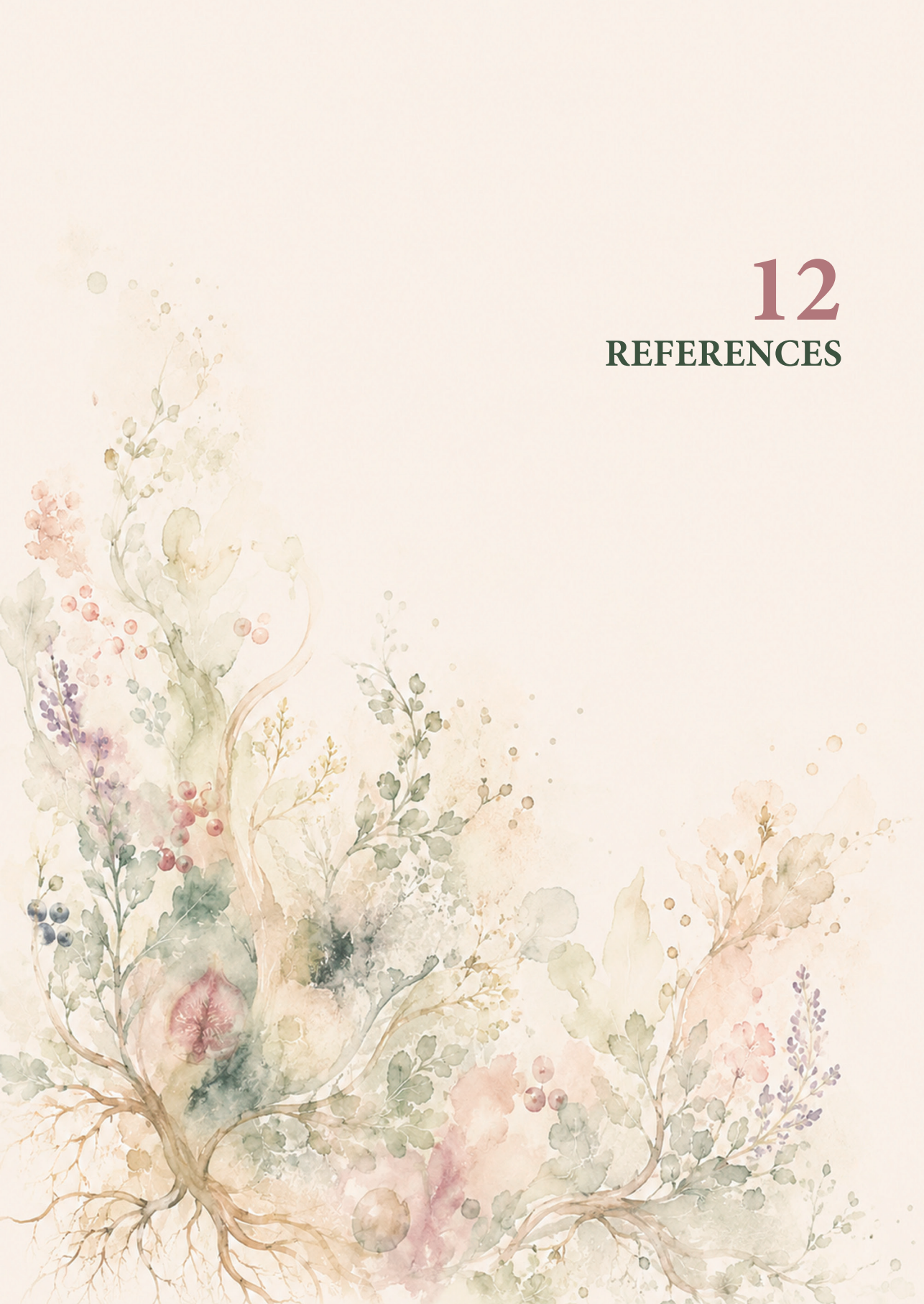
MANUSCRITO IV

Índices de dietas basadas en plantas y depresión en estudiantes universitarios: el estudio Nuts4Brain-Z

Objetivo: Examinar las asociaciones entre la adherencia a dietas basadas en plantas, diferenciando entre patrones saludables y no saludables, y la depresión en estudiantes universitarios españoles.

Nuestros hallazgos sugieren que los estudiantes universitarios con una mayor adherencia a dietas saludables basadas en plantas presentaban una menor probabilidad de padecer depresión leve a grave en comparación con aquellos con menor adherencia. Por el contrario, una mayor adherencia a una dieta poco saludable basada en plantas se asoció con una mayor probabilidad de depresión leve a grave, aunque esta asociación se atenuó tras ajustar por factores relacionados con el estilo de vida. Estos resultados ponen de manifiesto la importancia de la calidad de los alimentos de origen vegetal, más que de las dietas basadas en plantas en sí mismas, en relación con los síntomas depresivos en adultos jóvenes. No obstante, dado el diseño transversal del estudio, el uso de datos auto informados y el tamaño relativamente reducido de la muestra, los resultados deben interpretarse con cautela. Son necesarios estudios longitudinales futuros que empleen definiciones estandarizadas de las dietas basadas en plantas y muestras de mayor tamaño para confirmar estas asociaciones y contribuir al desarrollo de estrategias preventivas dirigidas a la población joven.

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REFERENCES



1. World Health Organization (WHO). Mental Health. Available from: https://www.who.int/es/news-room/fact-sheets/detail/mental-health-strengthening-our-response

2. GBD 2023 Mental Disorder Collaborators. Updated trends in the global prevalence and burden of mental disorders, 1990-2023: a systematic analysis for the Global Burden of Disease Study 2023. Lancet. 2026;407:2040–64. doi:10.1016/S0140-6736(26)00519-2

3. Arias D, Saxena S, Verguet S. Quantifying the global burden of mental disorders and their economic value. EClinicalMedicine. 2022;54:101675. doi:10.1016/J.ECLINM.2022.101675

4. Jones KC. Update on Major Neurocognitive Disorders. Focus (Madison). 2021;19:271–81. doi:10.1176/APPI.FOCUS.20210004

5. Nichols E, Steinmetz JD, Vollset SE, Fukutaki K, Chalek J, Abd-Allah F, et al. Estimation of the global prevalence of dementia in 2019 and forecasted prevalence in 2050: an analysis for the Global Burden of Disease Study 2019. Lancet Public Health. 2022;7:e105–25. doi:10.1016/S2468-2667(21)00249-8

6. McDonald WM. Overview of Neurocognitive Disorders. Focus (Madison). 2017;15:4–12. doi:10.1176/APPI.FOCUS.20160030

7. Diagnostic and Statistical Manual of Mental Disorders 5th edn, Revision DSM-5-TR (American Psychiatric Publishing, 2022). 2022.

8. McGrath JJ, Al-Hamzawi A, Alonso J, Altwaijri Y, Andrade LH, Bromet EJ, et al. Age of onset and cumulative risk of mental disorders: a cross-national analysis of population surveys from 29 countries. Lancet Psychiatry. 2023;10:668–81. doi:10.1016/S2215-0366(23)00193-1

9. Solmi M, Radua J, Olivola M, Croce E, Soardo L, Salazar de Pablo G, et al. Age at onset of mental disorders worldwide: large-scale meta-analysis of 192 epidemiological studies. Molecular Psychiatry 2021 27:1. 2021;27:281–95. doi:10.1038/s41380-021-01161-7

10. Lee J, Barnett P, Goldsmith LP, Yang J, Appleton R, Lloyd-Evans B, et al. Early interventions for first onset of symptoms of mental health conditions: an umbrella

review of systematic reviews. BMC Med. 2026;24:116. doi:10.1186/S12916-026-04617-1

11. Fan Y, Fan A, Yang Z, Fan D. Global burden of mental disorders in 204 countries and territories, 1990–2021: results from the global burden of disease study 2021. BMC Psychiatry. 2025;25:486. doi:10.1186/S12888-025-06932-Y

12. World Health Organization (WHO). Depressive Disorder (Depression). Available from: https://www.who.int/news-room/fact-sheets/detail/depression

13. Arias-de la Torre J, Vilagut G, Ronaldson A, Bakolis I, Dregan A, Martín V, et al. Prevalence and variability of depressive symptoms in Europe: update using representative data from the second and third waves of the European Health Interview Survey (EHIS-2 and EHIS-3). Lancet Public Health. 2023;8:e889–98. doi:10.1016/S2468-2667(23)00220-7

14. Cuijpers P, De Graaf R, Van Dorsselaer S. Minor depression: risk profiles, functional disability, health care use and risk of developing major depression. J Affect Disord. 2004;79:71–9. doi:10.1016/S0165-0327(02)00348-8

15. Goldney RD, Fisher LJ, Dal Grande E, Taylor AW. Subsyndromal depression: Prevalence, use of health services and quality of life in an Australian population. Soc Psychiatry Psychiatr Epidemiol. 2004;39:293–8. doi:10.1007/S00127-004-0745-5/METRICS

16. Kessler RC, Birnbaum H, Bromet E, Hwang I, Sampson N, Shahly V. Age Differences in Major depression: Results from the National Comorbidity Surveys Replication (NCS-R). Psychol Med. 2009;40:225. doi:10.1017/S0033291709990213

17. Sutin AR, Terracciano A, Milaneschi Y, An Y, Ferrucci L, Zonderman AB. The Trajectory of Depressive Symptoms Across the Adult Life Span. JAMA Psychiatry. 2013;70:803–11. doi:10.1001/JAMAPSYCHIATRY.2013.193

18. Goodwin RD, Dierker LC, Wu M, Galea S, Hoven CW, Weinberger AH. Trends in U.S. Depression Prevalence From 2015 to 2020: The Widening Treatment Gap. Am J Prev Med. 2022;63:726–33. doi:10.1016/j.amepre.2022.05.014

19. Kranjac AW, Kranjac D, Chung V. Temporal and generational changes in depression among young American adults. J Affect Disord Rep. 2025;21:100949. doi:10.1016/J.JADR.2025.100949

20. Liu Z, Kuai M. The global burden of depression in adolescents and young adults, 1990–2021: systematic analysis of the global burden of disease study. BMC Psychiatry. 2025;25:767. doi:10.1186/S12888-025-07201-8

21. Wood D, Crapnell T, Lau L, Bennett A, Lotstein D, Ferris M, et al. Emerging adulthood as a critical stage in the life course. Handbook of Life Course Health Development. 2017;123–43. doi:10.1007/978-3-319-47143-3_7/FIGURES/1

22. Patton GC, Sawyer SM, Santelli JS, Ross DA, Afifi R, Allen NB, et al. Our future: a Lancet commission on adolescent health and wellbeing. The Lancet. 2016;387:2423–78. doi:10.1016/S0140-6736(16)00579-1

23. Thapar A, Eyre O, Patel V, Brent D. Depression in young people. The Lancet. 2022;400:617–31. doi:10.1016/S0140-6736(22)01012-1

24. Clayborne ZM, Varin M, Colman I. Systematic Review and Meta-Analysis: Adolescent Depression and Long-Term Psychosocial Outcomes. J Am Acad Child Adolesc Psychiatry. 2019;58:72–9. doi:10.1016/J.JAAC.2018.07.896

25. Greden JF. The burden of recurrent depression: causes, consequences, and future prospects. J Clin Psychiatry. 2001;62 Suppl 22:5–9.

26. Sachdev PS, Blacker D, Blazer DG, Ganguli M, Jeste D V., Paulsen JS, et al. Classifying neurocognitive disorders: the DSM-5 approach. Nat Rev Neurol. 2014;10:634–42. doi:10.1038/NRNEUROL.2014.181

27. Cheng ST. Cognitive Reserve and the Prevention of Dementia: the Role of Physical and Cognitive Activities. Curr Psychiatry Rep. 2016;18:85-. doi:10.1007/S11920-016-0721-2/METRICS

28. Loeffler DA. Modifiable, Non-Modifiable, and Clinical Factors Associated with Progression of Alzheimer's Disease. Journal of Alzheimer's Disease. 2021;80:1–27. doi:10.3233/JAD-201182

29. Tsiakiri A, Bakirtzis C, Plakias S, Vlotinou P, Vadikolias K, Terzoudi A, et al. Predictive Models for the Transition from Mild Neurocognitive Disorder to Major Neurocognitive Disorder: Insights from Clinical, Demographic, and Neuropsychological Data. Biomedicines. 2024;12. doi:10.3390/BIOMEDICINES12061232

30. Stephan BCM, Cochrane L, Kafadar AH, Brain J, Burton E, Myers B, et al. Population attributable fractions of modifiable risk factors for dementia: a systematic review and meta-analysis. Lancet Healthy Longev. 2024;5:e406–21. doi:10.1016/S2666-7568(24)00061-8

31. Livingston G, Huntley J, Liu KY, Costafreda SG, Selbæk G, Alladi S, et al. Dementia prevention, intervention, and care: 2024 report of the Lancet standing Commission. The Lancet. 2024;404:572–628. doi:10.1016/S0140-6736(24)01296-0

32. Arcelus J, Mitchell AJ, Wales J, Nielsen S. Mortality Rates in Patients With Anorexia Nervosa and Other Eating Disorders: A Meta-analysis of 36 Studies. Arch Gen Psychiatry. 2011;68:724–31. doi:10.1001/ARCHGENPSYCHIATRY.2011.74

33. Rikani AA, Choudhry Z, Choudhry AM, Ikram H, Asghar MW, Kajal D, et al. A critique of the literature on etiology of eating disorders. Ann Neurosci. 2013;20:157–61. doi:10.5214/ANS.0972.7531.200409

34. Keski-Rahkonen A. Eating disorders: etiology, risk factors, and suggestions for prevention. Curr Opin Psychiatry. 2024;37:381–7. doi:10.1097/YCO.0000000000000965

35. Weissman RS. The Role of Sociocultural Factors in the Etiology of Eating Disorders. Psychiatric Clinics of North America. 2019;42:121–44. doi:10.1016/j.psc.2018.10.009

36. Lipson SK, Sonneville KR. Eating disorder symptoms among undergraduate and graduate students at 12 U.S. colleges and universities. Eat Behav. 2017;24:81–8. doi:10.1016/j.eatbeh.2016.12.003

37. Vall E, Wade TD. Predictors of treatment outcome in individuals with eating disorders: A systematic review and meta-analysis. Int J Eat Disord. 2015;48:946–71. doi:10.1002/EAT.22411

38. Olatunji BO, Levinson C, Calebs B. A network analysis of eating disorder symptoms and characteristics in an inpatient sample. Psychiatry Res. 2018;262:270–81. doi:10.1016/j.psychres.2018.02.027

39. Ward ZJ, Rodriguez P, Wright DR, Austin SB, Long MW. Estimation of Eating Disorders Prevalence by Age and Associations With Mortality in a Simulated Nationally Representative US Cohort. JAMA Netw Open. 2019;2:e1912925–e1912925. doi:10.1001/JAMANETWORKOPEN.2019.12925

40. Santomauro DF, Melen S, Mitchison D, Vos T, Whiteford H, Ferrari AJ. The hidden burden of eating disorders: an extension of estimates from the Global Burden of Disease Study 2019. Lancet Psychiatry. 2021;8:320–8. doi:10.1016/S2215-0366(21)00040-7

41. Filipponi C, Visentini C, Filippini T, Cutino A, Ferri P, Rovesti S, et al. The Follow-Up of Eating Disorders from Adolescence to Early Adulthood: A Systematic Review. International Journal of Environmental Research and Public Health 2022, Vol 19,. 2022;19. doi:10.3390/IJERPH192316237

42. Xu Y, Yin C, Jia H, Li X, Zhao S, Lv Y, et al. Global, regional, and national burdens of eating disorders in adolescents and young adults aged 10–24 years from 1990 to 2021, with projections to 2040. J Affect Disord. 2025;389:119680. doi:10.1016/J.JAD.2025.119680

43. Horovitz O, Argyrides M. Orthorexia and Orthorexia Nervosa: A Comprehensive Examination of Prevalence, Risk Factors, Diagnosis, and Treatment. Nutrients. 2023;15:3851. doi:10.3390/NU15173851

44. Health Food: Health Food Junkies: Orthorexia Nervosa: Overcoming the Obsession With Healthful Eating. JAMA. 2001;285:2255–6. doi:10.1001/JAMA.285.17.2255-JBK0502-2-1

45. Mateo-Martínez G, Vázquez-Sellán A, Díaz-Martínez ML, Sellán-Soto MC. Orthorexia nervosa: Healthy habit or pathology? Experiences and expansion of the consciousness of the correct diet. Heliyon. 2025;11:e42254. doi:10.1016/j.heliyon.2025.e42254

46. Bratman S. Orthorexia vs. theories of healthy eating. Eating and Weight Disorders - Studies on Anorexia, Bulimia and Obesity 2017 22:3. 2017;22:381–5. doi:10.1007/S40519-017-0417-6

47. Koven NS, Senbonmatsu R. A neuropsychological evaluation of orthorexia nervosa. Open J Psychiatr. 2013;03:214–22. doi:10.4236/OJPSYCH.2013.32019

48. López-Gil JF, Tárraga-López PJ, Hershey MS, López-Bueno R, Gutiérrez-Espinoza H, Soler-Marín A, et al. Overall proportion of orthorexia nervosa symptoms: A systematic review and meta-analysis including 30 476 individuals from 18 countries. J Glob Health. 2023;13:04087. doi:10.7189/JOGH.13.04087

49. Moccia L, Anesini MB, Callovini T, Janiri D, Policola C, Cintoni M, et al. Understanding Orthorexia Nervosa: A Systematic Review of Meta-analytical Findings. Curr Nutr Rep. 2025;14. doi:10.1007/S13668-025-00714-4

50. Varga M, Dukay-Szabó S, Túry F, Van Furth Eric F. Evidence and gaps in the literature on orthorexia nervosa. Eat Weight Disord. 2013;18:103–11. doi:10.1007/S40519-013-0026-Y

51. Barrada JR, Meule A. Orthorexia nervosa: Research based on invalid measures is invalid. J Glob Health. 2024;14:03007. doi:10.7189/JOGH.14.03007

52. Fidan T, Ertekin V, Işikay S, Kirpinar I. Prevalence of orthorexia among medical students in Erzurum, Turkey. Compr Psychiatry. 2010;51:49–54. doi:10.1016/j.comppsych.2009.03.001

53. Atchison AE, Zickgraf HF. Orthorexia nervosa and eating disorder behaviors: A systematic review of the literature. Appetite. 2022;177. doi:10.1016/j.appet.2022.106134

54. Melnychuk M, Zhylin M, Makarchuk N, Sakharova K, Shven Y. The Influence of Genetic Markers on the Development of Mental Disorders: A Systematic Review of Studies. Journal of Pioneering Medical Sciences. 2024;13:30–7. doi:10.61091/JPMS202413306

55. Hyman SE. The genetics of mental illness: implications for practice. Bull World Health Organ. 2000;78:455.

56. Li R, Li R, Xie J, Chen J, Liu S, Pan A, et al. Associations of socioeconomic status and healthy lifestyle with incident early-onset and late-onset dementia: a prospective cohort study. Lancet Healthy Longev. 2023;4:e693–702. doi:10.1016/S2666-7568(23)00211-8

57. Chen Z, Wang X, Teng Z, Liu M, Liu F, Huang J, et al. Modifiable lifestyle factors influencing psychiatric disorders mediated by plasma proteins: A systemic Mendelian randomization study. J Affect Disord. 2024;350:582–9. doi:10.1016/J.JAD.2024.01.169

58. Dong Y, Zhang P, Zhong J, Wang J, Xu Y, Huang H, et al. Modifiable lifestyle factors influencing neurological and psychiatric disorders mediated by structural brain reserve: An observational and Mendelian randomization study. J Affect Disord. 2025;372:440–50. doi:10.1016/J.JAD.2024.12.038

59. Gibala MJ, Little JP. Physiological basis of brief vigorous exercise to improve health. Journal of Physiology. 2020;598:61–9. doi:10.1113/JP276849

60. Garber CE, Blissmer B, Deschenes MR, Franklin BA, Lamonte MJ, Lee IM, et al. American College of Sports Medicine position stand. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. Med Sci Sports Exerc. 2011;43:1334–59. doi:10.1249/MSS.0B013E318213FEFB

61. Caspersen C, Powell K, Gregory C. Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. Public Health Reports. 1985;100:126.

62. Arena R, Myers J, Williams MA, Gulati M, Kligfield P, Balady GJ, et al. Assessment of functional capacity in clinical and research settings: A scientific statement from the American Heart Association committee on exercise, rehabilitation, and prevention of the council on clinical cardiology and the council on cardiovascular …. Circulation. 2007;116:329–43. doi:10.1161/CIRCULATIONAHA.106.184461

63. Pettee Gabriel K, Jaeger BC, Lewis CE, Sidney S, Dooley EE, Carnethon MR, et al. Analysis of Cardiorespiratory Fitness in Early Adulthood and Midlife With All-Cause Mortality and Fatal or Nonfatal Cardiovascular Disease. JAMA Netw Open. 2023;6. doi:10.1001/JAMANETWORKOPEN.2023.0842

64. Kodama S, Saito K, Tanaka S, Maki M, Yachi Y, Asumi M, et al. Cardiorespiratory fitness as a quantitative predictor of all-cause mortality and cardiovascular events in healthy men and women: a meta-analysis. JAMA. 2009;301:2024–35. doi:10.1001/JAMA.2009.681

65. Tarp J, Støle AP, Blond K, Grøntved A. Cardiorespiratory fitness, muscular strength and risk of type 2 diabetes: a systematic review and meta-analysis. Diabetologia. 2019;62:1129–42. doi:10.1007/S00125-019-4867-4

66. Schmid D, Leitzmann MF. Cardiorespiratory fitness as predictor of cancer mortality: A systematic review and meta-analysis. Annals of Oncology. 2015;26:272–8. doi:10.1093/annonc/mdu250

67. Lang JJ, Prince SA, Merucci K, Cadenas-Sanchez C, Chaput JP, Fraser BJ, et al. Cardiorespiratory fitness is a strong and consistent predictor of morbidity and mortality among adults: an overview of meta-analyses representing over 20.9 million observations from 199 unique cohort studies. Br J Sports Med. 2024;58:556–66. doi:10.1136/BJSPORTS-2023-107849

68. Xu L, Wang S, Maimaitiyiming M, Yang W, Sakakibara S, Qi X, et al. Cardiorespiratory Fitness, Multimorbidity Risk, and 15-Year Trajectories in Chronic Disease Accumulation: A Prospective Longitudinal Study. JACC: Advances. 2025;4:102198. doi:10.1016/J.JACADV.2025.102198

69. Tomkinson GR, Lang JJ, Tremblay MS. Temporal trends in the cardiorespiratory fitness of children and adolescents representing 19 high-income and upper middle-income countries between 1981 and 2014. Br J Sports Med. 2019;53:478–86. doi:10.1136/BJSPORTS-2017-097982

70. Bouchard C, Warwick Daw E, Rice T, Pérusse L, Gagnon J, Province MA, et al. Familial resemblance for VO2max in the sedentary state: the HERITAGE family study. Med Sci Sports Exerc. 1998;30:252–8. doi:10.1097/00005768-199802000-00013

71. Øvretveit K, Klevjer M, Brumpton BM, Wisløff U, Hveem K, Bye A. Polygenic prediction of cardiorespiratory fitness in the Trøndelag health study (HUNT). Scientific Reports 2025 16:1. 2025;16:184-. doi:10.1038/s41598-025-28894-7

72. Myers J, Kokkinos P, Arena R, LaMonte MJ. The impact of moving more, physical activity, and cardiorespiratory fitness: Why we should strive to measure and improve fitness. Prog Cardiovasc Dis. 2021;64:77–82. doi:10.1016/j.pcad.2020.11.003

73. LaMonte MJ, Blair SN. Physical activity, cardiorespiratory fitness, and adiposity: Contributions to disease risk. Curr Opin Clin Nutr Metab Care. 2006;9:540–6. doi:10.1097/01.MCO.0000241662.92642.08

74. Raghuveer G, Hartz J, Lubans DR, Takken T, Wiltz JL, Mietus-Snyder M, et al. Cardiorespiratory Fitness in Youth: An Important Marker of Health: A Scientific Statement From the American Heart Association. Circulation. 2020;142:E101–18. doi:10.1161/CIR.0000000000000866

75. Zeiher J, Ombrellaro KJ, Perumal N, Keil T, Mensink GBM, Finger JD. Correlates and Determinants of Cardiorespiratory Fitness in Adults: a Systematic Review. Sports Medicine - Open 2019 5:1. 2019;5:39-. doi:10.1186/S40798-019-0211-2

76. Bonikowske AR, Taylor JL, Larson KF, Hardwick J, Ozemek C, Harber MP, et al. Evaluating current assessment techniques of cardiorespiratory fitness. Expert Rev Cardiovasc Ther. 2024;22:231–41. doi:10.1080/14779072.2024.2363393

77. Armstrong N, Welsman JO. Traditional and New Perspectives on Youth Cardiorespiratory Fitness. Med Sci Sports Exerc. 2020;52:2563–73. doi:10.1249/MSS.0000000000002418

78. Gabriel KP, Jaeger BC, Sternfeld B, Dooley EE, Carnethon MR, Jacobs DR, et al. Factors Associated with Age-Related Declines in Cardiorespiratory Fitness from Early Adulthood Through Midlife: CARDIA. Med Sci Sports Exerc. 2022;54:1147–54. doi:10.1249/MSS.0000000000002893

79. García-Hermoso A, Ramírez-Campillo R, Izquierdo M. Is Muscular Fitness Associated with Future Health Benefits in Children and Adolescents? A Systematic Review and Meta-Analysis of Longitudinal Studies. Sports Med. 2019;49:1079–94. doi:10.1007/S40279-019-01098-6

80. Folkins CH, Sime WE. Physical fitness training and mental health. American Psychologist. 1981;36:373–89. doi:10.1037/0003-066X.36.4.373

81. Kandola A, Ashdown-Franks G, Stubbs B, Osborn DPJ, Hayes JF. The association between cardiorespiratory fitness and the incidence of common mental health disorders: A systematic review and meta-analysis. J Affect Disord. 2019;257:748. doi:10.1016/J.JAD.2019.07.088

82. Lee J. Influence of Cardiorespiratory Fitness on Risk of Dementia and Dementia Mortality: A Systematic Review and Meta-Analysis of Prospective Cohort Studies. J Aging Phys Act. 2021;29:878–85. doi:10.1123/JAPA.2019-0493

83. Alves Donato AN, Waclawovsky AJ, Tonello L, Firth J, Smith L, Stubbs B, et al. Association between cardiorespiratory fitness and depressive symptoms in children and adolescents: A systematic review and meta-analysis. J Affect Disord. 2021;282:1234–40. doi:10.1016/J.JAD.2021.01.032

84. Papasavvas T, Bonow RO, Alhashemi M, Micklewright D. Depression Symptom Severity and Cardiorespiratory Fitness in Healthy and Depressed Adults: A Systematic Review and Meta-Analysis. Sports Medicine 2015 46:2. 2015;46:219–30. doi:10.1007/S40279-015-0409-5

85. Schuch FB, Vancampfort D, Sui X, Rosenbaum S, Firth J, Richards J, et al. Are lower levels of cardiorespiratory fitness associated with incident depression? A systematic review of prospective cohort studies. Prev Med (Baltim). 2016;93:159–65. doi:10.1016/j.ypmed.2016.10.011

86. Wiklund CA, Lindwall M, Ekblom Ö, Nyberg J, Åberg MI, Paulsson S, et al. Change in Cardiorespiratory Fitness and Risk of Depression, Anxiety, and Cerebrovascular Disease. Am J Prev Med. 2024;67:849–58. doi:10.1016/j.amepre.2024.07.012

87. Chiang HL, Chuang YF, Chen YA, Hsu C Te, Ho CC, Hsu HT, et al. Physical Fitness and Risk of Mental Disorders in Children and Adolescents. JAMA Pediatr. 2024;178:595–607. doi:10.1001/JAMAPEDIATRICS.2024.0806

88. Hörder H, Johansson L, Guo X, Grimby G, Kern S, Östling S, et al. Midlife cardiovascular fitness and dementia: A 44-year longitudinal population study in women. Neurology. 2018;90:e1298–305. doi:10.1212/WNL.0000000000005290

89. Tari AR, Walker TL, Huuha AM, Sando SB, Wisloff U. Neuroprotective mechanisms of exercise and the importance of fitness for healthy brain ageing. The Lancet. 2025;405:1093–118. doi:10.1016/S0140-6736(25)00184-9

90. Kandola A, Hendrikse J, Lucassen PJ, Yücel M. Aerobic Exercise as a Tool to Improve Hippocampal Plasticity and Function in Humans: Practical Implications for Mental Health Treatment. Front Hum Neurosci. 2016;10. doi:10.3389/FNHUM.2016.00373

91. Smith PJ, Merwin RM. The Role of Exercise in Management of Mental Health Disorders: An Integrative Review. Annu Rev Med. 2021;72:45–62. doi:10.1146/ANNUREV-MED-060619-022943

92. Hird EJ, Slanina-Davies A, Lewis G, Hamer M, Roiser JP. From movement to motivation: a proposed framework to understand the antidepressant effect of exercise. Transl Psychiatry. 2024;14. doi:10.1038/S41398-024-02922-Y

93. P S, Vellapandian C. Hypothalamic-Pituitary-Adrenal (HPA) Axis: Unveiling the Potential Mechanisms Involved in Stress-Induced Alzheimer's Disease and Depression. Cureus. 2024;16:e67595. doi:10.7759/CUREUS.67595

94. Misiak B, Łoniewski I, Marlicz W, Frydecka D, Szulc A, Rudzki L, et al. The HPA axis dysregulation in severe mental illness: Can we shift the blame to gut microbiota? Prog Neuropsychopharmacol Biol Psychiatry. 2020;102:109951. doi:10.1016/J.PNPBP.2020.109951

95. Duclos M, Tabarin A. Exercise and the Hypothalamo-Pituitary-Adrenal Axis. Front Horm Res. 2016;47:12–26. doi:10.1159/000445149

96. Kandola A, Ashdown-Franks G, Hendrikse J, Sabiston CM, Stubbs B. Physical activity and depression: Towards understanding the antidepressant mechanisms of physical activity. Neurosci Biobehav Rev. 2019;107:525–39. doi:10.1016/J.NEUBIOREV.2019.09.040

97. Leitzmann C. Vegetarian nutrition: past, present, future. Am J Clin Nutr. 2014;100:496S-502S. doi:10.3945/AJCN.113.071365

98. Cramer H, Kessler CS, Sundberg T, Leach MJ, Schumann D, Adams J, et al. Characteristics of Americans Choosing Vegetarian and Vegan Diets for Health Reasons. J Nutr Educ Behav. 2017;49:561-567.e1. doi:10.1016/j.jneb.2017.04.011

99. Ruby MB. Vegetarianism. A blossoming field of study. Appetite. 2012;58:141–50. doi:10.1016/J.APPET.2011.09.019

100. Müssig M, Pfeiler TM, Egloff B. Why They Eat What They Eat: Comparing 18 Eating Motives Among Omnivores and Veg*ns. Front Nutr. 2022;9:780614. doi:10.3389/FNUT.2022.780614/FULL

101. Hopwood CJ, Rosenfeld D, Chen S, Bleidorn W. An investigation of plant-based dietary motives among vegetarians and omnivores. Collabra Psychol. 2021;7. doi:10.1525/COLLABRA.19010

102. Nelson ME, Hamm MW, Hu FB, Abrams SA, Griffin TS. Alignment of healthy dietary patterns and environmental sustainability: A systematic review. Advances in Nutrition. 2016;7:1005–25. doi:10.3945/an.116.012567

103. Scarborough P, Clark M, Cobiac L, Papier K, Knuppel A, Lynch J, et al. Vegans, vegetarians, fish-eaters and meat-eaters in the UK show discrepant environmental impacts. Nature Food 2023 4:7. 2023;4:565–74. doi:10.1038/s43016-023-00795-w

104. Storz MA. Will the plant-based movement redefine physicians' understanding of chronic disease? The New Bioethics. 2020;26:141–57. doi:10.1080/20502877.2020.1767921

105. Medawar E, Huhn S, Villringer A, Veronica Witte A. The effects of plant-based diets on the body and the brain: a systematic review. Transl Psychiatry. 2019;9:226. doi:10.1038/S41398-019-0552-0

106. Storz MA. What makes a plant-based diet? a review of current concepts and proposal for a standardized plant-based dietary intervention checklist. European Journal of Clinical Nutrition 2021 76:6. 2021;76:789–800. doi:10.1038/S41430-021-01023-Z

107. Hargreaves SM, Rosenfeld DL, Moreira AVB, Zandonadi RP. Plant-based and vegetarian diets: an overview and definition of these dietary patterns. Eur J Nutr. 2023;62:1109–21. doi:10.1007/S00394-023-03086-Z

108. Kent G, Kehoe L, Flynn A, Walton J. Plant-based diets: a review of the definitions and nutritional role in the adult diet. Proceedings of the Nutrition Society. 2022;81:62–74. doi:10.1017/S0029665121003839

109. Landry MJ, Ward CP. Health Benefits of a Plant-Based Dietary Pattern and Implementation in Healthcare and Clinical Practice. Am J Lifestyle Med. 2024;18:657. doi:10.1177/15598276241237766

110. Oussalah A, Levy J, Berthezène C, Alpers DH, Guéant JL. Health outcomes associated with vegetarian diets: An umbrella review of systematic reviews and meta-analyses. Clinical Nutrition. 2020;39:3283–307. doi:10.1016/j.clnu.2020.02.037

111. Jaiswal A, Shrivastava T. The Ethics of Veganism. Cureus. 2024;16:e56214. doi:10.7759/CUREUS.56214

112. Selinger E, Neuenschwander M, Koller A, Gojda J, Kühn T, Schwingshackl L, et al. Evidence of a vegan diet for health benefits and risks – an umbrella review of meta-analyses of observational and clinical studies. Crit Rev Food Sci Nutr. 2023;63:9926–36. doi:10.1080/10408398.2022.2075311

113. Mota-Roja D, Whittaker AL, De La Vega LT, Ghezzi M, Lezama-Garcí K, Domínguez-Oliv A, et al. Veganism and animal welfare, scientific, ethical, and philosophical arguments. Journal of Animal Behaviour and Biometeorology. 2023;11:2023015–2023015. doi:10.31893/JABB.23015

114. Zhang QS, Tian FW, Zhao JX, Zhang H, Zhai QX, Chen W. The influence of dietary patterns on gut microbiome and its consequences for nonalcoholic fatty liver disease. Trends Food Sci Technol. 2020;96:135–44. doi:10.1016/J.TIFS.2019.12.013

115. Forestell CA, Spaeth AM, Kane SA. To eat or not to eat red meat. A closer look at the relationship between restrained eating and vegetarianism in college females. Appetite. 2012;58:319–25. doi:10.1016/j.appet.2011.10.015

116. Craig WJ, Mangels AR, Fresán U, Marsh K, Miles FL, Saunders A V., et al. The Safe and Effective Use of Plant-Based Diets with Guidelines for Health Professionals. Nutrients. 2021;13:4144. doi:10.3390/NU13114144

117. Willett W, Rockström J, Loken B, Springmann M, Lang T, Vermeulen S, et al. Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. The Lancet. 2019;393:447–92. doi:10.1016/S0140-6736(18)31788-4

118. Orlich MJ, Singh PN, Sabaté J, Jaceldo-Siegl K, Fan J, Knutsen S, et al. Vegetarian Dietary Patterns and Mortality in Adventist Health Study 2. JAMA Intern Med. 2013;173:1230. doi:10.1001/JAMAINTERNMED.2013.6473

119. Capodici A, Mocciaro G, Gori D, Landry MJ, Masini A, Sanmarchi F, et al. Cardiovascular health and cancer risk associated with plant based diets: An umbrella review. PLoS One. 2024;19. doi:10.1371/JOURNAL.PONE.0300711

120. Fraser GE. Associations between diet and cancer, ischemic heart disease, and all-cause mortality in non-Hispanic white California Seventh-day Adventists. Am J Clin Nutr. 1999;70. doi:10.1093/AJCN/70.3.532S

121. Tonstad S, Stewart K, Oda K, Batech M, Herring RP, Fraser GE. Vegetarian diets and incidence of diabetes in the Adventist Health Study-2. Nutr Metab Cardiovasc Dis. 2011;23:292. doi:10.1016/J.NUMECD.2011.07.004

122. Appleby PN, Davey GK, Key TJ. Hypertension and blood pressure among meat eaters, fish eaters, vegetarians and vegans in EPIC–Oxford. Public Health Nutr. 2002;5:645–54. doi:10.1079/PHN2002332

123. Miller V, Webb P, Cudhea F, Shi P, Zhang J, Reedy J, et al. Global dietary quality in 185 countries from 1990 to 2018 show wide differences by nation, age, education, and urbanicity. Nat Food. 2022;3:694. doi:10.1038/S43016-022-00594-9

124. Scott P. Global panel on agriculture and food systems for nutrition: food systems and diets: facing the challenges of the 21st century. Food Secur. 2017;9:653–4. doi:10.1007/S12571-017-0678-Y

125. Koli NK, Munsur RB, Rouf NZ. Exploring the impact of plant-based diets on environmental sustainability and human health. J Adv Biotechnol Exp Ther 2025; 8(3): 405-419. 2025;8:405–19. doi:10.5455/JABET.2025.33

126. Satija A, Bhupathiraju SN, Rimm EB, Spiegelman D, Chiuve SE, Borgi L, et al. Plant-Based Dietary Patterns and Incidence of Type 2 Diabetes in US Men and Women: Results from Three Prospective Cohort Studies. PLoS Med. 2016;13. doi:10.1371/JOURNAL.PMED.1002039

127. Satija A, Hu FB. Plant-based diets and cardiovascular health. Trends Cardiovasc Med. 2018;28:437–41. doi:10.1016/j.tcm.2018.02.004

128. Bizzozero-Peroni B, Díaz-Goñi V, Fernández-Rodríguez R, Martínez-Vizcaíno V, Jiménez-López E, Visier-Alfonso ME, et al. Plant-Based Diets and Mental and Neurocognitive Health Outcomes: A Systematic Review With Meta-Analysis. Nutr Rev. 2025;83:2282–95. doi:10.1093/NUTRIT/NUAF080

129. Pandey VK, Tripathi A, Choudhary P, Thapliyal S. Exploring the role of diet in modulating stress and emotional health: a review on mental nutrition and cognitive resilience. J Sci Food Agric. 2026;106. doi:10.1002/JSFA.70526

130. Gianfredi V, Dinu M, Nucci D, Eussen SJPM, Amerio A, Schram MT, et al. Association between dietary patterns and depression: an umbrella review of meta-analyses of observational studies and intervention trials. Nutr Rev. 2023;81:346–59. doi:10.1093/NUTRIT/NUAC058

131. Gessa GL, Biggio G, Fadda F, Corsini GU, Tagliamonte A. Effect of the oral administration of tryptophan-free amino acid mixtures on serum tryptophan, brain tryptophan and serotonin metabolism. J Neurochem. 1974;22:869–70. doi:10.1111/J.1471-4159.1974.TB04308.X

132. Sánchez-Villegas A, Delgado-Rodríguez M, Alonso A, Schlatter J, Lahortiga F, Serra-Majem L, et al. Association of the Mediterranean Dietary Pattern With the Incidence of Depression: The Seguimiento Universidad de Navarra/University of Navarra Follow-up (SUN) Cohort. Arch Gen Psychiatry. 2009;66:1090–8. doi:10.1001/ARCHGENPSYCHIATRY.2009.129

133. Jacobs DR, Tapsell LC. Food synergy: the key to a healthy diet. Proc Nutr Soc. 2013;72:200–6. doi:10.1017/S0029665112003011

134. Marx W, Moseley G, Berk M, Jacka F. Nutritional psychiatry: the present state of the evidence. Proc Nutr Soc. 2017;76:427–36. doi:10.1017/S0029665117002026

135. Heiss S, Hormes JM, Timko CA. Vegetarianism and Eating Disorders. Vegetarian and Plant-Based Diets in Health and Disease Prevention. 2017;51–69. doi:10.1016/B978-0-12-803968-7.00004-6

136. Barthels F, Meyer F, Pietrowsky R. Orthorexic and restrained eating behaviour in vegans, vegetarians, and individuals on a diet. Eating and Weight Disorders - Studies on Anorexia, Bulimia and Obesity 2018 23:2. 2018;23:159–66. doi:10.1007/S40519-018-0479-0

137. McLean CP, Chen Z, Song R, Le J, Fielding J, Sharp G. Development and preliminary validation of a novel eating disorder screening tool for vegetarians and vegans: the V-EDS. Journal of Eating Disorders 2024 12:1. 2024;12:4-. doi:10.1186/S40337-024-00964-7

138. Sergentanis TN, Chelmi ME, Liampas A, Yfanti CM, Panagouli E, Vlachopapadopoulou E, et al. Vegetarian Diets and Eating Disorders in Adolescents and Young Adults: A Systematic Review. Children 2021, Vol 8,. 2020;8. doi:10.3390/CHILDREN8010012

139. McLean CP, Kulkarni J, Sharp G. Disordered eating and the meat-avoidance spectrum: a systematic review and clinical implications. Eating and Weight Disorders. 2022;27:2347. doi:10.1007/S40519-022-01428-0

140. Mathieu S, Hanras E, Dorard G. Associations between vegetarianism, body mass index, and eating disorders/disordered eating behaviours: a systematic review of literature. Int J Food Sci Nutr. 2023;74:424–62. doi:10.1080/09637486.2023.2232953

141. Dunn TM, Bratman S. On orthorexia nervosa: A review of the literature and proposed diagnostic criteria. Eat Behav. 2016;21:11–7. doi:10.1016/j.eatbeh.2015.12.006

142. Ioannidis JPA. The Challenge of Reforming Nutritional Epidemiologic Research. JAMA. 2018;320:969–70. doi:10.1001/JAMA.2018.11025

143. Elstgeest LEM, Visser M, Penninx BWJH, Colpo M, Bandinelli S, Brouwer IA. Bidirectional associations between food groups and depressive symptoms: longitudinal findings from the Invecchiare in Chianti (InCHIANTI) study. Br J Nutr. 2019;121:439–50. doi:10.1017/S0007114518003203

144. Van Der Pols JC. Nutrition and mental health: bidirectional associations and multidimensional measures. Public Health Nutr. 2018;21:829. doi:10.1017/S1368980017003974

145. Han X, Liu Y, Wei Y, Ma L, Lim SS, Wang Z. The mechanism of natural dietary polyphenols on inhibiting inflammation and modulating gut-brain axis: an effective way to prevent depression. Agricultural Products Processing and Storage. 2026;2. doi:10.1007/S44462-025-00054-0

146. Valdes AM, Walter J, Segal E, Spector TD. Role of the gut microbiota in nutrition and health. BMJ. 2018;361:36–44. doi:10.1136/BMJ.K2179

147. Mann ER, Lam YK, Uhlig HH. Short-chain fatty acids: linking diet, the microbiome and immunity. Nat Rev Immunol. 2024;24:577–95. doi:10.1038/S41577-024-01014-8

148. Tian J, Zhang Y, Zhao X. The Effects and Mechanisms of n-3 and n-6 Polyunsaturated Fatty Acids in the Central Nervous System. Cell Mol Neurobiol. 2025;45. doi:10.1007/S10571-025-01543-3

149. Bizzozero-Peroni B, Fernández-Rodríguez R, Martínez-Vizcaíno V, Garrido-Miguel M, Medrano M, Jiménez-López E, et al. Nut consumption is associated with a lower risk of depression in adults: A prospective analysis with data from the UK Biobank cohort. Clin Nutr. 2023;42:1728–36. doi:10.1016/J.CLNU.2023.07.020

150. Gibson-Smith D, Bot M, Brouwer IA, Visser M, Giltay EJ, Penninx BWJH. Association of food groups with depression and anxiety disorders. Eur J Nutr. 2020;59:767–78. doi:10.1007/S00394-019-01943-4

151. Mazzolani BC, Smaira FI, Esteves GP, Santini MH, Leitão AE, Santo André HC, et al. Disordered Eating Attitudes and Food Choice Motives Among Individuals Who Follow a Vegan Diet in Brazil. JAMA Netw Open. 2023;6:e2321065–e2321065. doi:10.1001/JAMANETWORKOPEN.2023.21065

152. Viroli G, Kalmpourtzidou A, Cena H. Exploring Benefits and Barriers of Plant-Based Diets: Health, Environmental Impact, Food Accessibility and Acceptability. Nutrients. 2023;15:4723. doi:10.3390/NU15224723

13
FUTURE RESEARCH LINES



The findings of this doctoral thesis highlight several avenues for future research, including the following:

Outcome: mental and neurocognitive health

- Associations between cardiorespiratory fitness and symptoms of depression, anxiety, and psychological distress in university students: a cross-sectional study.
- Associations between cardiorespiratory fitness and mental health in children and adolescents: a systematic review and meta-analysis.
- Associations between plant-based diet indices and cognitive function in Spanish young adults: Nuts4Brain-Z study.

Outcome: eating disorder symptoms

- Associations between vegetarian and vegan diets and eating disorder symptoms in university students: a cross-sectional study.
- Motivations for adopting vegetarian and vegan diets and their relationship with eating disorder symptoms: a mixed-methods study.
- Associations between adherence to plant-based dietary patterns and symptoms of eating disorder: a prospective cohort study from the UK-Biobank.

Outcome: depressive symptoms

- Associations between 24-hour movement behaviors and depressive symptoms in university students: compositional data analysis from the Nuts4Brain-Z study.
- Longitudinal associations between healthy and unhealthy plant-based diet indices and depressive symptoms in young adults.
- Lifestyle behavior clusters and depression in middle-aged and older adults: the combined role of diet quality, physical activity, sedentary behavior and sleep.

14
APPENDIX



APPENDIX I. PROSPERO PROTOCOL MANUSCRIPT I

Manuscript I: Cardiorespiratory fitness and risk of mental disorders and dementia: a systematic review and meta-analysis

NIHR | National Institute for Health and Care Research

PROSPERO
International prospective register of systematic reviews

Prospective associationas between cardiorespiratory fitness and mental health outcomes: a systematic review and meta-analysis

Bruno Bizzozero Peroni, Arthur E Mesas, Vicente Martínez Vizcaíno

To enable PROSPERO to focus on COVID-19 submissions, this registration record has undergone basic automated checks for eligibility and is published exactly as submitted. PROSPERO has never provided peer review, and usual checking by the PROSPERO team does not endorse content. Therefore, automatically published records should be treated as any other PROSPERO registration. Further detail is provided here.

Citation
Bruno Bizzozero Peroni, Arthur E Mesas, Vicente Martínez Vizcaíno. Prospective associationas between cardiorespiratory fitness and mental health outcomes: a systematic review and meta-analysis. PROSPERO 2024 CRD42024547081. Available from https://www.crd.york.ac.uk/PROSPERO/view/CRD42024547081.

REVIEW TITLE AND BASIC DETAILS

Review title
Prospective associationas between cardiorespiratory fitness and mental health outcomes: a systematic review and meta-analysis

Review objectives
Does the available evidence support protective associations between high levels of cardiorespiratory fitness and mental health outcomes?

Keywords
adults, mental disorders, Physical fitness

SEARCHING AND SCREENING

Searches
This systematic review will be conducted according to the PRISMA statement (Page et al., 2020, BMJ) and the MOOSE recommendations for observational studies (Stroup et al., 2000, JAMA).
A systematic search will be conducted on MEDLINE (PubMed), Scopus, Web of Science and SPORTDiscus from database inception up to July 2024. We will use keywords related to both cardiorespiratory fitness and mental health outcomes (e.g., anxiety, depression), in addition to terms related to the study design. These search terms will be combined with Boolean operators adapted for each database. Furthermore, additional searches of Google Scholar, reference lists of included studies, and relevant systematic reviews will be conducted to detect possible new studies for inclusion.
In case of lack of data, experts will be contacted to provide information about other possible data.

Study design
Prospective cohort studies.
Studies will be excluded if they report:
(i) Duplicate data published in another included study;
(ii) CRF measured by self-report.
(iii) Special interest groups data (e.g., elite athletes or firefighters) or with specific diseases (e.g., cardiovascular, cancer); or
(iv) Data published as conference/meeting abstracts.

ELIGIBILITY CRITERIA

Condition or domain being studied
Cardiorespiratory fitness in the general adult population.
Cardiorespiratory fitness is a strong predictor of morbidity. However, the certainty of the evidence was very low as a protective factor on mental health outcomes, such as anxiety or depression.

Population
We will include studies recruiting general adult population (≥18 years of age).

Intervention(s) or exposure(s)
High levels of cardiorespiratory fitness.
CRF in the included studies may be measured by maximal or submaximal exercise testing with or without gas analysis or by non-exercise prediction equations.

Comparator(s) or control(s)
Low levels of cardiorespiratory fitness.

Context
Cohort studies of the associations between CRF levels and mental health-related outcomes in the general adult population over 18 years of age.

OUTCOMES TO BE ANALYSED

Main outcomes
Anxiety, depression, cognitive decline, dementia.

Measures of effect
Higher vs lower CRF levels were compared for each mental health outcome, and these data will be synthesized narratively. Once the main characteristics of the included studies have been extracted, we will determine whether a meta-analysis is possible. For each study, data on effect sizes (e.g., relative risks, odds ratios, frequencies, hazard ratios) and their 95% confidence intervals (95% CI) will be extracted.

Additional outcomes
Psychological distress, eating disorders, sleep disorders.

DATA COLLECTION PROCESS

Data extraction (selection and coding)
The procedures will be divided in steps:
First step: Title and abstract screening
Firstly, two independent reviewers will screen the titles for potential inclusion. Then, both reviewers will continue with the abstracts of the selected articles. In case of disagreement, in title and in abstract inclusion, a third reviewer will decide. In cases where a decision for exclusion or potential inclusion cannot be made by the title/abstract, the full text will be retrieved.
Second step: Full-text screening
The two independent reviewers will review the full texts of the previously included articles and will decide the inclusion or exclusion based on the selected criteria (inclusion and exclusion) by the completion of a checklist. A third reviewer will decide on the inclusion or exclusion if there is no consensus between reviewers.

Risk of bias (quality) assessment
The included studies will be assessed for methodological quality and risk of bias independently by two researchers. In case of discrepancies, a third reviewer will act to solve the disagreements. The tools to evaluate the methodological quality and risk of bias for observational studies will be the Quality Assessment Tool for Observational Cohort and CrossSectional Studies (National Heart, Lung, and Blood Institute, 2022) and the The Risk Of Bias In Non-randomized Studies - of Exposure (Higgins et al., 2023), respectively.

PLANNED DATA SYNTHESIS

Strategy for data synthesis
The potential for conducting a meta-analysis will be assessed based on the data which has been extracted.
R software will be used to combine the pooled effect sizes (e.g., frequencies, odds ratios, hazard ratios) with 95% CIs to pooled relative risks. A fixed effect model will be used if there is no evidence of heterogeneity, otherwise, a random-effects model will be used. Study heterogeneity will be assessed using the I^2 statistic.

Analysis of subgroups or subsets
If there is available information we will divide the information by sex (women, men), BMI status (underweight, normoweight, obese), adult age groups (young, middle-aged, older), and geographic location.

REVIEW AFFILIATION, FUNDING AND PEER REVIEW

Review team members

- Dr Bruno Bizzozero Peroni, Health and Social Research Center, Universidad de Castilla-La Mancha, Cuenca, Spain. Instituto Superior de Educación Física, Universidad de la República, Rivera 40000, Uruguay.
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TIMELINE OF THE REVIEW

Review timeline
Start date: 01 July 2024. End date: 31 December 2024

Date of first submission to PROSPERO
15 May 2024

Date of registration in PROSPERO
25 May 2024

CURRENT REVIEW STAGE

Publication of review results 1 change
Results of the review will be published in English.

Journal publication
Published in an academic journal.

Additional information about publications
Cardiorespiratory fitness and risk of mental disorders and dementia: a systematic review and meta-analysis. Nat. Mental Health 4, 653–663 (2026). https://doi.org/10.1038/s44220-026-00599-4

Stage of the review at this submission 1 change

Review stage	Started	Completed
Pilot work	✓	✓
Formal searching/study identification	✓	✓
Screening search results against inclusion criteria	✓	✓
Data extraction or receipt of IPD	✓	✓
Risk of bias/quality assessment	✓	✓
Data synthesis	✓	✓

Review status
The review is completed.

ADDITIONAL INFORMATION

PROSPERO version history 1 change

- Version 1.3, published 08 Jul 2026
- Version 1.2, published 20 Mar 2026
- Version 1.1, published 25 May 2024
- Version 1.0, published 25 May 2024

Review conflict of interest
None known

Country
Spain, Uruguay

Medical Subject Headings
Cardiorespiratory Fitness; Exercise; Humans; Outcome Assessment, Health Care; Prospective Studies

Revision note 1 change
Study published at Nature Mental Health

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Any enquiries about the record should be referred to the named review contact

APPENDIX II. SUPPLEMENTARY MATERIAL MANUSCRIPT I

Supplementary material: Cardiorespiratory fitness and risk of mental disorders and dementia: a systematic review and meta-analysis

nature mental health

Supplementary information https://doi.org/10.1038/s44220-026-00599-4

Cardiorespiratory fitness and risk of mental disorders and dementia: a systematic review and meta-analysis

In the format provided by the authors and unedited

Supplementary methods

Inclusion criteria: outcome

Mental disorders were categorized according to the DSM-5-TR (Diagnostic and Statistical Manual of Mental Disorders-Text Revision of the fifth edition) classification of the American Psychiatric Association,[1] i.e., neurodevelopmental disorders; schizophrenia spectrum and other psychotic disorders; bipolar and related disorders; depressive disorders; anxiety disorders; obsessive-compulsive and related disorders; trauma- and stressor-related disorders; dissociative disorders; somatic symptom and related disorders; feeding and eating disorders; elimination disorders; sleep-wake disorders; sexual dysfunctions; disruptive, impulse-control, and conduct disorders; substance-related and addictive disorders; neurocognitive disorders; personality disorders; paraphilic disorders; and medication-induced movement disorders and other adverse effects of medication. Mental disorders were considered either as clinical diagnoses or as measures of symptom severity, including: (i) clinical diagnosis by physicians or trained health professionals using recognized diagnostic criteria, registry data, or self-reported medical diagnoses; and (ii) symptom severity (ranging from mild to severe), assessed using validated observer-rated or self-reported scales.

Exclusion criteria

Studies were excluded if they reported: 1) exclusive data on clinical populations or with occupations closely associated with exercise (e.g., elite athletes, military service); 2) data on self-perceived cardiorespiratory fitness (CRF); 3) mental and neurocognitive disorder data on specific items of self-report scales or without overall scores categorized as mild, moderate or severe symptoms; 4) mental disorders related to pregnancy (e.g., postpartum depression); and 5) noneligible publications such as conference or meeting abstracts, preprints, and letters to the editor.

Methodological quality assessment

The methodological quality of the cohort studies was evaluated using the National Institutes of Health (NIH) Quality Assessment Tool for Observational Cohort Studies.[2] The tool assesses 14

items across a range of domains, including the study population, the timeframe for associations, the exposure and outcome measures, and the statistical analyses. Each item could be scored as "yes" when the study achieved the criterion, "no" when the study did not achieve the criterion, and "cannot determine" or "not reported", when the study did not clearly report the required information. The responses to these domains were used to make an overall assessment. The quality of each cohort study was classified as good (if most criteria were met), fair (if some criteria were met), or poor (if few criteria were met) according to the NIH quality rating guide (table S4).

Certainty of evidence

The Grading of Recommendations, Assessment, Development, and Evaluations[3] approach was used for assessing the quality of evidence and the strength of recommendations for the study associations. The certainty of evidence for each mental and neurocognitive disorder was classified as high, moderate, low, or very low, based on the study design, risk of bias, inconsistency, indirect evidence, imprecision, and publication bias. Following guidance for the use of the GRADE approach for prognostic research, evidence from prospective cohort studies was initially rated as 'high' certainty.[4]

Methodological considerations

Other methodological considerations of data collection and analysis should be noted. The maximum extent of adjustment for risk estimation was selected in all the included studies. To place all effect sizes in a common frame, the hazard ratio (HR) was converted to 1/HR when the highest level of CRF was set as the reference group. When the studies included categorized CRF levels into group percentiles, the extreme categories (i.e., fit *vs.* unfit, tertile 3 *vs.* tertile 1, quartile 4 *vs.* quartile 1, quintile 5 *vs.* quintile 1) were compared. Cohort studies that reported results according to an increase in CRF with values other than 1-MET[5,6] were included in the meta-analysis assuming a linear relationship between the exposure as a continuous variable and the incidence of mental and neurocognitive disorders. Studies that analyzed CRF as a continuous variable but did not specify the increase or decrease value[7–12] were excluded from the meta-analysis. In turn, studies comparing high *vs.* medium levels of CRF were not included in the meta-

analysis to allow for more accurate quantification of results and to ensure harmonization of highest *vs.* lowest exposure categories.[13]

When studies reported CRF levels as continuous and categorical exposure,[6,8,14–18] data were included according to the appropriate meta-analysis. This strategy facilitates the inclusion of a greater number of studies without the occurrence of double counting of participants in each meta-analysis. In turn, when two or more studies examine data from the same cohort, exposure harmonization and outcome,[5,14–21] we proceed to combine the respective measures to calculate a single pooled estimate for each study. A three-level random effects meta-analysis was conducted for these combinations.[22] The multilevel approach accounts for dependence between effect sizes and comprises three pooling steps (i.e., sampling variance, variance between effect sizes from the same sample, and variance between studies) that result in an overall true effect size, thereby increasing statistical power and extracting maximum information from the data.[23] The estimates and standard errors for each multilevel analysis were extracted and subsequently applied to the main meta-analyses. When studies drawing upon the same cohort of data were combined, the largest sample size was utilized to account for the total population and incident cases.

Dealing with missing data

Corresponding authors of five studies[7,10–12,24–26] were contacted at least twice by e-mail to request substantial missing data for the study associations (e.g., supplementary analyses, increment values of CRF as continuous variable). Two studies[7,12,24–26] provided additional data of interest that contributed to the present analyses. When authors did not send additional data,[7,10,11,24,26] we reported them as missing values.

References cited in this section

1. American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition, Text Revision (DSM-5-TR). Diagnostic and Statistical Manual of Mental Disorders. Published online March 18, 2022. doi:10.1176/APPI.BOOKS.9780890425787
2. National Heart Lung and Blood Institute. Quality Assessment Tool for Observational Cohort and Cross-sectional Studies. Published 2021. https://www.nhlbi.nih.gov/health-topics/study-quality-assessment-tools (accessed 20 January 2025).

3. Guyatt GH, Oxman AD, Schünemann HJ, Tugwell P, Knottnerus A. GRADE guidelines: A new series of articles in the Journal of Clinical Epidemiology. J Clin Epidemiol. 2011;64(4):380-382. doi:10.1016/j.jclinepi.2010.09.011
4. Iorio A, Spencer FA, Falavigna M, et al. Use of GRADE for assessment of evidence about prognosis: rating confidence in estimates of event rates in broad categories of patients. BMJ. 2015;350. doi:10.1136/BMJ.H870
5. Dishman RK, Sui X, Church TS, Hand GA, Trivedi MH, Blair SN. Decline in cardiorespiratory fitness and odds of incident depression. Am J Prev Med. 2012;43(4):361-368. doi:10.1016/J.AMEPRE.2012.06.011
6. Wiklund CA, Ekblom Ö, Paulsson S, Lindwall M, Ekblom-Bak E. Cardiorespiratory fitness in midlife and subsequent incident depression, long-term sickness absence, and disability pension due to depression in 330,247 men and women. Prev Med (Baltim). 2024;181. doi:10.1016/J.YPMED.2024.107916
7. Baumeister SE, Leitzmann MF, Bahls M, et al. Associations of Leisure-Time and Occupational Physical Activity and Cardiorespiratory Fitness With Incident and Recurrent Major Depressive Disorder, Depressive Symptoms, and Incident Anxiety in a General Population. J Clin Psychiatry. 2017;78(1):e41-e47. doi:10.4088/JCP.15M10474
8. Shigdel R, Stubbs B, Sui X, Ernstsen L. Cross-sectional and longitudinal association of non-exercise estimated cardiorespiratory fitness with depression and anxiety in the general population: The HUNT study. J Affect Disord. 2019;252:122-129. doi:10.1016/J.JAD.2019.04.016
9. Gianfredi V, Koster A, Eussen SJPM, et al. The association between cardio-respiratory fitness and incident depression: The Maastricht Study. J Affect Disord. 2021;279:484-490. doi:10.1016/j.jad.2020.09.090
10. Hietanen H, Pietilä A, Kähönen M, Salomaa V. Ankle blood pressure and dementia: a prospective follow-up study. Blood Press Monit. 2013;18(1):16-20. doi:10.1097/MBP.0B013E32835D131C

11. Wang S, Xu L, Yang W, et al. Association of cardiorespiratory fitness with dementia risk across different levels of genetic predisposition: a large community-based longitudinal study. Br J Sports Med. 2025;59(3):150-158. doi:10.1136/BJSPORTS-2023-108048
12. Wiklund CA, Lindwall M, Ekblom Ö, et al. Change in Cardiorespiratory Fitness and Risk of Depression, Anxiety, and Cerebrovascular Disease. Am J Prev Med. 2024;67(6). doi:10.1016/J.AMEPRE.2024.07.012
13. Hörder H, Johansson L, Guo X, et al. Midlife cardiovascular fitness and dementia: A 44-year longitudinal population study in women. Neurology. 2018;90(15):e1298-e1305. doi:10.1212/WNL.0000000000005290
14. Sui X, Laditka JN, Church TS, et al. Prospective study of cardiorespiratory fitness and depressive symptoms in women and men. J Psychiatr Res. 2009;43(5):546-552. doi:10.1016/J.JPSYCHIRES.2008.08.002
15. Willis BL, Leonard D, Barlow CE, Martin SB, DeFina LF, Trivedi MH. Association of Midlife Cardiorespiratory Fitness With Incident Depression and Cardiovascular Death After Depression in Later Life. JAMA Psychiatry. 2018;75(9):911-917. doi:10.1001/JAMAPSYCHIATRY.2018.1467
16. Gafni T, Weinstein G, Leonard D, et al. Independent and joint associations of cardiorespiratory fitness and BMI with dementia risk: the Cooper Center Longitudinal Study. BMJ Open. 2023;13(12). doi:10.1136/BMJOPEN-2023-075571
17. DeFina LF, Willis BL, Radford NB, et al. The association between midlife cardiorespiratory fitness levels and later-life dementia: a cohort study. Ann Intern Med. 2013;158(3):162-168. doi:10.7326/0003-4819-158-3-201302050-00005
18. Tari AR, Nauman J, Zisko N, et al. Temporal changes in cardiorespiratory fitness and risk of dementia incidence and mortality: a population-based prospective cohort study. Lancet Public Health. 2019;4(11):e565-e574. doi:10.1016/S2468-2667(19)30183-5
19. Becofsky KM, Sui X, Lee DC, Wilcox S, Zhang J, Blair SN. A prospective study of fitness, fatness, and depressive symptoms. Am J Epidemiol. 2015;181(5):311-320. doi:10.1093/AJE/KWU330

20. Lerfald M, Allore H, Nilsen TIL, et al. Longitudinal Patterns of Systolic Blood Pressure, Diastolic Blood Pressure, Cardiorespiratory Fitness, and Their Association With Dementia Risk: The HUNT Study. J Gerontol A Biol Sci Med Sci. 2024;79(8). doi:10.1093/GERONA/GLAE161

21. Meernik C, Eilat-Adar S, Leonard D, et al. Dietary patterns and cardiorespiratory fitness in midlife and subsequent all-cause dementia: findings from the cooper center longitudinal study. Int J Behav Nutr Phys Act. 2024;21(1):109. doi:10.1186/S12966-024-01663-X

22. Cheung MWL. Modeling dependent effect sizes with three-level meta-analyses: a structural equation modeling approach. Psychol Methods. 2014;19(2):211-229. doi:10.1037/A0032968

23. Van den Noortgate W, López-López JA, Marín-Martínez F, Sánchez-Meca J. Three-level meta-analysis of dependent effect sizes. Behav Res Methods. 2013;45(2):576-594. doi:10.3758/S13428-012-0261-6

24. Gianfredi V, Koster A, Eussen SJPM, et al. The association between cardio-respiratory fitness and incident depression: The Maastricht Study. J Affect Disord. 2021;279:484-490. doi:10.1016/J.JAD.2020.09.090

25. Chiang HL, Chuang YF, Chen YA, et al. Physical Fitness and Risk of Mental Disorders in Children and Adolescents. JAMA Pediatr. 2024;178(6):595-607. doi:10.1001/JAMAPEDIATRICS.2024.0806

26. Kandola AA, Osborn DPJ, Stubbs B, Choi KW, Hayes JF. Individual and combined associations between cardiorespiratory fitness and grip strength with common mental disorders: a prospective cohort study in the UK Biobank. BMC Med. 2020;18(1). doi:10.1186/S12916-020-01782-9

Table S1. List of the studies fully assessed for eligibility and excluded.

Ineligible population (not meeting inclusion criteria)	
1.	Cheng Y, Zamrini E, Faselis C, et al. Cardiorespiratory fitness and risk of Alzheimer's disease and related dementias among American veterans. *Alzheimers Dement*. 2023;19(10):4325-4334. doi: 10.1002/alz.12998.
2.	Marzolini S, Colella TJF. Factors That Predispose Women to Greater Depressive Symptoms: A Sex-, Age-, and Diagnosis-Matched Cardiac Rehabilitation Cohort. *Can J Cardiol.* 2021;37(3):382-390. doi: 10.1016/j.cjca.2020.08.019.
3.	Müller J, Chan K, Myers JN. Association Between Exercise Capacity and Late Onset of Dementia, Alzheimer Disease, and Cognitive Impairment. *Mayo Clin Proc*. 2017;92(2):211-217. doi: 10.1016/j.mayocp.2016.10.020.
4.	Müller J, Ganeshamoorthy S, Myers J. Risk factors associated with posttraumatic stress disorder in US veterans: A cohort study. *PLoS One*. 2017;12(7):e0181647. doi: 10.1371/journal.pone.0181647.
5.	Muntaner-Mas A, Ortega FB, Femia P, Kiive E, Eensoo D, Mäestu J, Franke B, Reif A, Faraone SV, Harro J. Low cardiorespiratory fitness and obesity for ADHD in childhood and adolescence: A 6-year cohort study. *Scand J Med Sci Sports*. 2021;31(4):903-913. doi: 10.1111/sms.13905.
6.	Taanila H, Hemminki AJ, Suni JH, Pihlajamäki H, Parkkari J. Low physical fitness is a strong predictor of health problems among young men: a follow-up study of 1411 male conscripts. *BMC Public Health*. 2011;11:590. doi: 10.1186/1471-2458-11-590.
Ineligible exposure (not meeting inclusion criteria)	
7.	Bullain SS, Corrada MM, Perry SM, Kawas CH. Sound Body Sound Mind? Physical Performance and the Risk of Dementia in the Oldest-Old: The 90+ Study. *J Am Geriatr Soc*. 2016;64(7):1408-15. doi: 10.1111/jgs.14224.
8.	Calvo MG, Cano-Vindel A. The nature of trait anxiety: Cognitive and biological vulnerability. *European Psychologist. 1997*;2(4):301-12. doi: 10.1027/1016-9040.2.4.301.
9.	Kulmala J, Solomon A, Kåreholt I, et al. Association between mid- to late life physical fitness and dementia: evidence from the CAIDE study. *J Intern Med*. 2014;276(3):296-307. doi: 10.1111/joim.12202.
10.	Larson EB, Wang L, Bowen JD, et al. Exercise is associated with reduced risk for incident dementia among persons 65 years of age and older. *Ann Intern Med*. 2006;144(2):73-81. doi: 10.7326/0003-4819-144-2-200601170-00004.
11.	Norris T, Mitchell JJ, Blodgett JM, Hamer M, Pinto Pereira SM. Does cardiorespiratory fitness mediate or moderate the association between mid-life physical activity frequency and cognitive function? findings from the 1958 British birth cohort study. *PLoS One*. 2024;19(6):e0295092. doi: 10.1371/journal.pone.0295092.
12.	Payette H, Gueye NR, Gaudreau P, Morais JA, Shatenstein B, Gray-Donald K. Trajectories of physical function decline and psychological functioning: the Quebec longitudinal study on nutrition and successful aging (NuAge). *J Gerontol B Psychol Sci Soc Sci*. 2011;66 Suppl 1:i82-90. doi: 10.1093/geronb/gbq085.
13.	Rhebergen D, Batelaan NM, de Graaf R, et al. The 7-year course of depression and anxiety in the general population. *Acta Psychiatr Scand*. 2011;123(4):297-306. doi: 10.1111/j.1600-0447.2011.01677.x.
14.	Sattler C, Erickson KI, Toro P, Schröder J. Physical fitness as a protective factor for cognitive impairment in a prospective population-based study in Germany. *J Alzheimers Dis*. 2011;26(4):709-18. doi: 10.3233/JAD-2011-110548.
15.	Sibbett RA, Russ TC, Allerhand M, Deary IJ, Starr JM. Physical fitness and dementia risk in the very old: a study of the Lothian Birth Cohort 1921. *BMC Psychiatry*. 2018;18(1):285. doi: 10.1186/s12888-018-1851-3.
16.	Stegenga BT, Nazareth I, Torres-González F, et al. Depression, anxiety and physical function: exploring the strength of causality. *J Epidemiol Community Health*. 2012;66(7):e25. doi: 10.1136/jech.2010.128371.
17.	Yamada M, Mimori Y, Kasagi F, Miyachi T, Ohshita T, Sasaki H. Incidence and risks of dementia in Japanese women: Radiation Effects Research Foundation Adult Health Study. *J Neurol Sci.* 2009;283(1-2):57-61. doi: 10.1016/j.jns.2009.02.338.
18.	Zhou TL, Kroon AA, Henry RMA, et al. Exercise SBP response and incident depressive symptoms: The Maastricht Study. *J Hypertens*. 2021;39(3):494-502. doi: 10.1097/HJH.0000000000002657.

Ineligible outcome (not meeting inclusion criteria)
19. Barnes DE, Yaffe K, Satariano WA, Tager IB. A longitudinal study of cardiorespiratory fitness and cognitive function in healthy older adults. *J Am Geriatr Soc*. 2003 Apr;51(4):459-65. doi: 10.1046/j.1532-5415.2003.51153.x.
20. Belsky DW, Caspi A, Israel S, Blumenthal JA, Poulton R, Moffitt TE. Cardiorespiratory fitness and cognitive function in midlife: neuroprotection or neuroselection? *Ann Neurol*. 2015;77(4):607-17. doi: 10.1002/ana.24356.
21. Boots EA, Schultz SA, Oh JM, et al. Cardiorespiratory fitness is associated with brain structure, cognition, and mood in a middle-aged cohort at risk for Alzheimer's disease. *Brain Imaging Behav.* 2015;9(3):639-49. doi: 10.1007/s11682-014-9325-9.
22. Carlsen T, Stensvold D, Wisløff U, Ernstsen L, Halvorsen T. The association of change in peak oxygen uptake with use of psychotropics in community-dwelling older adults - The Generation 100 study. *BMC Geriatr*. 2022;22(1):575. doi: 10.1186/s12877-022-03262-6.
23. Dishman RK, Sui X, Church TS, Kline CE, Youngstedt SD, Blair SN. Decline in cardiorespiratory fitness and odds of incident sleep complaints. Med Sci Sports Exerc. 2015;47(5):960-6. doi: 10.1249/MSS.0000000000000506.
24. Dougherty RJ, Jonaitis EM, Gaitán JM, et al. Cardiorespiratory fitness mitigates brain atrophy and cognitive decline in adults at risk for Alzheimer's disease. *Alzheimers Dement*. 2021;13(1):e12212. doi: 10.1002/dad2.12212.
25. Dougherty RJ, Schultz SA, Boots EA, et al. Relationships between cardiorespiratory fitness, hippocampal volume, and episodic memory in a population at risk for Alzheimer's disease. *Brain Behav*. 2017;7(3):e00625. doi: 10.1002/brb3.625.
26. Holmlund T, Blom V, Hemmingsson E, et al. Change in cardiorespiratory fitness on self-rated health: prospective cohort study in 98 718 Swedish adults. Scand *J Public Health*. 2023;51(4):542-551. doi: 10.1177/14034948211047140.
27. Jetten J, Haslam C, von Hippel C. "Let's get physical" - or social: The role of physical activity versus social group memberships in predicting depression and anxiety over time. *J Affect Disord*. 2022;306:55-61. doi: 10.1016/j.jad.2022.03.027.
28. Lee I, Song M, Kang H. Association of Estimated Cardiorespiratory Fitness with the Incidence of Cognitive Impairment in Middle-Aged and Older Adults: Based on 12 Years Follow-Up Data from the Korean Longitudinal Study of Aging. *Exerc Sci.* 2021;30(1):16-24. doi: 10.15857/ksep.2021.30.1.16
29. Luria G, Torjman A. Resources and coping with stressful events. *J Organ Behav*. 2022;306:55-61. doi: 10.1016/j.jad.2022.03.027.
30. Pentikäinen H, Savonen K, Ngandu T, et al. Cardiorespiratory Fitness and Cognition: Longitudinal Associations in the FINGER Study. *J Alzheimers Dis*. 2019;68(3):961-968. doi: 10.3233/JAD-180897.
31. Ruggero CJ, Petrie T, Sheinbein S, Greenleaf C, Martin S. Cardiorespiratory Fitness May Help in Protecting Against Depression Among Middle School Adolescents. *J Adolesc Health.* 2015;57(1):60-5. doi: 10.1016/j.jadohealth.2015.03.016.
32. Shuval K, Leonard D, DeFina LF, et al. Cardiorespiratory fitness and depression symptoms among adults during the COVID-19 Pandemic: Cooper Center Longitudinal Study. *Prev Med Rep*. 2022;30:102065. doi: 10.1016/j.pmedr.2022.102065.
33. Silva DAS, de Lima TR, Lavie CJ, Sui X. Association between cardiorespiratory fitness and low back pain is anxiety-dependent: A prospective cohort study among adults and older adults. *J Sports Sci.* 2023;41(10):947-954. doi: 10.1080/02640414.2023.2249756.
34. Tait JL, Collyer TA, Gall SL. Longitudinal associations of childhood fitness and obesity profiles with midlife cognitive function: an Australian cohort study. *J Sci Med Sport*. 2022;25(8):667-672. doi: 10.1016/j.jsams.2022.05.009.
35. Vesperman CJ, Wang R, Schultz SA, et al. Cardiorespiratory fitness and cognition in persons at risk for Alzheimer's disease. *Alzheimers Dement*. 2022;14(1):e12330. doi: 10.1002/dad2.12330.
36. Vidoni ED, Honea RA, Billinger SA, Swerdlow RH, Burns JM. Cardiorespiratory fitness is associated with atrophy in Alzheimer's and aging over 2 years. *Neurobiol Aging*. 2012;33(8):1624-32. doi: 10.1016/j.neurobiolaging.2011.03.016.
37. Wendell CR, Gunstad J, Waldstein SR, Wright JG, Ferrucci L, Zonderman AB. Cardiorespiratory fitness and accelerated cognitive decline with aging. *J Gerontol A Biol Sci Med Sci*. 2014;69(4):455-

62. doi: 10.1093/gerona/glt144.

Ineligible study association

38. Almeida OP, Hankey GJ, Yeap BB, Golledge J, Hill KD, Flicker L. Depression Among Nonfrail Old Men Is Associated With Reduced Physical Function and Functional Capacity After 9 Years Follow-up: The Health in Men Cohort Study. *J Am Med Dir Assoc*. 2017;18(1):65-69. doi: 10.1016/j.jamda.2016.09.002.
39. Koivukangas J, Tammelin T, Kaakinen M, et al. Physical activity and fitness in adolescents at risk for psychosis within the Northern Finland 1986 Birth Cohort. *Schizophr Res*. 2010;116(2-3):152-8. doi: 10.1016/j.schres.2009.10.022.

Ineligible study design

40. Farrell SW, Abramowitz AR, Willis BL, et al. The Relationship between Cardiorespiratory Fitness and Montreal Cognitive Assessment Scores in Older Adults. *Gerontology.* 2018;64(5):440-445. doi: 10.1159/000489336.
41. Garcia-Argibay M, Du Rietz E, Hartman CA, Lichtenstein P, Chang Z, Fava C, Cortese S, Larsson H. Cardiovascular risk factors in attention-deficit/hyperactivity disorder: A family design study of Swedish conscripts. Int J Methods Psychiatr Res. 2022;31(4):e1930. doi: 10.1002/mpr.1930.
42. Gerber M, Lindwall M, Lindegård A, Börjesson M, Jonsdottir IH. Cardiorespiratory fitness protects against stress-related symptoms of burnout and depression. *Patient Educ Couns.* 2013;93(1):146-52. doi: 10.1016/j.pec.2013.03.021.
43. Greenleaf CA, Petrie TA, Martin SB. Psychosocial variables associated with body composition and cardiorespiratory fitness in middle school students. *Res Q Exerc Sport*. 2010;81(3 Suppl):S65-74. doi: 10.1080/02701367.2010.10599695.
44. Haapala EA, Leppänen MH, Skog H, et al. Childhood Physical Fitness as a Predictor of Cognition and Mental Health in Adolescence: The PANIC Study. Sports Med. 2024. doi: 10.1007/s40279-024-02107-z.
45. Kunutsor SK, Laukkanen T, Laukkanen JA. Cardiorespiratory fitness is associated with reduced risk of future psychosis: A long-term prospective cohort study. Schizophr Res. 2018;192:473-474. doi: 10.1016/j.schres.2017.04.042.
46. Law LL, Sprecher KE, Dougherty RJ, et al. Cardiorespiratory Fitness Modifies Influence of Sleep Problems on Cerebrospinal Fluid Biomarkers in an At-Risk Cohort. *J Alzheimers Dis*. 2019;69(1):111-121. doi: 10.3233/JAD-180291.
47. Nixdorf R, Bechmann J, Oberhoffer R, Weberrub H, Nixdorf I. Associations between physical fitness and mental health among German adolescents. *J Sport Health Res*. 2021;13(1): 125-138.
48. Sheinbein ST, Petrie TA, Martin S, Greenleaf CA. Psychosocial Mediators of the Fitness-Depression Relationship Within Adolescents. *J Phys Act Health*. 2016;13(7):719-25. doi: 10.1123/jpah.2015-0127.
49. Suija K, Timonen M, Suviola M, Jokelainen J, Järvelin MR, Tammelin T. The association between physical fitness and depressive symptoms among young adults: results of the Northern Finland 1966 birth cohort study. *BMC Public Health*. 2013;13:535. doi: 10.1186/1471-2458-13-535.

Table S2. Baseline characteristics of the cohort studies included in the systematic review and meta-analysis.

Study characteristics					Study sample					Cardiorespiratory fitness			Mental and neurocognitive disorders	
Reference	**Country**	**Cohort / Register [a]**	**Data collection period**	**Follow-up, y [b]**	**N**	**Race / Ethnicity [c]**	**Female, %**	**Age, y [b]**	**BMI, kg/m² [b]**	**Measure and test**	**Metric**	**Mean [b]**	**Outcome**	**Data [d]**
Aberg et al.,[42] 2012	Sweden	SMSCR	1969-2008	16.7 (NR)	1,117,292	NR	0	18.0 (NR)	NR	Indirect, maximal CPET-CE	Peak workload (W_{max}/kg)	NR	Depression	Medical records
Baumeister et al.,[41] 2017	Germany	SHIP	2002-2010	4.5 (NR)	1080	White [e], European	47.2	25-83	NR	Direct, maximal CPET-CE	VO_{2peak} (ml/min)	2042.7 (NR)	Anxiety, depression	Medical diagnosis, self-reported symptoms (BDI-II)
Becofsky et al.,[40] 2015	US	ACLS	1979-1999	9.9 (5.7)	12,599	White, non-Hispanic	18.4	44.9 (9.5)	25.2 (3.4)	Indirect, maximal CPET-CE	Duration (minutes)	18.5 (4.8)	Depression	Self-reported symptoms (CES-D-10)
Chiang et al.,[44] 2024	Taiwan	NHIRD, NSFTD	2009-2019	6.0 (2.4)	1,920,596 1,996,633	NR	49.2 48.1	10.6 (0.5)	NR	Indirect, submaximal FBT-800 meters run	Duration (minutes)	5.0 (1.0)	ADHD Anxiety, depression	Medical diagnosis
Crump et al.,[39] 2019	Sweden	SMSCR	1969-2012	28.2 (NR)	1,547,478	NR	0	18.0 (NR)	21.6 (2.8)	Indirect, maximal CPET-CE	Peak workload (W_{max})	266.6 (54.4)	Sleep apnea	Medical records
DeFina et al.,[38] 2013	US	CCLS	1971-2009	24.0 (8.3)	19,458	White, non-Hispanic	21.1	49.8 (8.7)	25.7 (3.8)	Indirect, maximal CPET-CE	METs	10.6 (2.4)	All-cause dementia	Medical records

Dishman et al.,[37] 2012	US	ACLS	1971-2006	5.1 (1.5)	9197	White, non-Hispanic	13.7	49.2 (10.5)	25.3 (3.1)	Indirect, maximal CPET-TM	METs	11.9 (2.3)	Depression	Self-reported medical complaint
Gafni et al.,[36] 2023	US	CCLS	1970-2009	15.7 (6.2)	6428	White, non-Hispanic	15	50.9 (7.6)	25.4 (3.2)	Indirect, maximal CPET-TM	METs	11.6 (2.3)	All-cause dementia	Medical records
Gianfredi et al.,[35] 2021	Netherlands	MS	2010-NR	5.0 (NR)	1730	White [e], European	50.8	59.9 (8.0)	NR	Indirect, submaximal CPET-CE	Peak workload (W_{max}/kg)	2.2 (0.3)	Depression	Self-reported symptoms (PHQ-9)
Hietanen et al.,[34] 2013	Finland, Sweden	NA	1989-2008	18.0 (NR)	3859	NR	33.6	50.3 (9.5)	26.1 (3.8)	Indirect, submaximal CPET-CE	METs	7.7 (2.8)	All-cause dementia	Medical records
Horder et al.,[46] 2018	Sweden	PPSW	1968-2012	29.0 (NR)	191	NR	100	50.2 (7.0)	24.6 (4.0)	Indirect, submaximal CPET-CE	Peak workload (W_{max})	103.0 (21.0)	All-cause dementia	Medical records
Kandola et al.,[33] 2020	UK	UKB	2006-2017	7.0 (NR)	22,667	NR	54.4	56.6 (8.1)	NR	Indirect, submaximal CPET-CE	METs	10.0 (3.0)	Anxiety, depression	Self-reported symptoms (GAD-7, PHQ-9)
Kunutsor et al.,[45] 2024	Finland	KIHD	1984-2013	23.4 (6.4)	2221	White, European	0	53.0 (5.0)	26.8 (3.4)	Direct, maximal CPET-CE	VO_{2max} (ml/kg/min)	30.4 (8.0)	Psychotic disorders	Medical records
Kurl et al.,[32] 2018	Finland	KIHD	1984-2013	22.0 (7.4)	2031	White, European	0	52.8 (5.0)	26.8 (3.5)	Direct, maximal CPET-CE	VO_{2max} (ml/kg/min)	30.2 (8.6)	All-cause dementia	Medical records
Lerfald et al.,[31] 2024	Norway	HUNT	1984-2019	10.0 (NR)	7594	White, European	54.9	44.7 (6.3)	NR	Indirect, prediction equation	VO_{2max} (ml/kg/min)	38.6 (6.4)	All-cause dementia	Medical diagnosis

Lu et al.,[20] 2024	UK	UKB	2006-NR	11.0 (NR)	73,396	White (87%), Asian/British (5%), Black/British (1%), other (2%)	54.1	56.7 (8.0)	27.1 (4.2)	Indirect, submaximal CPET-CE	METs	17.3 (3.3)	Alzheimer's disease	Medical records
Meernik et al.,[21] 2024	US	CCLS	1987-2019	9.2 (5.8)	9095	White, non-Hispanic	22.5	50.6 (8.4)	25.8 (3.9)	Indirect, maximal CPET-TM	METs	11.4 (2.6)	All-cause dementia	Medical records
Nyberg et al.,[30] 2014	Sweden	SMSCR	1968-2010	25.7 (9.3)	1,174,483	NR	0	18.0 (NR)	NR	Indirect, maximal CPET-CE	Peak workload (W_{max}/kg)	NR	All-cause dementia	Medical records
Nyberg et al.,[43] 2017	Sweden	SMSCR	1968-2010	24.9 (9.6)	1,109,786	NR	0	18.0 (NR)	21.7 (2.7)	Indirect, maximal CPET-CE	Peak workload (W_{max})	NR	Psychotic and other disorders [f]	Medical records
Shigdel et al.,[29] 2019	Norway	HUNT	1995-2008	11.0 (NR)	14,020	White, European	52.0	52.2 (9.0)	26.4 (3.7)	Indirect, prediction equation	VO_{2max} (ml/kg/min)	38.7 (7.0)	Anxiety, depression	Self-reported symptoms (HADS-A/D)
Sui et al.,[28] 2009	US	ACLS	1970-1995	12.0 (NR)	14,343	White [e], non-Hispanic	22.0	44.9 (9.7)	25.0 (3.3)	Indirect, maximal CPET-TM	METs	11.5 (2.5)	Depression	Self-reported symptoms (CES-D-20)
Tari et al.,[27] 2019	Norway	HUNT	1984-2016	7.5 (3.1)	30,375	White, European	52.4	53.5 (13.1)	26.6 (3.9)	Indirect, prediction equation	VO_{2max} (ml/kg/min)	37.5 (8.1)	All-cause dementia	Medical records
Veronese et al.,[26] 2017	Italy	ProVA	1995-NR	4.4 (NR)	970	White [e], European	54.6	72.5 (6.0)	27.9 (4.4)	Indirect, submaximal FBT-6MWT	Distance (meters)	377.3 (84.2)	Depression	Self-reported symptoms (GDS)

Wang et al.,[22] 2024	UK	UKB	2006-2022	11.7 (0.2)	61,214	White (87%)	52.0	56.3 (8.2)	27.1 (4.3)	Indirect, submaximal CPET-CE	METs	NR	All-cause dementia	Medical records
Wiklund et al.,[25] 2024	Sweden	HPA	1982-2020	10.0 (5.5)	330,247	NR	46.2	42.4 (11.1)	25.6 (4.1)	Indirect, submaximal CPET-CE	VO_{2max} (ml/kg/min)	36.4 (10.0)	Depression	Medical records
Wiklund et al.,[24] 2024b	Sweden	SMSCR	1972-2020	NR	131,431	NR	0	18.3 (0.7)	21.8 (2.7)	Indirect, maximal CPET-CE	VO_{2max} (ml/kg/min)	47.5 (6.7)	Anxiety, depression	Medical records
		HPA		8.3 (5.4)				42.9 (8.9)	26.5 (3.8)	Indirect, submaximal CPET-CE		36.6 (9.9)		
Willis et al.,[23] 2018	US	CCLS	1971-2009	6.5 (NR)	17,989	White, non-Hispanic	19.8	50.0 (8.7)	25.7 (3.4)	Indirect, maximal CPET-TM	METs	10.6 (1.7)	Depression	Medical records

Reference numbers correspond to those used in the main manuscript. [a] Main cohort or register of included studies, which in many cases are linked to other national registers. [b] Values are reported as means ± SD or range. [c] Most race/ethnicity data refers to the predominant group in each cohort; when percentages were reported in the original studies, these are specified in the table. [d] Medical records and registries include data from diagnosis codes submitted by healthcare providers, clinical interviews, and/or hospitalizations. [e] Reported as "Caucasian White" or "Caucasian". [f] Neurotic, obsessive–compulsive, stress-related and somatoform disorders.

Abbreviations: ACLS, Aerobics Center Longitudinal Study; BDI–II, Beck Depression Inventory Scale–version II; BMI, body mass index; CCLS, Cooper Center Longitudinal Study; CES-D, Center for Epidemiologic Studies Depression Scale-10 or 20 items; CPET-CE, cardiopulmonary exercise test-cycle ergometer; CPET-TM, cardiopulmonary exercise test-treadmill; ECPBHS, Estonian Children Personality Behavior and Health Study; ELSA, Longitudinal Study of Adult Health; EYHS, European Youth Heart Study; FBT, field-based test; GAD-7, Generalized Anxiety Disorder-7 items; GDS, Geriatric Depression Scale; HADS-A, Hospital Anxiety and Depression Scale–Anxiety subscale; HADS-D, Hospital Anxiety and Depression Scale–Depression subscale; HPA, Health Profile Assessment; HUNT, Trøndelag Health Study; 7-HS, 7-point Hyperactivity Scale; K-MMSE, Korean-Mini Mental State Examination); KIHD, Kuopio Ischemic Heart Disease study; KLoSA, Korean Longitudinal Study of Aging; MET, metabolic equivalent of task; MS, Maastricht Study; 6MWT, 6-Minute Walk Test; NA, not applicable; NHIRD, National Health Insurance Research Database; NR, not reported; NSFTD, National Student Fitness Tests Database; PHQ–9, Patient Health Questionnaire 9; PPSW, Prospective Population Study of Women; ProVA, Progetto Veneto Anziani study; SCI, severe cognitive disorder; SHIP, Study of Health in Pomerania; SMSCR, Swedish Military Service Conscription Register; UK, United Kingdom; UKB, UK Biobank; US, United States of America; VO_{2max}, maximum oxygen consumption; VO_{2peak}, peak oxygen consumption; W_{max}, maximum workload in watts.

Table S3. Exposure analysis, effect sizes, main results, and covariate adjustments of included studies.

Reference	CRF analysis	Outcome	Effect size	Incident cases, %	Result	Covariate adjustment
Aberg et al., 2012	High (stanine score 7–9) vs. low (stanine score 1–3)	Depression	HR (95% CI)	1.1	0.55 (0.50–0.61)	Calendar year, BMI, region, conscription test center, and parental education
Baumeister et al., 2017	Continuous (per 1-SD increase)	Anxiety	HR (95% CI)	16.9	0.69 (0.50–0.95)	Age, sex, BMI, marital status, household income, education level, mode of transportation, smoking and drinking status, presence of abnormal sleeping duration, alternated sleep phase, and severe medical conditions
		Depression		10.7	0.88 (0.82–0.93)	
Becofsky et al., 2015	High (Q5) vs. low (Q1) [a]	Depression	OR (95% CI)	17.0	0.53 (0.42–0.65)	Age, baseline examination year, survey response year, current smoking, alcohol intake, physical activity level, percentage of body fat, and personal history of hypertension, diabetes, and hypercholesterolemia
Chiang et al., 2024	Continuous (per 30-s decrease)	ADHD	HR (95% CI)	0.6	0.93 (0.92–0.94)	Age, BMI, comorbidities, urbanization, and birth years
	High (♀4.1 min, ♂3.8 min) vs. low (♀5.3 min, ♂5.1 min)				0.80 (0.73–0.86)	
	Continuous (per 30-s decrease)	Anxiety		0.7	0.97 (0.96–0.98)	
	High (♀4.1 min, ♂3.8 min) vs. low (♀5.3 min, ♂5.1 min)				0.91 (0.85–0.97)	
	Continuous (per 30-s decrease)	Depression		0.4	0.97 (0.96–0.99)	
	High (♀4.1 min, ♂3.8 min) vs. low (♀5.3 min, ♂5.1 min)				0.96 (0.88–1.05)	
Crump et al., 2019	Continuous (per 100 W increase)	Sleep apnea	RR (95% CI)	2.9	0.71 (0.70–0.73)	Year of conscription examination, muscular strength, height, weight, education level, neighborhood socioeconomic status, and family history of sleep apnea
	High (≥289 W) vs. low (<240 W)				0.69 (0.67–0.71)	

DeFina et al., 2013	Continuous (per 1 MET increase) High (13.3 MET) vs. low (8.1 MET)	All-cause dementia	HR (95% CI)	8.5	0.93 (0.90−0.95) 0.64 (0.54−0.77)	Age, sex, examination year, examination age × follow-up time, hypertension, fasting glucose level, current tobacco use, BMI, total cholesterol level, hyperlipidemia, systolic blood pressure, and diabetes
Dishman et al., 2012	Continuous (per 1 min decline)	Depression	OR (95% CI)	6.5	0.99 (0.98−1.00)	Age, time between visits, BMI, smoking, alcohol use, number of medical conditions, anxiety, and sleep problems
Gafni et al., 2023	Continuous (per 1 MET increase) High (top 80%) vs. low (bottom 20%) [b]	All-cause dementia	HR (95% CI)	9.8	0.95 (0.90−0.99) 0.54 (0.39−0.76)	Age, sex, education, fasting glucose, total cholesterol, and resting systolic blood pressure
Gianfredi et al., 2021	Continuous (NR) High (2.7 W_{max}) vs. low (1.6 W_{max})	Depression	HR (95% CI)	9.6	0.56 (0.38−0.83) 0.52 (0.33−0.83)	Age, sex, level of education, diabetes status, lifestyle risk factors as smoking status, alcohol use, energy intake, waist circumference, use of antidepressant medication, moderate to vigorous physical activity, mobility limitations, and history of cardiovascular disease
Hietanen et al., 2013	Continuous (NR)	All-cause dementia	HR (95% CI)	3.2	0.84 (0.73−0.96)	Age, sex, smoking, physical working capacity, self-reported elevated cholesterol and abnormal blood glucose, early parental cardiovascular disease, and resting brachial systolic blood pressure
Horder et al., 2018	High (≥120 W) vs. medium (88-112 W)	All-cause dementia	HR (95% CI)	23.0	0.12 (0.03−0.54)	Age, body height, triglycerides, smoker, hypertension, wine consumption, physical inactivity, and income
Kandola et al., 2020	Continuous (per 1 MET increase) High (12.5 MET) vs. low (7.2 MET) Continuous (per 1 MET increase) High (12.5 MET) vs. low (7.2 MET)	Anxiety Depression	OR (95% CI)	NR NR	-1.2% (-2% to -0.3%) 0.81 (0.67−0.98) -2.4% (-3% to -1.8%) 0.63 (0.54−0.73)	Age, sex, deprivation, smoking status, baseline symptoms, physical activity, education, parental depression, chronic illness, and diet

Kunutsor et al., 2024	Continuous (per 1-SD increase, ~8 ml/kg/min) High (21.8 ml/kg/min) vs. low (35.5 ml/kg/min)	Psychotic disorders	HR (95% CI)	9.7	0.84 (0.70−1.00 0.77 (0.53−1.10)	Age, total cholesterol, smoking status, prevalent type 2 diabetes and coronary heart disease, years of education, alcohol consumption, total energy intake, socioeconomic status, physical activity, high-sensitivity C-reactive protein, and frequency of sauna bathing
Kurl et al., 2018	High (>36.5 ml/kg/min) vs. low (<23.7 ml/kg/min)	All-cause dementia	RR (95% CI)	11.5	0.51 (0.33−0.81)	Age, examination year, cigarette smoking, alcohol consumption, systolic blood pressure, prevalent coronary heart disease, and type 2 diabetes mellitus
Lerfald et al., 2024	High (NR) vs. low (NR)	All-cause dementia	OR (95% CI)	13.4	0.67 (0.58−0.77)	Sex, education, marital status, diabetes, and APOE ε4
Lu et al., 2024	Continuous (per 1 MET increase)	Alzheimer's disease	HR (95% CI)	1.4	0.68 (0.63−0.73)	Age, sex, Townsend index of deprivation, smoking status, diabetes status, hypertension, and BMI
Meernik et al., 2024	Continuous (per 1 MET increase)	All-cause dementia	HR (95% CI)	12.6	0.95 (0.92−0.98)	Age, sex, clinic examination year, current smoking, education, CRF, caloric intake, BMI, fasting glucose, total cholesterol, and resting systolic blood pressure
Nyberg et al., 2014	High (stanine score 7−9) vs. low (stanine score 1−3)	All-cause dementia	HR (95% CI)	0.1	0.52 (0.39−0.70)	Calendar year, BMI, region, conscription test center, parental education, and CRF at age 18
Nyberg et al., 2017	High (stanine score 8−9) vs. low (stanine score 1−4)	Psychotic disorders Neurotic, stress-related and somatoform disorders	HR (95% CI)	0.9 1.6	0.70 (0.65−0.76) 0.69 (0.65−0.73)	Calendar year, BMI, region, parental education, intelligence quotient
Shigdel et al., 2019	Continuous (per 1 MET increase) High (41.0 ml/kg/min) vs. low (30.6 ml/kg/min)	Anxiety	OR (95% CI)	6.0	0.98 (0.95–1.01) 0.92 (0.83–1.02)	Age, sex, marital status, smoking, alcohol intake, education, diabetes, hypertension, depressive symptom severity, and limiting long term illness

	Continuous (per 1 MET increase)	Depression		7.2	0.89 (0.86–0.92)	Age, sex, marital status, smoking, alcohol intake, education, diabetes, hypertension, anxiety depressive severity, and limiting long term illness
	High (41.0 ml/kg/min) vs. low (30.6 ml/kg/min)				0.74 (0.66–0.83)	
Sui et al., 2009	Continuous (per 1 MET increase)	Depression	OR (95% CI)	7.1	0.91 (0.88–0.93)	Age, baseline examination year, and survey response year
	High (upper 40%) vs. low (lowest 20%) [a]				0.52 (0.43–0.64)	Age, baseline examination year, survey response year, stressful occupation, current smoking, alcohol consumption, body mass index, hypertension, diabetes, and abnormal exercise electrocardiogram responses
Tari et al., 2019	Continuous (per 1 MET increase)	All-cause dementia	HR (95% CI)	1.1	0.84 (0.75–0.93)	Age, sex, smoking status, BMI, diabetes, education, hypertension, cholesterol, and family history of stroke
	High (38.1 ml/kg/min) vs. low (31.3 ml/kg/min) [c]				0.56 (0.39–0.82)	
Veronese et al., 2017	High (♀ >385 m, ♂ >444 m) vs. low (♀ <320 m, ♂ <376 m)	Depression	OR (95% CI)	21.3	0.53 (0.34–0.81)	Age, BMI, preserved activities of daily living, baseline scores in the Mini Mental State Examination and Geriatric Depression Scale, physical activity, smoking habits, monthly income, and presence at the baseline of cardiovascular diseases, hypertension, fractures, chronic obstructive pulmonary disease, and cancer
Wang et al., 2024	Continuous (per 1-SD increase, ~0.5 MET)	All-cause dementia	RR (95% CI)	0.9	0.81 (0.73–0.89)	Age, race, socioeconomic status, education, body mass index, smoking status, alcohol consumption, physical activity, social connection, diabetes, hypertension, cardiovascular disease, dyslipidemia, global cognitive function, and polygenic risk score for Alzheimer's disease
	High (-1.02 MET) vs. low (1.12 MET)				0.60 (0.48–0.76)	
Wiklund et al., 2024	Continuous (per 1ml/kg/min increase)	Depression	HR (95% CI)	0.8	0.99 (0.99–1.00)	Sex, age, educational level, exercise habits, smoking, BMI, somatic and psychiatric co-morbidity, overall perceived health, and use of mood stabilizing medication at baseline, insomnia, and perceived loneliness
	High (≥46 ml/kg/min) vs. low (<25 ml/kg/min)				0.79 (0.65–0.96)	

Wiklund et al., 2024b	Continuous (NR)	Anxiety	HR (95% CI)	1.2	0.90 (0.83–0.98)	Age, BMI, body weight, year, CRF, conscription test side, intelligence quotient, and lifetime somatic and psychiatric comorbidity at late adolescence, and age, body weight, CRF, stress, loneliness, overall health status, smoking, and weekly exercise in adulthood
		Depression		1.5	0.94 (0.87–1.01)	
Willis et al., 2018	Continuous (per 1 min decline)	Depression	HR (95% CI)	15.0	0.95 (0.93–0.97)	Age, sex, examination year, systolic blood pressure, total cholesterol level, body mass index, smoking status, and sex × stratum interaction
	High (12.3 MET) vs. low (8.1 MET) [a]				0.84 (0.74–0.95)	

[a] According to previous defined sex- and age-specific fitness quintiles for this cohort, detailed in previous studies: Sui X, LaMonte MJ, Blair SN. Cardiorespiratory fitness as a predictor of nonfatal cardiovascular events in asymptomatic women and men. *Am J Epidemiol*. 2007;165(12):1413-23. doi: 10.1093/aje/kwm031. [b] The unfit and fit categories were defined based on the lower 20% and the remaining 80% of the sex- and age-standardized fitness distribution, respectively, detailed in previous studies: Farrell SW, Finley CE, Radford NB, Haskell WL. Cardiorespiratory fitness, body mass index, and heart failure mortality in men: Cooper Center Longitudinal Study. *Circ Heart Fail*. 2013;6(5):898-905. doi: 10.1161/CIRCHEARTFAILURE.112.000088. [c] The unfit and fit categories were defined based on the lower 20% and the remaining 80% of the sex- and age-standardized fitness distribution, respectively, detailed in previous studies: Lee DC, Sui X, Ortega FB, Kim YS, Church TS, Winett RA, Ekelund U, Katzmarzyk PT, Blair SN. Comparisons of leisure-time physical activity and cardiorespiratory fitness as predictors of all-cause mortality in men and women. *Br J Sports Med*. 2011;45(6):504-10. doi: 10.1136/bjsm.2009.066209.

Abbreviations: ADHD, attention-deficit/hyperactivity disorder; BMI, body mass index; CRF, cardiorespiratory fitness; HR, hazard ratio; kg, kilograms; m, meters; MET, metabolic equivalent of task; min, minute; ml, milliliters; NR, not reported; OR, odds ratio, RR, risk ratio; s, seconds; SD, standard deviation; W, Watts.

Table S4. Methodological quality assessment of included studies.[a]

Reference	1	2	3	4	5	6	7	8	9	10	11	12	13	14 [b]	Score	Quality [c]
Aberg et al., 2012	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	13	Good
Baumeister et al., 2017	Y	Y	Y	Y	Y	Y	Y	N	N	N	Y	Y	N	Y	10	Fair
Becofsky et al., 2015	Y	N	CD	Y	Y	Y	Y	Y	N	N	N	N	N	Y	7	Fair
Chiang et al., 2024	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	12	Good
Crump et al., 2019	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	13	Good
DeFina et al., 2013	Y	Y	CD	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	11	Good
Dishman et al., 2012	Y	Y	N	Y	Y	Y	Y	N	Y	Y	N	N	CD	Y	10	Fair
Gafni et al., 2023	Y	Y	CD	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	12	Good
Gianfredi et al., 2021	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N	Y	9	Fair
Hietanen et al., 2013	Y	Y	CD	Y	N	Y	Y	N	N	N	Y	Y	Y	Y	9	Fair
Horder et al., 2018	Y	Y	Y	Y	N	Y	Y	Y	Y	N	Y	Y	N	Y	11	Good
Kandola et al., 2020	Y	CD	N	Y	Y	Y	Y	Y	N	N	N	N	N	Y	7	Fair
Kunutsor et al., 2024	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	13	Good
Kurl et al., 2018	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	12	Good
Lerfald et al., 2024	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y	N	Y	11	Good
Lu et al., 2024	Y	Y	N	Y	Y	Y	Y	N	Y	N	Y	Y	CD	Y	10	Fair
Meernik et al., 2024	Y	Y	CD	Y	Y	Y	Y	N	Y	N	Y	Y	CD	Y	10	Fair
Nyberg et al., 2014	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	13	Good
Nyberg et al., 2017	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	13	Good
Shigdel et al., 2019	Y	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N	Y	9	Fair
Sui et al., 2009	Y	Y	CD	Y	Y	Y	Y	Y	Y	Y	N	N	CD	Y	10	Fair
Tari et al., 2019	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y	Y	Y	12	Good
Veronese et al., 2017	Y	Y	N	Y	N	Y	Y	Y	N	N	N	N	N	Y	7	Fair
Wang et al., 2024	Y	Y	N	Y	Y	Y	Y	Y	Y	N	Y	Y	CD	Y	11	Good
Wiklund et al., 2024	Y	Y	CD	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	12	Good
Wiklund et al., 2024b	Y	Y	CD	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	12	Good
Willis et al., 2018	Y	Y	CD	Y	Y	Y	Y	Y	Y	N	Y	Y	CD	Y	11	Good

[a] Numbers represent the questions included in the National Institutes of Health's Quality Assessment Tool for Observational Cohort Studies: 1. Question clear? 2. Population clearly defined? 3. >50% participants? 4. Recruitment populations consistent? 5. Sample size justified? 6. Exposure assessed prior to outcome? 7. Sufficient timeframe? 8. Different exposure levels? 9. Valid exposure? 10. Repeated exposure assessment? 11. Valid outcomes? 12. Outcome assessors blinded? 13. Loss to follow up <20%? 14. Confounders adjusted for? [b] Although all cohort studies adjust for covariates pertinent to the study associations, certain crucial confounding factors have been inadequately considered in risk estimation models for mental and neurocognitive disorders, such as diet quality, medicines, or family history of mental illness. [c] Each cohort study was rated as good, fair, or poor according to quality rating guide. Abbreviations: CD, cannot determine; N, no; Y, yes.

Table S5. GRADE assessment of the certainty of evidence for high vs. low cardiorespiratory fitness.

Certainty assessment							Population		Effect		Certainty
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication bias	Events	Total	Relative (95% CI)	Absolute (95% CI)	
Anxiety											
2	Prospective cohort	very serious [a]	very serious [b]	not serious	very serious [c]	Not assessed [d]	1009 (2.8%)	36,687	HR 0.90 (0.75 to 1.09)	1 fewer per 1000	⊕◯◯◯ Very low [a,b,c,d]
Depression											
9	Prospective cohort	very serious [a]	very serious [b]	not serious	not serious	Not assessed [d]	18,958 (1.3%)	1,504,915	HR 0.64 (0.56 to 0.74)	1 fewer per 1000	⊕◯◯◯ Very low [a,b,d]
All-cause dementia											
7	Prospective cohort	not serious	not serious	not serious	not serious	Not assessed [d]	3428 (0.3%)	1,287,561	HR 0.61 (0.55 to 0.68)	1 fewer per 1000	⊕⊕⊕◯ Moderate [d]
Psychotic disorders											
2	Prospective cohort	not serious	not serious	not serious	very serious [c]	Not assessed [d]	10,420 (0.9%)	1,112,007	HR 0.71 (0.65 to 0.77)	1 fewer per 1000	⊕◯◯◯ Very low [c,d]

Abbreviations: CI: confidence interval; HR: hazard ratio.

Following guidance for the use of the GRADE approach for prognostic research, evidence from prospective cohort studies was rated as 'high' certainty at baseline (Reference: Iorio A, Spencer FA, Falavigna M, et al. Use of GRADE for assessment of evidence about prognosis: rating confidence in estimates of event rates in broad categories of patients. *BMJ.* 2015;350. doi:10.1136/BMJ.H870).

Explanations: certainty of evidence was downgraded by serious (one level) or very serious (two levels) concerns for: a) risk of bias: ≥80% of the studies were classified as having fair methodological quality; b) inconsistency: variability in effect sizes across studies and moderate to substantial between-study heterogeneity ($I^2 \geq 50\%$), potentially attributable to differences in outcome assessment; c) imprecision: crossing line of no significant association and/or limited number of studies (n=2) without estimation of prediction interval; and d) publication bias not assessed (n < 10 studies).

Table S6. GRADE assessment of the certainty of evidence for 1-MET increase in cardiorespiratory fitness.

Certainty assessment							Population		Effect		Certainty
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication bias	Events	Total	Relative (95% CI)	Absolute (95% CI)	
Depression											
5	Prospective cohort	serious [a]	not serious	not serious	very serious [b]	Not assessed [c]	6158 (1.7%)	362,256	HR 0.95 (0.92 to 0.98)	1 fewer per 1000	⊕◯◯◯ Very low [a,b,c]
All-cause dementia											
5	Prospective cohort	not serious	very serious [d]	not serious	very serious [b]	Not assessed [c]	2971 (2.4%)	123,229	HR 0.81 (0.67 to 0.98)	1 fewer per 1000	⊕◯◯◯ Very low [b,c,d]

Abbreviations: CI: confidence interval; HR: hazard ratio.

Following guidance for the use of the GRADE approach for prognostic research, evidence from prospective cohort studies was rated as 'high' certainty at baseline (Reference: Iorio A, Spencer FA, Falavigna M, et al. Use of GRADE for assessment of evidence about prognosis: rating confidence in estimates of event rates in broad categories of patients. *BMJ.* 2015;350. doi:10.1136/BMJ.H870).

Explanations: certainty of evidence was downgraded by serious (one level) or very serious (two levels) concerns for: a) risk of bias: ≥60% of the studies were classified as having fair methodological quality; b) imprecision: wide, nonsignificant prediction interval; c) publication bias not assessed (n < 10 studies); and d) inconsistency: considerable heterogeneity ($I^2 \geq 90\%$).

Table S7. Subgroup analyses stratified by participant age and sex, methodological quality of included studies, and by exposure and outcome measures.

High *vs.* low CRF	N/n	HR (95% CI)	*P* value	*P* value subgroup	I^2 (%)	*P* value
Depression						
Adult age group[a]				.966		
<50 years	5/3	0.64 (0.52–0.79)	<.001		80.2	.006
≥50 years	4/4	0.65 (0.52–0.80)	<.001		53.4	.092
Sex				.547		
Female	3/2	0.51 (0.39–0.66)	<.001		0	.789
Male	4/3	0.55 (0.51–0.60)	<.001		0	.931
Methodological quality				.939		
Good	2/2	0.66 (0.47–0.91)	.013		90.1	.002
Fair	7/5	0.65 (0.55–0.76)	<.001		39.2	.160
CRF assessment method				.238		
Indirect, maximal	4/2	0.56 (0.50–0.63)	<.001		0	.515
Indirect submaximal	4/4	0.64 (0.53–0.78)	<.001		48.1	.123
Indirect, prediction equation	1	0.81 (0.66–0.99)	NA		NA	NA
Outcome measure				.326		
Clinical diagnosis	3/3	0.71 (0.55–0.92)	.009		93.3	<.001
Self-reported symptoms	6/5	0.61 (0.51–0.73)	<.001		67.9	.014
All-cause dementia						
Adult age group[a]				.639		
<50 years	5/3	0.62 (0.54–0.70)	<.001		0	.393
≥50 years	2/2	0.60 (0.47–0.72)	<.001		0	.543
Sex				.224		
Female	1	0.68 (0.56–0.83)	NA		NA	NA
Male	3/3	0.58 (0.47–0.70)	<.001		0	.450
Methodological quality [b]				NA		
Good	7/5	0.61 (0.55–0.68)	<.001		0	.625
CRF assessment method				.646		
Direct, maximal	1	0.51 (0.33–0.81)	NA		NA	NA
Indirect, maximal	3/2	0.59 (0.49–0.70)	<.001		0	0.323
Indirect submaximal	1	0.60 (0.48–0.76)	NA		NA	NA
Indirect, prediction equation	2/1	0.65 (0.57–0.75)	NA		NA	NA
1-MET increase in CRF						
Depression						
Adult age group[a]				.328		
<50 years	4/2	0.96 (0.93–0.98)	.002		21.6	.259
≥50 years	1	0.65 (0.52–0.80)	NA		NA	NA
Sex				NA		
Female	1/1	0.99 (0.97–1.01)	NA		NA	NA
Male	1/1	0.99 (0.98–1.00)	NA		NA	NA
Methodological quality				.317		
Good	2/2	0.96 (0.94–0.97)	<.001		0	.350
Fair	3/2	0.93 (0.88–0.98)	.005		0	.659
CRF assessment method						
Indirect, maximal	3/1	0.94 (0.90–0.98)	NA		NA	NA
Indirect submaximal	1	0.97 (0.95–1.00)	NA		NA	NA
Indirect, prediction equation	1	0.92 (0.86–0.99)	NA		NA	NA
Outcome measure				.317		
Clinical diagnosis	2/2	0.96 (0.94–0.97)	<.001		0	.350
Self-reported symptoms	3/2	0.93 (0.88–0.98)	.005		0	.659

All-cause dementia					
Adult age group[a]			.639		
<50 years	1	0.93 (0.91–0.96)	NA	NA	NA
≥50 years	4/3	0.82 (0.67–0.99)	.041	97.3	<.001
Sex			NA		
Female	1/1	0.76 (0.72–0.79)	NA	NA	NA
Male	1/1	0.80 (0.77–0.83)	NA	NA	NA
Methodological quality			.520		
Good	3/2	0.90 (0.82–0.99)	.031	72.4	.057
Fair	2/2	0.80 (0.58–1.12)	.194	98.5	<.001
CRF assessment method					
Indirect, maximal	3/1	0.93 (0.91–0.95)	NA	NA	NA
Indirect submaximal	1	0.68 (0.63–0.73)	NA	NA	NA
Indirect, prediction equation	1	0.84 (0.75–0.93)	NA	NA	NA

[a] Defined according to mean age of participants at baseline. [b] All cohort studies were rated as good quality.
N/n indicates the number of studies/comparisons included in each analysis. There is insufficient data to perform a sex-specific meta-analysis between 1-MET increase in CRF and the risk of both depression and all-cause dementia.
Abbreviations: CI, confidence interval; CRF, cardiorespiratory fitness; HR, hazard ratio; NA, not applicable.

Table S8. Sensitivity analyses according to the effect estimate reported in the included studies.

High *vs.* low CRF	N/n	Effect estimates (95% CI)	*P* value	*P* value subgroup	I^2 (%)	*P* value
Depression						
High *vs.* low CRF				.554		
Hazard ratio	5/4	0.68 (0.54–0.86)	<.001		90.3	<.001
Odds ratio	4/4	0.62 (0.51–0.76)	<.001		74.9	.008
1-MET increase in CRF				.317		
Hazard ratio	2/2	0.96 (0.94–0.97)	<.001		0	.350
Odds ratio	3/2	0.93 (0.88–0.98)	.005		0	.659
All-cause dementia						
High *vs.* low CRF				.376		
Hazard ratio	5/4	0.58 (0.51–0.66)	<.001		0	0.706
Odds ratio	1	0.67 (0.58–0.77)	NA		NA	NA
Risk ratio	1	0.60 (0.48–0.76)	NA		NA	NA
1-MET increase in CRF				NA		
Hazard ratio	5/3	0.81 (0.67–0.97)	.025		97.1	<.001

N/n indicates the number of studies/comparisons included in each analysis.
Abbreviations: CI, confidence interval; CRF, cardiorespiratory fitness; MET, metabolic equivalent of task; NA, not applicable.

Table S9. Recommendations for future studies on the associations of cardiorespiratory fitness with mental and neurocognitive disorders in non-clinical populations.

Study domain	Recommendations
Population	Future studies should include representative samples spanning all age groups and provide stratified analyses by age, sex, socioeconomic status, family history of mental and neurocognitive disorders, and health status (e.g., multimorbidity patterns). Special attention should be given to populations underrepresented in current evidence, including children, adolescents, and older adults, as well as populations from low- and middle-income countries, racially and ethnically diverse groups, and underrepresented geographic regions such as Africa, Asia, Latin America and the Caribbean, and Oceania.
Exposure (CRF)	Future studies should employ standardized and validated methods to assess CRF, with clear and detailed definitions. Repeated assessments over time are recommended to capture within-person variability and long-term changes in CRF. Measurement protocols, device types, test procedures, and classification criteria (e.g., high vs. low categories) should be clearly reported to enable harmonization across studies. Continuous CRF metrics (e.g., per 1-MET increase) should complement categorical comparisons, and CRF values should be reported in sufficient detail to enable robust dose–response meta-analyses, which are essential for identifying clinically relevant thresholds of CRF for mental and neurocognitive health outcomes. When CRF is analyzed categorically, the value ranges used to define each category should be explicitly stated to facilitate comparability and clinical interpretation. Importantly, more studies using direct, laboratory-based CRF measurements are needed to determine whether the strength of association differs from that observed with indirect assessments. Finally, future research should also consider relative measures of CRF, normalizing fitness levels to individual characteristics such as fat-free mass, to improve comparability and accuracy of associations.
Outcome (mental and neurocognitive disorders)	Future cohort studies should investigate mental disorders that are currently unstudied or understudied, including anxiety disorders; schizophrenia spectrum and other psychotic disorders; disruptive, impulse-control, and conduct disorders; dissociative disorders; elimination disorders; feeding and eating disorders; medication-induced movement disorders and other adverse effects of medication; other neurocognitive disorders (i.e., delirium); neurodevelopmental disorders (i.e., attention-deficit/hyperactivity disorder, autism spectrum disorders, communication disorders, intellectual developmental disorders, motor disorders, and specific learning disorders); personality disorders; paraphilic disorders; sexual dysfunctions; and substance-related and addictive disorders. Where possible, future research should apply standardized diagnostic criteria (DSM-5-TR or ICD-10) and report symptom severity (e.g., mild, moderate, severe). Analyses stratified by the type of mental health assessment (e.g., clinical diagnoses vs. self-reported symptom severity) and by symptom dimension (e.g., cognitive, mood, somatic) are encouraged to capture distinct constructs and clinical relevance. Finally, repeated longitudinal assessments of mental health outcomes (e.g., incident trajectories, symptom progression) are essential to establish temporal directionality and reduce biases such as reverse causation and outcome misclassification.
Study design	Long-term prospective cohort studies are warranted to minimize reverse causality and strengthen causal inference. Such studies should enroll participants free of mental and neurocognitive disorders at baseline and ensure sufficiently long follow-up to capture incident cases, while maintaining high retention rates (>80%). Standardizing CRF exposure definitions, increasing the frequency of exposure assessments, and adjusting for key confounders (e.g., genetics, socioeconomic status, body mass index, physical activity, sleep, multimorbidity patterns) will enhance internal validity. Future studies are encouraged to use time-to-event models (e.g., hazard ratios) or cumulative incidence models (e.g., risk ratios), as these yield interpretable and temporally sensitive estimates of risk for mental and neurocognitive disorder onset. When data

	permit, multistate models should also be considered to capture transitions between health states (e.g., from healthy to subclinical symptoms to disorder onset), competing risks (e.g., death), and recovery or relapse, thereby providing a more nuanced understanding of disease dynamics over time. Additionally, genetically informed designs (e.g., Mendelian randomization studies) could help clarify the causal direction and disentangle genetic from behavioral or environmental contributions to these associations. Approaches such as linkage disequilibrium score regression could further quantify genetic correlations, providing complementary evidence on shared genetic architecture even in the absence of genome-wide significant variants. Finally, randomized controlled trials investigating the causal effects of improving CRF on mental and neurocognitive outcomes are warranted to complement the cohort evidence and inform precision prevention strategies.
Other considerations	Future studies should incorporate biomarker assessments—such as inflammatory, vascular, metabolic, and neurodegenerative markers—to elucidate the biological mechanisms linking CRF with mental and neurocognitive disorders. The integration of multi-omics approaches, including genomic, epigenetic, transcriptomic, metabolomic, and proteomic profiling, together with neuroimaging measures, may further clarify the underlying biological pathways and identify potential targets for prevention and intervention.

Abbreviations: CRF, cardiorespiratory fitness; DSM-5-TR, Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition-Text Revision; ICD-10, International Classification of Diseases, 10th Revision; VO_{2max}, maximum oxygen consumption.

Table S10. Detailed information on search strategies.

Information source	Method
Databases:[a] PubMed,[b] PsychINFO,[b] Scopus,[c] SPORTDiscus,[b] Web of Science[c]	("cardiorespiratory fitness" OR "physical fitness" OR "cardiovascular fitness" OR "cardiopulmonary fitness" OR "aerobic fitness" OR "cardiorespiratory endurance" OR "cardiorespiratory capacity" OR "aerobic endurance" OR "aerobic capacity" OR "exercise capacity") AND ("mental disorder" OR depress* OR mood OR "premenstrual dysphoric disorder" OR anxi* OR phobia OR "panic disorder" OR "neurocognitive disorder" OR "cognitive decline" OR "cognitive impairment" OR dementia OR "eating disorder" OR "disordered eating" OR anorexia OR bulimia OR "feeding disturbance" OR "eating disturbance" OR "binge eating" OR "sleep disorder" OR "sleep-wake disorder" OR insomnia OR "sleep apnea" OR "sleep problems" OR somnolence OR narcolepsy OR "stress disorder" OR "stress-related exhaustion" OR "stressor-related disorder" OR "psychological distress" OR "psychological stress" OR "posttraumatic stress" OR "neurodevelopmental disorder" OR autism OR "intellectual disorder" OR "learning disorder" OR "attention-deficit hyperactivity disorder" OR bipolar OR psychosis OR psychotic OR schizophrenia OR "substance-related disorder" OR "addictive disorder" OR "somatic symptom disorder" OR "dissociative disorder" OR "obsessive-compulsive disorder") AND (prospective OR cohort OR longitudinal)
Online resource and browsing	Portal (URL): Google Scholar (https://scholar.google.com). Search terms: "cardiorespiratory fitness" AND "mental disorder". The first 100 records (n=10 pages) were selected and screened.
Citation searching	Relevant systematic reviews were kept separate to screen their included studies.[1–4] References of included articles were manually screened to identify additional studies.
Other	PubMed's similar articles search (first 5 records) was performed on all included articles.

[a] Data were retained in Research Information Systems (RIS) or PubMed formats for each database. [b] Search strategy restricted to Title/Abstract. [c] Search strategy restricted to Title/Abstract/Keywords.

References cited in this table:
1. Lang JJ, Prince SA, Merucci K, et al. Cardiorespiratory fitness is a strong and consistent predictor of morbidity and mortality among adults: an overview of meta-analyses representing over 20.9 million observations from 199 unique cohort studies. *Br J Sports Med*. 2024;58(10):556-566. doi: 10.1136/bjsports-2023-107849.
2. Schuch FB, Vancampfort D, Firth J, et al. Physical Activity and Incident Depression: A Meta-Analysis of Prospective Cohort Studies. *Am J Psychiatry*. 2018;175(7):631-648. doi: 10.1176/appi.ajp.2018.17111194.
3. Kandola A, Ashdown-Franks G, Stubbs B, Osborn DPJ, Hayes JF. The association between cardiorespiratory fitness and the incidence of common mental health disorders: A systematic review and meta-analysis. *J Affect Disord*. 2019;257:748-757. doi: 10.1016/j.jad.2019.07.088.
4. Lee J. Influence of Cardiorespiratory Fitness on Risk of Dementia and Dementia Mortality: A Systematic Review and Meta-Analysis of Prospective Cohort Studies. *J Aging Phys Act*. 2021;29(5):878-885. doi: 10.1123/japa.2019-0493.

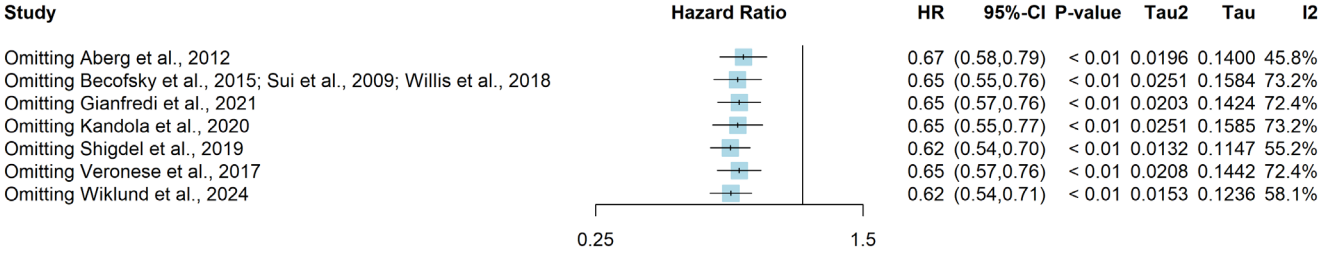


Figure S1. Sensitivity analysis by removing one-by-one cohort studies for the association between high vs. low levels of cardiorespiratory fitness and risk of depression.

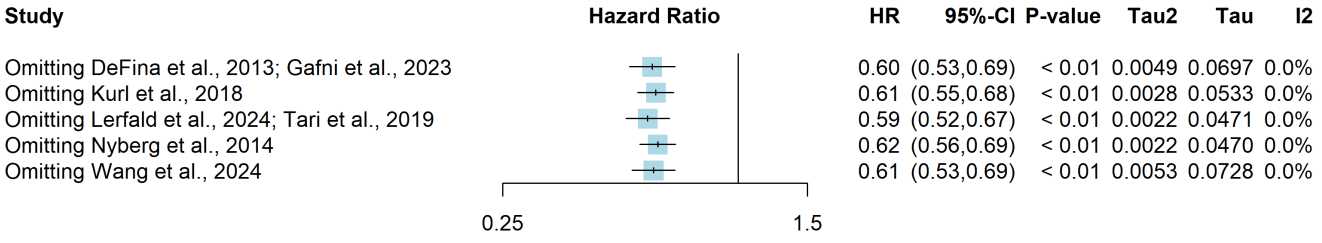


Figure S2. Sensitivity analysis by removing one-by-one cohort studies for the association between high vs. low levels of cardiorespiratory fitness and risk of all-cause dementia.

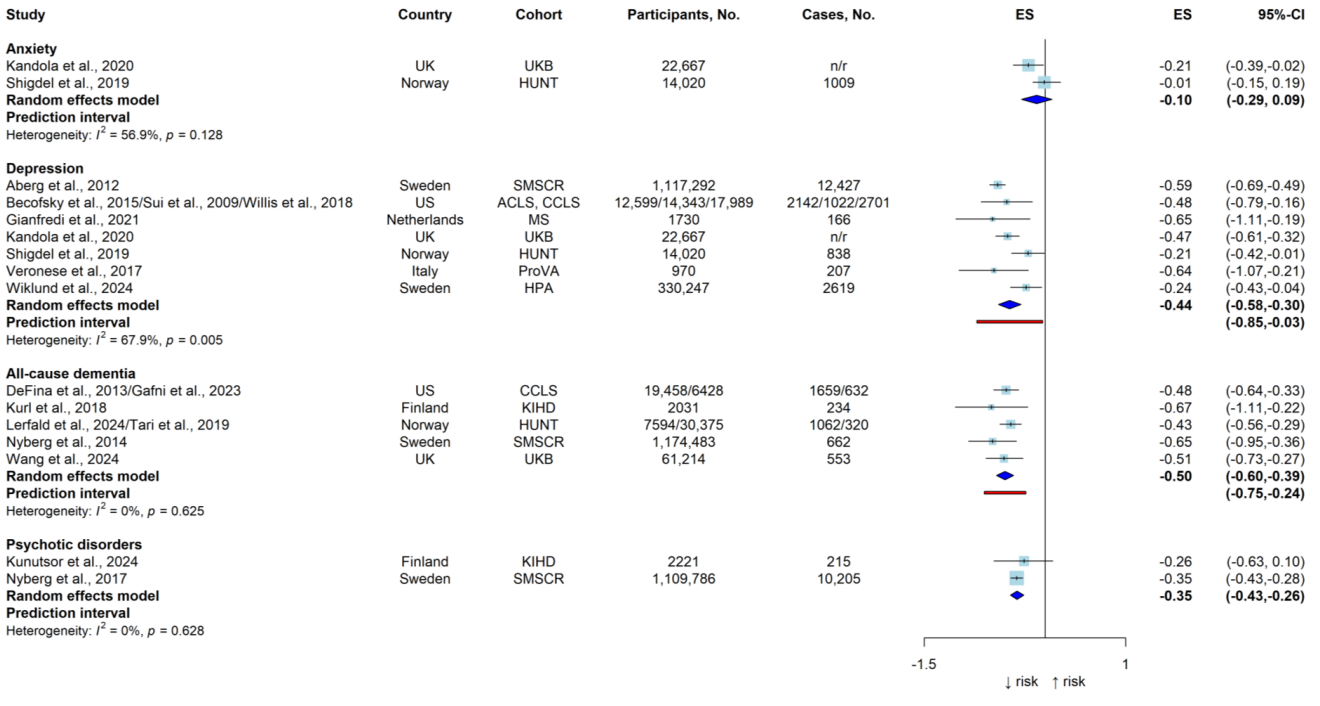


Figure S3. Prospective associations between high vs. low levels of cardiorespiratory fitness and risk of mental and neurocognitive disorders using a standardized effect size (Hedges *g*).

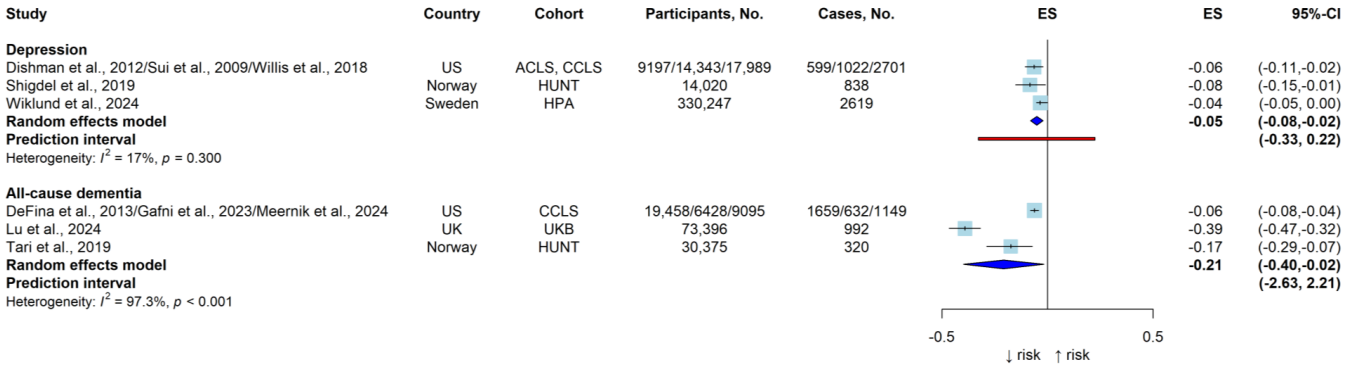


Figure S4. Prospective associations between 1-MET increase in cardiorespiratory fitness and risk of mental and neurocognitive disorders using a standardized effect size (Hedges *g*).

APPENDIX III. PROSPERO PROTOCOL MANUSCRIPTS II-III

Manuscript II: The Associations Between Vegetarian and Vegan Diets and Orthorexia Nervosa Symptoms in Adults: A Systematic Review and Meta-Analysis

Manuscript III: Are vegetarian and vegan diets associated with eating disorder symptoms? A systematic review and meta-analysis

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PROSPERO
International prospective register of systematic reviews

The associations between plant-based diets compared to omnivorous diets and eating disorders/disordered eating in adults: a systematic review with meta-analysis

Valentina Díaz Goñi, Arthur Eumann Mesas, Bruno Bizzozero Peroni

To enable PROSPERO to focus on COVID-19 submissions, this registration record has undergone basic automated checks for eligibility and is published exactly as submitted. PROSPERO has never provided peer review, and usual checking by the PROSPERO team does not endorse content. Therefore, automatically published records should be treated as any other PROSPERO registration. Further detail is provided here.

Citation
Valentina Díaz Goñi, Arthur Eumann Mesas, Bruno Bizzozero Peroni. The associations between plant-based diets compared to omnivorous diets and eating disorders/disordered eating in adults: a systematic review with meta-analysis. PROSPERO 2024 CRD42024527351. Available from https://www.crd.york.ac.uk/PROSPERO/view/CRD42024527351.

REVIEW TITLE AND BASIC DETAILS

Review title
The associations between plant-based diets compared to omnivorous diets and eating disorders/disordered eating in adults: a systematic review with meta-analysis

Review objectives
Does the available evidence support a relationship between a plant-based diet compared to an omnivorous diet and eating disorders/disordered eating behaviors throughout adulthood?

Keywords
adults, Diet, mental disorders

SEARCHING AND SCREENING

Searches
This systematic review will be conducted according to the PRISMA statement (Page et al., 2020, BMJ). A systematic search will be conducted on relevant electonic databases such as MEDLINE (PubMed), Scopus and Web of Science from database inception up to 2024. We will use keywords related to both diet (e.g., vegetarian, plant-based, omnivorous) and eating disorders/disordered eating outcomes. These search terms will be combined with Boolean operators adapted for each database.

Study design
Observational and experimental studies

ELIGIBILITY CRITERIA

Condition or domain being studied
According to the American Psychiatric Association (DSM-5), feeding and eating disorders are characterized by a persistent disturbance of eating or eating-related behavior that results in the altered consumption or absorption of food and that significantly impairs physical health or psychosocial functioning. Feeding and eating disorders include pica, rumination disorder, avoidant/restrictive food intake disorder, anorexia nervosa, bulimia nervosa, binge-eating disorder, other specified eating disorders (purging disorder) and other unspecified eating disorder. Furthermore, the term disordered eating identify some of the different eating behaviors that do not necessarily meet the diagnostic criteria for an eating disorder.

Population
General adult population (+18 years)

Intervention(s) or exposure(s)
Plant-based diet will include both vegan diets (total plant-based nutrition) and lacto-ovo-vegetarian diets (this allows for the consumption of dairy products and eggs).

Comparator(s) or control(s)
Omnivorous diet

Context

Inclusion criteria:
(a) General adult population aged 18+ years;
(b) Exposure: Plant-based term will include both vegan diets (total plant-based nutrition) and lacto-ovo-vegetarian diets (this allows for the consumption of dairy products and eggs); and,
(c) Outcome: feeding and eating disorders, and disordered eating behaviors.
Studies will be excluded if they report:
(a) Flexitarian, semi-vegetarian or pesco-vegetarian eating patterns.
(b) Special interest groups data (e.g., elite athletes);
(c) Data published as conference/meeting abstracts; or
(d) Qualitative data.

OUTCOMES TO BE ANALYSED

Main outcomes
Feeding and eating disorders, disordered eating behaviors

Additional outcomes
Orthorexia nervosa

DATA COLLECTION PROCESS

Data extraction (selection and coding)
The procedures will be divided in steps:
First step: Title and abstract screening
Firstly, two independent reviewers will screen the titles for potential inclusion. Then, both reviewers will continue with the abstracts of the selected articles. In case of disagreement, in title and in abstract inclusion, a third reviewer will decide. In cases where a decision for exclusion or potential inclusion cannot be made by the title/abstract, the full text will be retrieved.
Second step: Full-text screening
The two independent reviewers will review the full texts of the previously included articles and will decide the inclusion or exclusion based on the selected criteria (inclusion and exclusion) by the completion of a checklist. A third reviewer will decide on the inclusion or exclusion if there is no consensus between reviewers.

Risk of bias (quality) assessment
The included studies will be assessed for methodological quality and risk of bias as their full published versions independently by two researchers. In case of discrepancies, a third reviewer will act to solve the disagreements. The tools to evaluate the methodological quality and risk of bias for observational studies will be the Quality Assessment Tool for Observational Cohort and CrossSectional Studies (National Heart, Lung, and Blood Institute, 2022) and the The Risk Of Bias In Non-randomized Studies - of Exposure (Higgins et al., 2023), respectively. For experimental studies, the RoB 2 (Sterne et al., 2019) and ROBINS-I (Sterne and Higgins, 2014) tools will be used.

PLANNED DATA SYNTHESIS

Strategy for data synthesis
The potential for conducting a meta-analysis will be assessed based on the data which has been extracted.
R software will be used to combine the pooled effect sizes (e.g., r, frequencies, Beta, means, odds ratios, hazard ratios) with 95% CIs. A fixed effect model will be used if there is no evidence of heterogeneity, otherwise, a random-effects model will be used. Study heterogeneity will be assessed using the I^2 statistic.

Analysis of subgroups or subsets
If there is available information we will divide the information by sex (women, men), BMI status (underweight, normoweight, obese), adult age groups (young, middle-aged, odler), and diet quality (healthy, unhealthy).

REVIEW AFFILIATION, FUNDING AND PEER REVIEW

Review team members

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Funding source
Agencia Nacional de Investigación e Innovación

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TIMELINE OF THE REVIEW

Review timeline
Review start date: 21 March 2024. Review end date: 28 July 2026.

Date of first submission to PROSPERO
21 March 2024

Date of registration in PROSPERO
01 April 2024

CURRENT REVIEW STAGE

Publication of review results 1 change
Results of the review will be published in English.

Journal publication
Published in an academic journal.

Additional information about publications
The Associations Between Vegetarian and Vegan Diets and Orthorexia Nervosa Symptoms in Adults: A Systematic Review and Meta-Analysis

Are Vegetarian and Vegan Diets Associated With Eating Disorder Symptoms? A Systematic Review and Meta-Analysis

Stage of the review at this submission

Review stage	Started	Completed
Pilot work	✓	✓
Formal searching/study identification	✓	✓
Screening search results against inclusion criteria	✓	✓
Data extraction or receipt of IPD	✓	✓
Risk of bias/quality assessment	✓	✓
Data synthesis	✓	✓

Review status
The review is completed.

ADDITIONAL INFORMATION

Additional information
Following the screening process, a large body of eligible literature was identified addressing both orthorexia nervosa and eating disorder symptoms in relation to vegetarian and vegan dietary patterns. Given that orthorexia nervosa and eating disorders represent distinct conditions with different conceptual and clinical characteristics, it was decided to conduct two separate systematic reviews and meta-analyses to improve methodological clarity and facilitate interpretation of the findings. The orthorexia nervosa review has since been completed and published separately.

In addition, during the review process, the eligibility criteria for the eating disorder review were amended to remove the original age restriction (participant age ≥18 years). Consequently, non-clinical populations of all ages were considered eligible for inclusion. This amendment was implemented to provide a more comprehensive synthesis of the available evidence and was reflected in the updated analyses.

PROSPERO version history 1 change

- Version 1.3, published 08 Jul 2026
- Version 1.2, published 01 Jun 2026
- Version 1.1, published 01 Apr 2024
- Version 1.0, published 01 Apr 2024

Review conflict of interest
None known

Country
Spain

Medical Subject Headings
Adult; Conduct Disorder; Diet; Diet, Plant-Based; Feeding Behavior; Feeding and Eating Disorders; Humans

Revision note 1 change
Systematic review and meta-analysis published at the International Journal of Eating Disorders

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Any enquiries about the record should be referred to the named review contact

APPENDIX IV. SUPPLEMENTARY MATERIAL MANUSCRIPT II

Supplementary material: The Associations Between Vegetarian and Vegan Diets and Orthorexia Nervosa Symptoms in Adults: A Systematic Review and Meta-Analysis

Supplementary Table 1. Detailed information on search strategies.

Information source	*Method*
Databases[a]*: PubMed*[b]*, Scopus*[c]*,Web of Science*[c]*, PsycINFO*[c]	(vegetarian* OR vegan* OR plant-based OR "vegetable diet" OR Adventist OR meat-free OR “meat avoidance” OR “nonmeat eat*” OR “plant-rich diet”) AND (orthorex* OR “patholog* eating” OR “eating patholog*” OR “avoidant food” OR “feeding disorder*” OR “extreme diet*” OR “eating disorder*” OR “disorder* eating” OR “eating behavio*” OR “eating symptom*” OR “eating attitude*” OR “eating problem*” OR ORTO)
Online resources and browsing	Portal (URL): Google Scholar (https://scholar.google.com). Search terms: “vegetarian diet” AND orthorexia. The first 100 records (n=10 pages) were selected and screened.
Citation searching	Relevant systematic reviews were kept separate to screen their included studies[1,2,3]. References of included articles were manually screened to identify additional studies.

[a] Data were retained in Research Information Systems (RIS) or PubMed formats for each database. [b] Search strategy restricted to Title/Abstract. [c] Search strategy restricted to Title/Abstract/Keywords.

References cited in this table:

[1] Mathieu S, Hanras E, Dorard G. Associations between vegetarianism, body mass index, and eating disorders/disordered eating behaviours: a systematic review of literature. Int J Food Sci Nutr 2023; 74: 424–462.

[2] McLean CP, Kulkarni J, Sharp G. Disordered eating and the meat-avoidance spectrum: a systematic review and clinical implications. Eating and Weight Disorders 2022; 27: 2347–2375.

[3] Brytek-Matera A. Vegetarian diet and orthorexia nervosa: a review of the literature. Eating and Weight Disorders 2021; 26: 1–11

Supplementary Table 2. Effect sizes, main results, and covariate adjustments of included studies.

Reference	*Measure of ON symptoms*	*Effect size*	*Vegetarians*	*Vegans*	*Omnivores*	*Covariate adjustment*
Albery et al., 2025	TOS	Mean (SD)	8.18±3.77	7.38±3.68	8.45±3.03	-
Barnett et al., 2016	ORTO-15	Mean (SD)	35.02 ± 4.12	34.18 ± 3.66	36.85 ± 3.79	-
Barthels et al., 2018	DOS	Mean (SD)	20.56 ± 4.70	20.96 ± 6.04	16.09 ± 5.29	-
Bialek-Dratwa et al., 2024	ORTO-15	Mean (SD)	35.76 ± 3.50	-	37.24 ± 3.50	-
	ORTO-15 (≥35)	Prevalence, n (%)	41 (48.8)	-	30 (29.4)	-
Chard et al., 2018	DOS (≥30)	Prevalence, n (%)	6 (20)	-	15 (6)	-
Çiçekoğlu & Tunçay, 2018	ORTO-11	Mean (SD)	27.70 ± 2.80	-	27.10 ± 3.40	-
Coimbra & Ferrerira, 2021	DOS	Mean (SD)	20.07 ± 5.38	21.76 ± 7.35	16.69 ± 5.92	-
Dai & Leung, 2024	DOS	Mean (SD)	2.69 ± 0.69	-	2.05 ± 0.61	Age, gender, ethnicity, household income, urbanicity, physical health
	ORTO-15	Mean (SD)	35.23 ± 4.81	-	37.37 ± 3.98	-
	ORTO-15 (≥35)	Prevalence, n (%)	166 (53)		759 (30.2)	-
Dell'Osso et al., 2016	ORTO-15	OR (95% CI)	2.51 (1.97– 3.20)	-	Reference	Age, gender, education, professional role, parent educational level, appreciation of the project, weight
Dell`Osso et al., 2022	ORTO-R	Mean (SD)	14.19 ± 3.40	-	12.63 ± 3.59	Gender, type of diet, and presence of autistic traits

Dittfeld et al., 2017	BOT (≥10)	Prevalence, n (%)	1 (0.1)	-	8 (0.6)	-
Dunn et al., 2016	ORTO-15	Mean (SD)	36.50 ± 4.40	42.50 ± 1.00	37.40 ± 4.90	-
Ferrerira & Coimbra, 2021	DOS	Mean (SD)	20.39 ± 5.31	21.65 ± 7.29	16.94 ± 6.08	-
Gwiozdzik et al., 2022	ORTO-15 (≥35)	Prevalence, n (%)	38 (33)	-	54 (23.8)	-
Hessler et al., 2021	DOS	Mean (SD)	19.00 ± 5.00	-	16.00 ± 4.60	Age, sex, BMI
Heiss et al., 2019	ORTO-15	Mean (SD)	36.96 ± 4.30	35.2 ± 4.06	37.33 ± 3.96	BMI, gender
	ORTO-15 (≥40)	Prevalence, n (%)	38 (76)	161 (84.3)	73 (68.9)	
	DOS (≥30)	Prevalence, n (%)	19 (11)	-	6 (54)	-
Luck-Sikorski et al., 2019	DOS (≥30)	OR (95% CI)	4.37 (1.47–12.99)	-	Reference	Age, gender, school, depressive symptoms, BMI, allergies
Missbach et al., 2015	ORTO-15	Mean (SD)	23.47 ± 3.64	22.6 ± 3.82	24.72 ± 3.47	-
Novara et al., 2022	EHQ	β (95% CI)	0.08 (0.04- 0.13)	0.15 (0.06-0.25)	Reference	Eating disorder risk
Oberle et al., 2021	DOS	Mean (SD)	47.21 ± 15.75	48.78 ± 14.51	38.52 ± 12.30	-
Özbey Yücel et al., 2021	ORTO-15	Mean (SD)	36.50 ± 3.81	37.30 ± 3.85	38.20 ± 3.78	-
Reynolds et al., 2023	ORTO-15	Mean (SD)	38.90 ± 8.1	-	41.50 ± 6.30	-
	ORTO-15 (≥35)	Prevalence, n (%)	22 (31.4)	-	44 (11.8)	-
	TOS	Mean (SD)	4.97 ± 4.60	-	3.51 ± 3.35	-
Ruiz & Quiles, 2021	ORTO-11	Mean (SD)	25.86 ± 5.45	-	28.40 ± 5.51	-
	ORTO-11 (≥25)	Prevalence, n (%)	39 (45)	-	124 (27.68)	-
Şentürk et al., 2022	TOS	Mean (SD)	5.82 ± 4.00	5.73 ± 4.15	5.03 ± 4.20	-
Strahler et al., 2018	DOS (≥30)	Prevalence, n (%)	2 (7.4)	4 (14.8)	15 (55.6)	-
Tarsitano et al., 2022	DOS (≥35)	Prevalence, n (%)	254 (23.7)	-	888 (30.3)	-

Abbreviations: BMI, body mass index; BOT, Bratman Test for Orthorexia; CI, confidence interval; DOS, Duesseldorf Orthorexia Scale; EHQ, Eating Habits Questionnaire; OR, Odds Ratio; ORTO-15/11/R, Questionnaire for the Diagnosis of Orthorexia; ON, Orthorexia Nervosa; SD, standard deviation; TOS, Teruel Orthorexia Scale.

Supplementary Table 3. List of the studies fully assessed for eligibility and excluded.

Wrong exposure (n=9)
• *Maïano C, Aimé A, Almenara CA, et al. Psychometric properties of the Teruel Orthorexia Scale (TOS) among a French-Canadian adult sample. Eat Weight Disord 2022; 27: 3457–3467.*
• *Davies G, Kalika E, Hussain M, et al. Exploring the association of body mass index, mindful and emotional eating, and orthorexia. Health Psychol Rep 2022; 11: 342–353.*
• *Boutin C, Maïano C, Aimé A. Relation between orthorexia nervosa and healthy orthorexia: A latent profile analysis. Appetite; 194. Epub ahead of print 1 March 2024. DOI: 10.1016/J.APPET.2023.107165.*
• *Bellikci Koyu E, Karaağaç Y, Öner BN. The association between food neophobia, bi-dimensional aspects of orthorexia, and anxiety among vegetarians and omnivores. Appetite; 197. Epub ahead of print 1 June 2024. DOI: 10.1016/J.APPET.2024.107303.*
• *Coimbra M, Ferreira C. Making the leap from healthy to disordered eating: the role of intuitive and inflexible eating attitudes in orthorexic behaviours among women. Eat Weight Disord. 2021 Aug;26(6):1793-1800.*
• *Plichta M, Jezewska-Zychowicz M. Orthorexic Tendency and Eating Disorders Symptoms in Polish Students: Examining Differences in Eating Behaviors. Nutrients; 12. Epub ahead of print 1 January 2020. DOI: 10.3390/NU12010218.*
• *Roustaee R, Hajifaraji M, Djazayery A, et al. Major Dietary patterns among female adolescents with eating disorders: A factor analysis approach. Progress in Nutrition 2018; 20: 378–386.*
• *Steinmann A, Ruf A, Ahrens KF, et al. Bacon, Brownie, or Broccoli? Beliefs about Stress-Relieving Foods and Their Relationship to Orthorexia Nervosa. Nutrients; 14. Epub ahead of print 1 September 2022. DOI: 10.3390/NU14183673.*
• *Brytek-Matera A. The Polish version of the Düsseldorf Orthorexia Scale (PL-DOS) and its comparison with the English version of the DOS (E-DOS). Eating and Weight Disorders 2021; 26: 1223–1232.*
Wrong comparator (n=2)
• *Herranz Valera J, Acuña Ruiz P, Romero Valdespino B, et al. Prevalence of orthorexia nervosa among ashtanga yoga practitioners: a pilot study. Eat Weight Disord 2014; 19: 469–472.*
• *Erkin Ö, Göl I. Determination of health status perception and orthorexia nervosa tendencies of Turkish yoga practitioners: A cross-sectional descriptive study. Progress in Nutrition 2019; 21: 105–112.*
Wrong outcome (n=44)
• *AL-Mohaithef M. Prevalence of vegan/vegetarian diet and eating behavior among Saudi adults and its correlation with body mass index: A cross-sectional study. Front Nutr; 9. Epub ahead of print September 15, 2022. DOI: 10.3389/FNUT.2022.966629.*
• *Baş M, Karabudak E, Kiziltan G. Vegetarianism and eating disorders: association between eating attitudes and other psychological factors among Turkish adolescents. Appetite 2005; 44: 309-315.*
• *Bardone-Cone AM, Fitzsimmons-Craft EE, Harney MB, et al. The inter-relationships between vegetarianism and eating disorders among females. J Acad Nutr Diet 2012; 112: 1247-1252.*
• *Barrack MT, West J, Christopher M, et al. Disordered Eating Among a Diverse Sample of First-Year College Students. J Am Coll Nutr 2019; 38: 141-148.*
• *Brytek-Matera A. Interaction between Vegetarian Versus Omnivorous Diet and Unhealthy Eating Patterns (Orthorexia Nervosa, Cognitive Restraint) and Body Mass Index in Adults. Nutrients 2020, Vol 12, Page 646 2020; 12: 646.*
• *Brytek-Matera A. Restrained Eating and Vegan, Vegetarian and Omnivore Dietary Intakes. Nutrients 2020; 12: 1–16.*
• *Brytek-Matera A, Czepczor-Bernat K, Jurzak H, et al. Strict health-oriented eating patterns (orthorexic eating behaviours) and their connection with a vegetarian and vegan diet. Eat Weight Disord 2019; 24: 441–452.*

- *Collins M, Quinton S. The inter-relationship between diet, selflessness, and disordered eating in Australian women. Brain Behav; 10. Epub ahead of print September 1, 2020. DOI: 10.1002/BRB3.1774.*
- *de Carvalho RC, Moreira JM. Níveis de Concordância com Regras Descritivas sobre Comportamentos Alimentares entre Veg(etari)anos. Psico-USF 2020; 25: 533-545.*
- *Dorard G, Mathieu S. Vegetarian and omnivorous diets: A cross-sectional study of motivation, eating disorders, and body shape perception. Appetite; 156. Epub ahead of print January 1, 2021. DOI: 10.1016/J.APPET.2020.104972.*
- *Estima CCP, Philippi ST, Leal GVS, et al. Vegetarianism and eating disorder risk behavior in adolescents from São Paulo, Brazil. Revista Espanola de Nutricion Humana y Dietetica 2012; 16: 94-99.*
- *Fan J, Nagata JM, Cuccolo K, et al. Associations between dieting practices and eating disorder attitudes and behaviors: Results from the Canadian study of adolescent health behaviors. Eat Behav 2024; 54: 101886.*
- *Fatima W, Ahmad LM. Prevalence of disordered eating attitudes among adolescent girls in Arar City, Kingdom of Saudi Arabia. Health Psychol Res; 6. Epub ahead of print November 29, 2018. DOI: 10.4081/HPR.2018.7444.*
- *Fisak B, Peterson RD, Tantleff-Dunn S, et al. Challenging previous conceptions of vegetarianism and eating disorders. Eat Weight Disord 2006; 11: 195-200.*
- *Forestell CA, Spaeth AM, Kane SA. To eat or not to eat red meat. A closer look at the relationship between restrained eating and vegetarianism in college females. Appetite 2012; 58: 319-325.*
- *Heiss S, Boswell JF, Hormes JM. Confirmatory factor analysis of the Eating Disorder Examination-Questionnaire: A comparison of five factor solutions across vegan and omnivore participants. Int J Eat Disord 2018; 51: 418-428.*
- *Heiss S, Coffino JA, Hormes JM. Eating and health behaviors in vegans compared to omnivores: Dispelling common myths. Appetite 2017; 118: 129-135.*
- *Heiss S, Walker DC, Anderson DA, et al. Vegetarians and omnivores with diagnosed eating disorders exhibit no difference in symptomology: a retrospective clinical chart review. Eat Weight Disord 2021; 26: 1007-1012.*
- *JANELLE KC, BARR SI. Nutrient intakes and eating behavior scores of vegetarian and nonvegetarian women. J Am Diet Assoc 1995; 95: 180-189.*
- *Klopp SA, Heiss CJ, Smith HS. Self-reported vegetarianism may be a marker for college women at risk for disordered eating. J Am Diet Assoc 2003; 103: 745-747.*
- *Köse G, Tayfur M, Karayigit R. BMI, Physical Activity, Sleep Quality, Eating Attitudes, Emotions: Which One is Affected by Mindful Eating? Progress in Nutrition 2021; 23: e2021002.*
- *Lindeman M, Stark K, Latvala K. Vegetarianism and eating-disordered thinking. Eat Disord 2000; 8: 157-165.*
- *Lindeman M. The state of mind of vegetarians: Psychological well-being or distress? Ecol Food Nutr 2002; 41: 75-86.*
- *McLean CP, Kulkarni J, Sharp G. The 26-Item Eating Attitudes Test (EAT-26): Psychometric Properties and Factor Structure in Vegetarians and Vegans. Nutrients; 15. Epub ahead of print January 1, 2023. DOI: 10.3390/NU15020297.*
- *McLean CP, Lavale A, Kulkarni J, et al. Psychometric properties and factor structure of the Eating Disorder Examination-Questionnaire in omnivores, vegetarians, and vegans. Body Image 2022; 43: 374-384.*
- *McLean CP, Moeck EK, Sharp G, et al. Characteristics and clinical implications of the relationship between veganism and pathological eating behaviours. Eat Weight Disord 2022; 27: 1881-1886.*
- *Michalak J, Zhang XC, Jacobi F. Vegetarian diet and mental disorders: results from a representative community survey. International Journal of Behavioral Nutrition and Physical Activity 2012; 9: 67.*

- *Neumark-Sztainer D, Story M, Resnick MD, et al. Adolescent vegetarians. A behavioral profile of a school-based population in Minnesota. Arch Pediatr Adolesc Med 1997; 151: 833-838.*
- *Norwood R, Cruwys T, Chachay VS, et al. The psychological characteristics of people consuming vegetarian, vegan, paleo, gluten free and weight loss dietary patterns. Obes Sci Pract 2019; 5: 148-158.*
- *Parra-Fernández ML, Manzaneque-Cañadillas M, Onieva-Zafra MD, et al. Pathological Preoccupation with Healthy Eating (Orthorexia Nervosa) in a Spanish Sample with Vegetarian, Vegan, and Non-Vegetarian Dietary Patterns. Nutrients 2020; 12: 1–12.*
- *Paslakis G, Richardson C, Nöhre M, et al. Author Correction: Prevalence and psychopathology of vegetarians and vegans - Results from a representative survey in Germany (Scientific Reports, (2020), 10, 1, (6840), 10.1038/s41598-020-63910-y). Sci Rep 2020; 10: 19811.*
- *Perry CL, Mcguire MT, Neumark-Sztainer D, et al. Characteristics of vegetarian adolescents in a multiethnic urban population. Journal of Adolescent Health 2001; 29: 406-416.*
- *Reuber H, Muschalla B. Dietary identity and embitterment among vegans, vegetarians and omnivores. Health Psychol Behav Med 2022; 10: 1038-1055.*
- *Robinson-O'Brien R, Perry CL, Wall MM, et al. Adolescent and young adult vegetarianism: better dietary intake and weight outcomes but increased risk of disordered eating behaviors. J Am Diet Assoc 2009; 109: 648-655.*
- *S M Gilbody SFK. Vegetarianism in young women: another means of weight control? - PubMed. Int J Eat Disord 1999; 87-90.*
- *Sandri E, Sguanci M, Cantín Larumbe E, et al. Plant-Based Diets versus the Mediterranean Dietary Pattern and Their Socio-Demographic Determinants in the Spanish Population: Influence on Health and Lifestyle Habits. Nutrients; 16. Epub ahead of print April 25, 2024. DOI: 10.3390/NU16091278.*
- *Sieke EH, Carlson JL, Lock J, et al. To meat or not to meat: disordered eating and vegetarian status in university students. Eat Weight Disord 2022; 27: 831-837.*
- *Timko CA, Hormes JM, Chubski J. Will the real vegetarian please stand up? An investigation of dietary restraint and eating disorder symptoms in vegetarians versus non-vegetarians. Appetite 2012; 58: 982-990.*
- *Turner-McGrievy GM, Wilcox S, Frongillo EA, et al. Differences in dietary acceptability, restraint, disinhibition, and hunger among African American participants randomized to either a vegan or omnivorous soul food diet. Appetite 2024; 196: 1-8.*
- *Trautmann, J; Rau, S I.; Wilson, M A.; Walters, C. Vegetarian students in their first year of college: Are they at risk for restrictive or disordered eating behaviors?. College Student Journal 2008; 42: 2; 340-347.*
- *Wiśniewska K, Okręglicka KM, Jaworski M, Nitsch-Osuch A. Plant-Based vs. Animal-Based Diets: Appetitive Traits and Dietary Patterns in Adults Based on Cross-Sectional Surveys. Nutrients. 2025 Feb 4;17(3):573. doi: 10.3390/nu17030573. PMID: 39940431; PMCID: PMC11819905.*
- *Worsley A, Skrzypiec G. Teenage vegetarianism: Beauty or the beast? Nutrition Research 1997; 17: 391-404.*
- *Zickgraf HF, Hazzard VM, O'Connor SM, et al. Examining vegetarianism, weight motivations, and eating disorder psychopathology among college students. Int J Eat Disord 2020; 53: 1506-1514.*
- *Zuromski KL, Witte TK, Smith AR, et al. Increased prevalence of vegetarianism among women with eating pathology. Eat Behav 2015; 19: 24-27.*

Supplementary Table 4. Methodological quality of included studies[a].

Reference	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*Score*	*Quality*
Albery et al. (2025)	Y	Y	CD	Y	Y	N	N	NA	Y	N	Y	N	NA	N	6	Fair
Barnett et al. (2016)	Y	Y	CD	Y	N	N	N	NA	Y	N	Y	N	NA	N	5	Poor
Barthels et al. (2018)	Y	Y	CD	N	N	N	N	NA	N	N	Y	N	NA	N	3	Poor
Białek-Dratwa et al. (2024)	Y	Y	CD	Y	N	N	N	NA	N	N	Y	N	NA	N	4	Poor
Chard et al. (2019)	Y	Y	CD	Y	N	N	N	NA	N	N	Y	N	NA	N	4	Poor
Çiçekoğlu & Tunçay (2018)	Y	Y	CD	N	N	N	N	NA	N	N	Y	N	NA	N	3	Poor
Coimbra & Ferreira (2021)	Y	Y	Y	Y	N	N	N	NA	N	N	Y	N	NA	N	5	Poor
Dai & Leung (2024)	Y	Y	CD	N	Y	N	N	NA	Y	N	Y	N	NA	Y	5	Poor
Dell'Osso et al. (2016)	Y	Y	CD	Y	N	N	N	NA	N	N	Y	N	NA	N	4	Poor
Dell`Osso et al. (2022)	Y	Y	CD	Y	N	N	N	NA	N	N	Y	N	NA	N	4	Poor
Dittfeld et al. (2017)	Y	Y	CD	NR	N	N	N	NA	N	N	Y	N	NA	N	3	Poor
Dunn et al. (2017)	Y	Y	CD	Y	N	N	N	NA	N	N	Y	N	NA	Y	5	Poor
Ferrerira & Coimbra (2020)	Y	Y	CD	Y	N	N	N	NA	N	N	Y	N	NA	N	4	Poor
Gwiozdzik et al. (2022)	Y	Y	CD	Y	N	N	N	NA	N	N	Y	N	NA	N	4	Poor
Hessler et al. (2021)	Y	Y	Y	Y	N	N	N	NA	Y	N	Y	N	NA	Y	7	Fair
Heiss et al. (2019)	Y	Y	CD	Y	N	N	N	NA	Y	N	Y	N	NA	Y	6	Fair
Luck-Sikorski et al. (2019)	Y	Y	N	Y	N	N	N	NA	N	N	Y	N	NA	Y	5	Poor
Missbach et al. (2015)	Y	Y	Y	N	N	N	N	NA	N	N	Y	N	NA	Y	5	Poor
Novara et al. (2022)	Y	Y	N	Y	N	N	N	NA	Y	Y	Y	N	NA	Y	7	Fair
Oberle, De Nadai & Madrid (2021)	Y	Y	CD	N	N	N	N	NA	Y	N	Y	N	NA	Y	5	Poor
Özbey Yücel et al. (2021)	Y	Y	CD	N	N	N	N	NA	N	N	Y	N	NA	Y	4	Poor
Reynolds et al. (2023)	Y	Y	CD	Y	Y	N	N	NA	Y	N	Y	N	NA	N	5	Poor
Ruiz & Quiles (2021)	Y	Y	CD	Y	N	N	N	NA	N	N	Y	N	NA	N	4	Poor
Şentürk et al. (2022)	Y	Y	CD	Y	N	N	N	NA	N	N	Y	N	NA	N	4	Poor
Strahler et al. (2018)	Y	Y	CD	N	N	N	N	NA	Y	N	Y	N	NA	N	4	Poor
Tarsitano et al. (2022)	Y	Y	CD	N	N	N	N	NA	N	N	Y	N	NA	Y	4	Poor

[a] Numbers represent the questions included in the National Institutes of Health's Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies: 1. Question clear? 2. Population clearly defined? 3. >50% participants? 4. Recruitment populations consistent? 5. Sample size justified? 6. Exposure assessed prior to outcome? 7. Sufficient timeframe? 8. Different exposure levels? 9. Valid exposure? 10. Repeated exposure assessment? 11. Valid outcomes? 12. Outcome assessors blinded? 13. Loss to follow up <20%? 14. Confounders adjusted for? Item 8 was considered not applicable for dichotomous exposure. Item 13 was considered not applicable for cross sectional studies. Each cross-sectional study was rated as good, fair, or poor according to the National Institutes of Health's Quality Assessment Tool for Observational Cohort and Cross-Sectional quality rating guide. Abbreviations: CD: cannot determine; N, no; NA, not applicable; NR, not reported; Y, yes.

Supplementary Table 5. Subgroup analyses for the cross-sectional associations between vegetarian and/or vegan vs. omnivorous diets and orthorexia nervosa symptoms.

MA of SMDs	*n*	*SMD (95% CI)*	*p*	I^2 *(%)*	$p_{subgroup}$
Diet[a]					0.855
Vegetarian (vs. omnivorous)	12	0.455 (0.278; 0.663)	< 0.001	79.8	
Vegan (vs. omnivorous)	11	0.421 (0.095; 0.746)	0.003	87.8	
Scale					< 0.001
ORTO-15/11/R	11	0.382 (0.257; 0.507)	< 0.001	38.4	
DOS	6	0.765 (0.648; 0.881)	< 0.001	7.5	
Region[b]					0.838
Europe	11	0.509 (0.347; 0.672)	< 0.001	70.7	
North America (USA)	5	0.547 (0.223; 0.871)	< 0.001	83.8	

[a] Studies that did not report data on vegetarians and vegans separately were excluded from the analysis.
[b] Some regions could not be included because there were not enough studies that included them.
Abbreviations: CI, confidence interval; DOS, Duesseldorf Orthorexia Scale; MA, meta-analysis; ORTO-15/11/R, Questionnaire for the Diagnosis of Orthorexia; SMD, standardized mean difference.

Supplementary Table 6. Meta-regression analyses for the cross-sectional associations between vegetarian and/or vegan vs. omnivorous diets and orthorexia nervosa symptoms.[a]

Covariates		*Coefficients*			*Heterogeneity*			*Test of residual heterogeneity*		
MA of SMDs	**n**	**Estimate**	**SE**	***p***	**I^2 (%)**	**H^2**	**R^2 (%)**	**Q**	**df**	***p***
Age (mean years)	17	-0.001	0.013	0.912	87.8	8.2	0.0	80.4	15	<0.001
Sex (% female)	20	0.004	0.004	0.428	87.0	7.7	0.0	99.7	18	<0.001
BMI (mean kg/m^2)	9	0.002	0.053	0.977	78.1	4.6	0.0	42.1	7	<0.001
Educational Level	13	-0.004	0.003	0.171	80.8	5.2	8.6	35.1	11	<0.002
MA of ORs										
Age (mean years)	10	0.027	0.033	0.409	93.8	16.1	0.0	135.7	8	<0.001
Sex (% female)	11	-0.018	0.011	0.106	87.2	7.8	16.9	57.4	9	<0.001

[a] Univariate random-effects meta-regression models were used to estimate the proportion of between-study heterogeneity explained by each covariate (for pooled standardized mean differences: mean age –ranging from 20.9 to 43.4 years–, percentage of female –ranging from 40.6 to 100–, and body mass index –ranging from 22.6 to 27.1 kg/m^2–, and educational level (percentage of university degree) –ranging from 36.6 to 100–; for pooled odds ratios: mean age –ranging from 19.6 to 50.6 years– and percentage of female –ranging from 40.6 to 100–), as well as the change in the effect size estimates for each 1-unit change in the characteristic included as predictors in the model.
n represents the number of studies included in each meta-regression model.
Abbreviations: BMI, body mass index; MA, meta-analysis; OR, odds ratio; SE, standard error; SMD, standardized mean difference.

Supplementary Table 7. Sensitivity analyses excluding studies one by one.

Reference removed	***SMD***	***LL***	***UL***	I^2
All studies	0.462	0.325	0.598	81.0 %
Albery et al. (2025)	0.493	0.368	0.619	79.2 %
Barnett et al. (2016)	0.458	0.315	0.601	82.0%
Barthels et al. (2018)	0.439	0.303	0.575	79.1%
Białek-Dratwa et al. (2024)	0.463	0.320	0.607	82.0%
Çiçekoğlu & Tunçay, (2018)	0.485	0.357	0.613	80.8%
Coimbra & Ferreira, (2021)	0.449	0.307	0.590	81.2%
Dai & Leung, (2024)	0.435	0.303	0.567	78.3%
Dell`Osso et al. (2022)	0.463	0.319	0.606	82.0%
Dell' Osso et al. (2016)	0.457	0.313	0.601	81.7%
Dunn et al. (2016)	0.485	0.351	0.618	80.6%
Ferrerira & Coimbra, (2020)	0.450	0.308	0.592	81.3%
Heiss et al. (2019)	0.462	0.319	0.606	82.0%
Hessler et al. (2020)	0.452	0.310	0.594	81.7%
Missbach et al. (2015)	0.464	0.320	0.608	82.0%
Novara et al. (2022)	0.456	0.319	0.594	81.9%
Oberle, De Nadai & Madrid, (2020)	0.444	0.304	0.584	80.2%
Özbey Yücel et al. (2021)	0.467	0.324	0.611	81.6%
Reynolds et al. (2023)	0.465	0.321	0.608	82.0%
Ruiz & Quiles, (2021)	0.463	0.319	0.607	82.0%
Şentürk et al. (2022)	0.480	0.339	0.620	76.2%
Reference removed	OR	***LL***	***UL***	I^2
All studies	1.986	1.213	3.252	92.8%
Białek-Dratwa et al. (2024)	1.946	1.126	3.366	93.4%
Chard et al. (2018)	1.876	1.114	3.160	93.3%
Dell' Osso et al. (2016)	1.913	1.106	3.309	91.1%
Dittfeld et al. (2017)	2.179	1.519	3.128	93.3%
Gwiozdzik et al. (2022)	2.027	1.171	3.508	93.5%
Heiss et al. (2019)	1.840	1.090	3.106	92.6%
Luck-Sikorski et al. (2018)	1.864	1.100	3.159	93.1%
Reynolds et al. (2023)	1.870	1.098	3.185	93.0%
Ruiz & Quiles, (2021)	1.959	1.130	3.396	93.3%
Strahler et al. (2018)	2.051	1.198	3.512	93.5%

Tarsitano et al. (2022)	2.270	1.381	3.733	55.0%

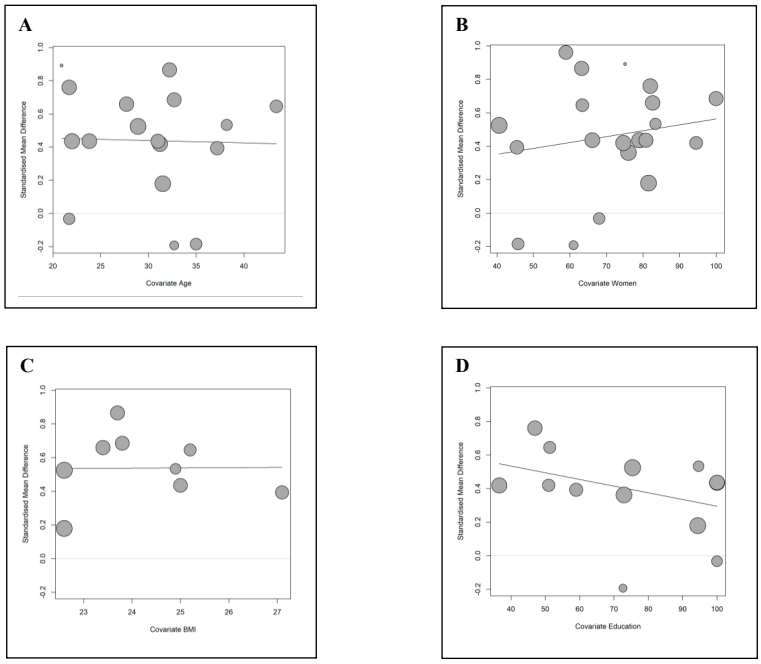
Abbreviations: LL, low limit; OR, odds ratio; SMD, standardized mean differences; UL, upper limit.

Supplementary Table 8. Meta-bias for the cross-sectional associations between vegetarian and/or vegan vs. omnivorous diets and orthorexia nervosa symptoms.

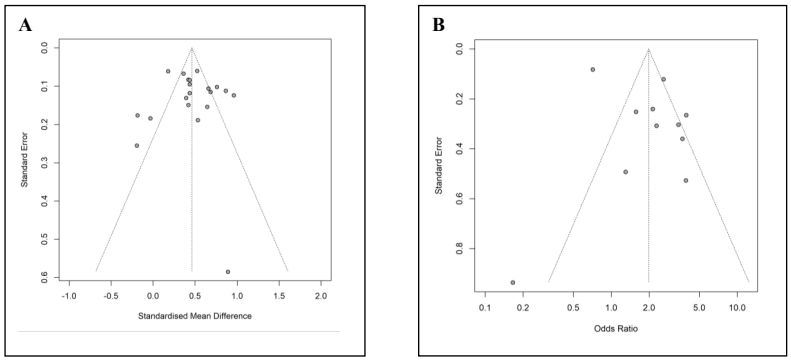
Meta-analysis (ES)	*n*	*Estimate (SE)*	*p*
SMD	20	0.407 (1.322)	0.762
OR	11	3.004 (1.753)	0.121

n represents the number of studies included in each analysis.
Abbreviations: ES, effect size; OR: odds ratio; SE, standard error; SMD, standardized mean difference

Supplementary Figure 1. Meta-regression models by age (A), sex (B), body mass index (C), and educational level (D) for the cross-sectional associations between vegetarian and/or vegan vs. omnivorous diets and orthorexia nervosa symptoms.



Supplementary Figure 2. Publication bias from cross-sectional meta-analyses of standardized mean differences (A) and odds ratio (B).



APPENDIX V. SUPPLEMENTARY MATERIAL MANUSCRIPT III

Supplementary material: Are vegetarian and vegan diets associated with eating disorder symptoms? A systematic review and meta-analysis

Supplementary Table 1. Detailed information on search strategies.

Information source	*Method*
Databases[a]: PubMed[b], Scopus[c], Cochrane Library[c], PsycINFO[c] and Web of Science[c]	(vegetarian* OR vegan* OR "plant-based" OR "plant based" OR "vegetable diet*" OR "plant-rich diet*" OR "meat-free" OR "meat free" OR "meat avoidance" OR "meat-avoid*" OR "nonmeat eat*" OR Adventist) AND ("eating disorder*" OR "disordered eating" OR "eating symptom*" OR "eating attitude*" OR "eating problem*" OR anorexi* OR bulimi* OR hyperphagia OR binge* OR overeating OR "avoidant food" OR "avoidant eating disorder" OR "Avoidant Restrictive Food Intake Disorder" OR "Avoidant/Restrictive Food Intake Disorder" OR "restrictive eating disorder" OR "selective eating disorder" OR "food avoidance disorder" OR "feeding disorder*" OR "compensatory behavio*" OR "extreme diet*" OR "cognitive restraint" OR "patholog* eating" OR "eating patholog*" OR SCOFF)
Online resources and browsing	Portal (URL): Google Scholar (https://scholar.google.com). Search terms: (vegetarian OR vegan) AND ("disordered eating OR "eating disorder"). The first 100 records (n=10 pages) were selected and screened.
Citation searching	Relevant systematic reviews were kept separate to screen their included studies[1-3].

[a]Data were retained in Research Information Systems (RIS) or PubMed formats for each database. [b] Search strategy restricted to Title/Abstract. [c] Search strategy restricted to Title/Abstract/Keywords.

References cited in this table:

[1] Mathieu S, Hanras E, Dorard G. Associations between vegetarianism, body mass index, and eating disorders/disordered eating behaviours: a systematic review of literature. Int J Food Sci Nutr 2023; 74: 424–462.

[2] McLean CP, Kulkarni J, Sharp G. Disordered eating and the meat-avoidance spectrum: a systematic review and clinical implications. Eating and Weight Disorders 2022; 27: 2347–2375.

[3] Sergentanis TN, Chelmi ME, Liampas A, Yfanti CM, Panagouli E, Vlachopapadopoulou E, Michalacos S, Bacopoulou F, Psaltopoulou T, Tsitsika A. Vegetarian Diets and Eating Disorders in Adolescents and Young Adults: A Systematic Review. Children (Basel). 2020;8(1):12.

Supplementary Table 2. Studies excluded after full-text assessment.

Wrong population (n=5)
• Bardone-Cone AM, Fitzsimmons-Craft EE, Harney MB, Maldonado CR, Lawson MA, Smith R, Robinson DP. The inter-relationships between vegetarianism and eating disorders among females. J Acad Nutr Diet. 2012;112(8):1247-52. doi: 10.1016/j.jand.2012.05.007.
• Fan J, Nagata JM, Cuccolo K, Ganson KT. Associations between dieting practices and eating disorder attitudes and behaviors: Results from the Canadian study of adolescent health behaviors. Eat Behav. 2024;54:101886. doi: 10.1016/j.eatbeh.2024.101886.
Wrong exposure (n=12)
• Barrack MT, West J, Christopher M, Pham-Vera AM. Disordered Eating Among a Diverse Sample of First-Year College Students. J Am Coll Nutr. 2019;38(2):141-148. doi: 10.1080/07315724.2018.1487345.
• Baş M, Karabudak E, Kiziltan G. Vegetarianism and eating disorders: association between eating attitudes and other psychological factors among Turkish adolescents. Appetite. 2005;44(3):309-15. doi: 10.1016/j.appet.2005.02.002.
• Coimbra M, Ferreira C. Making the leap from healthy to disordered eating: the role of intuitive and inflexible eating attitudes in orthorexic behaviours among women. Eat Weight Disord. 2021;26(6):1793-1800. doi: 10.1007/s40519-020-00998-1.
• Douglas CC, Shahan M, Camel SP, Vogel S. Negative Body Image and Limited Nutrition Knowledge among Collegiate Dancers Signals Need for Screening and Support. J Dance Med Sci. 2025 Sep;29(3):161-169. doi: 10.1177/1089313X241297770. Epub 2024 Nov 19. PMID: 39560063.
• Fatima W, Ahmad LM. Prevalence of disordered eating attitudes among adolescent girls in Arar City, Kingdom of Saudi Arabia. Health Psychol Res. 2018;6(1):7444. doi: 10.4081/hpr.2018.7444.
• Fisak B Jr, Peterson RD, Tantleff-Dunn S, Molnar JM. Challenging previous conceptions of vegetarianism and eating disorders. Eat Weight Disord. 2006;11(4):195-200. doi: 10.1007/BF03327571.
• Gilbody SM, Kirk SF, Hill AJ. Vegetarianism in young women: another means of weight control? Int J Eat Disord. 1999;26(1):87-90. doi: 10.1002/(sici)1098-108x(199907)26:1<87::aid-eat11>3.0.co;2-m.
• Klopp SA, Heiss CJ, Smith HS. Self-reported vegetarianism may be a marker for college women at risk for disordered eating. J Am Diet Assoc. 2003;103(6):745-7. doi: 10.1053/jada.2003.50139.
• Michalak J, Zhang XC, Jacobi F. Vegetarian diet and mental disorders: results from a representative community survey. Int J Behav Nutr Phys Act. 2012;9:67. doi: 10.1186/1479-5868-9-67.
• Plichta M, Jezewska-Zychowicz M. Orthorexic Tendency and Eating Disorders Symptoms in Polish Students: Examining Differences in Eating Behaviors. Nutrients. 2020;12(1):218. doi: 10.3390/nu12010218.
• Robinson-O'Brien R, Perry CL, Wall MM, Story M, Neumark-Sztainer D. Adolescent and young adult vegetarianism: better dietary intake and weight outcomes but increased risk of disordered eating behaviors. J Am Diet Assoc. 2009;109(4):648-55. doi: 10.1016/j.jada.2008.12.014.
• Salvia MG, Onteeru M, Lipson SK, Quatromoni PA. Adopting vegetarian and vegan eating patterns: Associations with disordered eating behaviors among young adult college students. Eat Behav. 2025;57:101967. doi: 10.1016/j.eatbeh.2025.101967.
• Trautmann J, Rau SI, Wilson MA, Walters C. Vegetarian students in their first year of college: Are they at risk for restrictive or disordered eating behaviors? College Student Journal. 2008;42(2):340-347.
Wrong outcome (n=11)
• Albery IP, Smith R, Frings D, Spada M. Patterns of implicit and explicit identity as a vegan or vegetarian in predicting healthy orthorexia and orthorexia nervosa. Eat Weight Disord. 2025

Mar 18;30(1):27. doi: 10.1007/s40519-025-01734-3. PMID: 40100515; PMCID: PMC11920311.
- Bataineh MF, Alhebshi SH, Al-Nawaiseh AM, Jarrar AH, Hamad MI, Al Dhaheri AS, Cheikh Ismail L, Ali HI. Validity and reliability of the Arabic orthorexia nervosa inventory scale in young adults: a validation study. Eat Weight Disord. 2026 Mar 6;31(1):18. doi: 10.1007/s40519-026-01838-4. PMID: 41792404; PMCID: PMC12982198.
- Brinkman BG, Khan A, Edner B, Rosén LA. Self-objectification, feminist activism and conformity to feminine norms among female vegetarians, semi-vegetarians, and non-vegetarians. Eat Behav. 2014;15(1):171-4. doi: 10.1016/j.eatbeh.2013.11.006.
- Brytek-Matera A. Restrained Eating and Vegan, Vegetarian and Omnivore Dietary Intakes. Nutrients. 2020;12(7):2133. doi: 10.3390/nu12072133.
- Brytek-Matera A, Czepczor-Bernat K, Jurzak H, Kornacka M, Kołodziejczyk N. Strict health-oriented eating patterns (orthorexic eating behaviours) and their connection with a vegetarian and vegan diet. Eat Weight Disord. 2019;24(3):441-452. doi: 10.1007/s40519-018-0563-5.
- Reuber H, Muschalla B. Dietary identity and embitterment among vegans, vegetarians and omnivores. Health Psychol Behav Med. 2022;10(1):1038-1055. doi: 10.1080/21642850.2022.2134870.
- Martins Rodrigues CJ, Galvão OF, Albuquerque LC. Analysis of Inflexibility and Eating Disorders According to the Theory of Control by Justifications and Immediate Consequences (TJC). Nutrients. 2026 Mar 23;18(6):1011. doi: 10.3390/nu18061011. PMID: 41901186; PMCID: PMC13028811.
- Saintila J, Calizaya-Milla YE, Javier-Aliaga DJ. Knowledge of Vegetarian and Nonvegetarian Peruvian Dietitians about Vegetarianism at Different Stages of Life. Nutr Metab Insights. 2021;14. doi: 10.1177/1178638821997123.
- Sandri E, Sguanci M, Cantín Larumbe E, Cerdá Olmedo G, Werner LU, Piredda M, Mancin S. Plant-Based Diets versus the Mediterranean Dietary Pattern and Their Socio-Demographic Determinants in the Spanish Population: Influence on Health and Lifestyle Habits. Nutrients. 2024;16(9):1278. doi: 10.3390/nu16091278.
- Webb JB, Tran T, Bauert L, Pringle S. Body- and Fitness-Related Shame Helps Explain the Association Between Internalized Weight Bias and Orthorexia Symptoms Among North American Female Yoga Professionals. J Acad Nutr Diet. 2025 Dec;125(12):1864-1876. doi: 10.1016/j.jand.2025.04.013. Epub 2025 Apr 28. PMID: 40306434.
- Zuromski KL, Witte TK, Smith AR, Goodwin N, Bodell LP, Bartlett M, Siegfried N. Increased prevalence of vegetarianism among women with eating pathology. Eat Behav. 2015;19:24-7. doi: 10.1016/j.eatbeh.2015.06.017.

Wrong study design (n=1)

- McLean CP, de Boer K, Bray M. "If There Are Restrictions Within the Restrictions, That's When You Can Probably Get Concerned": Key Indicators for Untying Vegetarianism and Veganism From Eating Disorder Pathology. Int J Eat Disord. 2025 Sep;58(9):1723-1731. doi: 10.1002/eat.24475. Epub 2025 May 23. PMID: 40406828; PMCID: PMC12423574.

No study association (n=4)

- Brytek-Matera A, Onieva-Zafra MD, Parra-Fernández ML, Staniszewska A, Modrzejewska J, Fernández-Martínez E. Evaluation of Orthorexia Nervosa and Symptomatology Associated with Eating Disorders among European University Students: A Multicentre Cross-Sectional Study. Nutrients. 2020;12(12):3716. doi: 10.3390/nu12123716.
- Heiss S, Timko CA, Hormes JM. Confirmatory factor analysis of the EDE-Q in vegans and omnivores: Support for the brief three factor model. Eat Behav. 2020;39:101447. doi: 10.1016/j.eatbeh.2020.101447.
- Lindeman M, Stark K. Pleasure, pursuit of health or negotiation of identity? Personality correlates of food choice motives among young and middle-aged women. Appetite. 1999;33(1):141-61. doi: 10.1006/appe.1999.0241.
- McLean JA, Barr SI. Cognitive dietary restraint is associated with eating behaviors, lifestyle practices, personality characteristics and menstrual irregularity in college women. Appetite. 2003;40(2):185-92. doi: 10.1016/s0195-6663(02)00125-3.

Supplementary Table 3. Effect sizes, main results, and covariate adjustments of included studies.

References	***Measure of ED symptoms***	***Reported statistic***	***Vegetarian***	***Vegan***	***Omnivores***
Barnett et al. (2016)	EDE-Q	Mean ± SD	1.28±1.2	2.16±1.67	1.37±1.10
	EDDS	N events (%), sub/full threshold	1 (4.5)	2 (18.2)	18 (9.5)
Białek-Dratwa et al. (2024)	EAT-26	Median (CI)	9.5 (7.6, 11.4)		8.0 (6.8, 9.2)
		N events (%), cutoff ≥20	20 (23.8)		15 (14.7)
Çiçekoğlu & Tunçay (2018)	EAT-40	Mean ± SD	18.8±8.3		15.3±7.4
Coimbra & Ferreira (2021)	EDE-Q	Mean ± SD	1.3±1.2	0.9±1.2	1.1±1.2
Collins & Quinton (2020)	EAT-26	B (SE)	-0.01 (0.02)	-0.03 (0.01)	Reference group
Dorard & Mathieu (2021)	EAT-26	Mean ± SD	10.5±6.3		12.1±6.9
		N events (%), cutoff ≥20	3 (6.1)		7 (13.5)
Forestell et al. (2012)	EAT-26	Mean ± SD	16.7±1.5		21.1±2.5
Gorgoni et al. (2026)	EDE-Q	Mean ± SD	1.66±1.41		1.89±1.43
Gwiozdzik et al. (2022)	SCOFF	N events (%), cutoff ≥2	64 (55.7)	-	126 (55.5)
Hanras et al. (2022)	EAT-26	Mean ± SD	10.3±7.9	8.5±8.0	12.2±9.1
		N events (%), cutoff ≥20	16 (14.3)	10 (7.9)	38 (17.9)
Heiss et al. (2017) [a]	EDE-Q	Mean ± SD	-	1.8±1.2	2.2±1.4
Heiss et al. (2019) [a]		Mean ± SD	2.1±1.3	-	2.2±1.4
Köse & Tayfur (2021)	EAT-40	N events (%), cutoff ≥31	28 (39.4)		64 (26.4)

Lindeman, Stark & Latvala (2000) [b]	EAT-26	Mean ± SD	11.53±13.17		6.01±6.28
Lindeman M. (2002) [b]	EAT-26	Mean ± SD	13.86±8.98		9.60±7.32
McLean et al. (2021)	EAT-26	Mean ± SD	-	10.2±9.1	6.8±7.4
	EDE-Q	Mean ± SD	-	1.6±1.1	1.4±1.1
McLean et al. (2022) [c]	EDE-Q	Mean ± SD	1.9±1.4	1.9±1.5	1.7±1.3
	Self-report diagnosis	n (%)	33 (11.9)	78 (13.5)	35 (4.8)
McLean et al. (2023) [c]	EAT-26	Mean ± SD	9.8±10.7	10.5±11.3	8.1±8.9
Norwood et al. (2019) [d]	EDI-3	Mean (SD)	1.0 (1.0)	0.9 (0.9)	1.1 (1.1)
Paslakis et al. (2020)	EDE-Q8	Mean ± SD	1.3±1.4		1.0±1.3
Perry et al. (2001)	Self-report diagnosis	n (%)	4 (4.3)		148 (3.4)
Sieke et al. (2021)	EDE-Q	Mean ± SD	1.7±1.4		1.3±1.2
		N events (%), >85th percentile	22 (16)		154 (11)
Timko et al. (2012)	EAT-26	Mean ± SD	10.1±11.6	9.2±13.4	8.0±8.9
Zickgraf et al. (2020)	S-EDE-Q	Mean ± SE	2.3±0.06		2.1±0.02

Notes: All studies are cross-sectional. [a] Vegan participants in Heiss et al. (2019) overlapped with those included in Heiss et al. (2017); therefore, only vegetarian participants from the 2019 study were retained to prevent double counting. [b] To avoid double counting, only the adolescent sample from Lindeman, Stark, and Latvala (2000) was included, as the adult participants were subsequently reported in Lindeman (2002). [c] These studies analyzed different scales measuring eating disorder symptoms within the same study sample. [c] Standard deviation was not reported and was assumed to be equal to the mean. Abbreviations: CI, confidence interval; EAT, Eating Attitudes Test; ED, eating disorder; EDDS, Eating Disorder Diagnostic Scale; EDE-Q, Eating Disorder Examination-Questionnaire; EDI, Eating Disorder Inventory; SCOFF, Sick-Control-Fat-Food questionnaire; S-EDE-Q, Short-Eating Disorder Examination-Questionnaire.

Supplementary Table 4. Methodological quality of included studies.

Reference	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*Score*
Barnett et al. (2016)	Y	Y	CD	Y	N	N	N	NA	Y	N	Y	N	NA	N	5
Białek-Dratwa et al. (2024)	Y	Y	CD	Y	N	N	N	NA	Y	N	Y	N	NA	N	5
Çiçekoğlu & Tunçay (2018)	Y	Y	CD	N	N	N	N	NA	N	N	Y	N	NA	N	4
Coimbra & Ferreira (2021)	Y	Y	CD	Y	N	N	N	NA	N	N	Y	N	NA	N	4
Collins & Quinton (2020)	Y	Y	CD	Y	N	N	N	NA	Y	N	Y	N	NA	N	5
Dorard & Mathieu (2021)	Y	Y	CD	N	N	N	N	NA	N	N	Y	N	NA	Y	4
Forestell et al. (2012)	Y	Y	CD	Y	N	N	N	NA	Y	N	Y	N	NA	N	5
Gorgoni et al. (2026)	Y	Y	CD	N	N	N	N	NA	Y	N	Y	N	NA	Y	5
Gwiozdzik et al. (2022)	Y	Y	CD	Y	Y	N	N	NA	N	N	Y	N	NA	N	5
Hanras et al. (2022)	Y	Y	CD	Y	N	N	N	NA	Y	N	Y	N	NA	N	5
Heiss et al. (2017)	Y	Y	CD	Y	Y	N	N	NA	Y	N	Y	N	NA	Y	7
Heiss et al. (2019)	Y	Y	CD	Y	Y	N	N	NA	Y	N	Y	N	NA	Y	7
Köse & Tayfur (2021)	Y	Y	CD	Y	N	N	N	NA	N	N	Y	N	NA	N	4
Lindeman, Stark & Latvala (2000)	Y	Y	N	Y	N	N	N	NA	N	N	Y	N	NA	N	4
Lindeman M. (2002)	Y	Y	Y	Y	N	N	N	NA	N	N	Y	N	NA	N	5
McLean et al. (2021)	Y	Y	CD	N	Y	N	N	NA	Y	N	Y	N	NA	N	5
McLean et al. (2022)	Y	Y	Y	Y	N	N	N	NA	N	N	Y	N	NA	N	5
McLean et al. (2023)	Y	Y	Y	Y	N	N	N	NA	N	N	Y	N	NA	N	5
Norwood et al. (2019)	Y	Y	Y	Y	N	N	N	NA	Y	N	Y	N	NA	N	6
Paslakis et al. (2020)	Y	Y	N	Y	N	N	N	NA	Y	N	Y	N	NA	N	5
Perry et al. (2001)	Y	Y	Y	Y	N	N	N	NA	Y	N	Y	N	NA	Y	7
Sieke et al. (2021)	Y	Y	CD	Y	N	N	N	NA	Y	N	Y	N	NA	Y	6
Timko et al. (2012)	Y	Y	Y	Y	N	N	N	NA	N	N	Y	N	NA	N	5
Zickgraf et al. (2020)	Y	Y	N	Y	N	N	N	NA	N	N	Y	N	NA	Y	5

Notes: Each cross-sectional study was rated as good (most criteria met), fair (some criteria met), or poor (few criteria met) according to the National Institutes of Health's Quality Assessment Tool for Observational Cohort and Cross-Sectional quality rating guide. Numbers represent the questions included in the National Institutes of Health's Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies: 1. Question clear? 2. Population clearly defined? 3. >50% participants? 4. Recruitment populations consistent? 5. Sample size justified? 6. Exposure assessed prior to outcome? 7. Sufficient timeframe? 8. Different exposure levels? 9. Valid exposure? 10. Repeated exposure assessment? 11. Valid outcomes? 12. Outcome assessors blinded? 13. Loss to follow up <20%? 14. Confounders adjusted for? Item 8 was considered not applicable for dichotomous exposure. Item 13 was considered not applicable for cross sectional studies. Abbreviations: CD: cannot determine; N, no; NA, not applicable; NR, not reported; Y, yes.

Supplementary Table 5. Subgroup analyses for the cross-sectional associations between vegetarian and vegan vs. omnivorous diets and eating disorder symptoms.

Subgroups	***n***	***SMD (95% CI)***	***p***	***I^2 (%)***	***$p_{subgroup}$***
Adolescents and adults					
Diet type [a]					0.524
Vegetarian (vs. omnivorous)	9	0.024 (-0.088, 0.137)	0.632	40.3	
Vegan (vs. omnivorous)	9	-0.050 (-0.291, 0.196)	0.650	86.7	
Measurement scale [b]					0.392
EAT	12	0.154 (-0.057, 0.366)	0.135	83.2	
EDE-Q [c]	10	0.055 (-0.094, 0.204)	0.427	80.1	
Region [d]					0.633
Europe	8	0.106 (-0.168, 0.379)	0.391	82.1	
North America	8	0.044 (-0.156, 0.245)	0.620	80.5	
Oceania	4	-0.051 (-0.556, 0.455)	0.709	89.5	
Adults	**n**	**SMD (95% CI)**	**p**	**I^2 (%)**	**$p_{subgroup}$**
Diet type [a]					0.660
Vegetarian (vs. omnivorous)	8	0.037 (-0.089, 0.163)	0.509	41.1	
Vegan (vs. omnivorous)	8	-0.019 (-0.296, 0.257)	0.872	94.5	
Measurement scale [b]					0.628
EAT	9	0.111 (-0.108, 0.330)	0.276	80.1	
EDE-Q [c]	10	0.055 (-0.094, 0.204)	0.427	80.1	
Region [d]					0.848
Europe	6	-0.031 (-0.232, 0.171)	0.709	75.0	
North America	7	0.039 (-0.192, 0.270)	0.694	83.2	
Oceania	2	0.011 (-2.105, 2.128)	0.957	86.0	

Notes: Results are presented for studies including both adolescent and adult populations. [a] Studies that did not report data on vegetarians or vegans separately were excluded from the analysis. [b] Scales represented by ≤2 studies (i.e., EDI and SCOFF) were excluded from the analysis. [c] Studies included only adult populations. [d] Europe: France, Germany, Poland, and Portugal; North America: USA; and Oceania: Australia. Studies that included populations from multiple countries without reporting region-specific results were excluded from the analysis. Regions represented by ≤2 studies (i.e., Asia [Turkey]) were also excluded. Abbreviations: CI, confidence interval; EAT, Eating Attitudes Test; EDE-Q, Eating Disorder Examination-Questionnaire; SMD, standardized mean difference.

Supplementary Table 6. Meta-regression analyses for the cross-sectional associations between vegetarian and vegan vs. omnivorous diets and eating disorder symptoms.

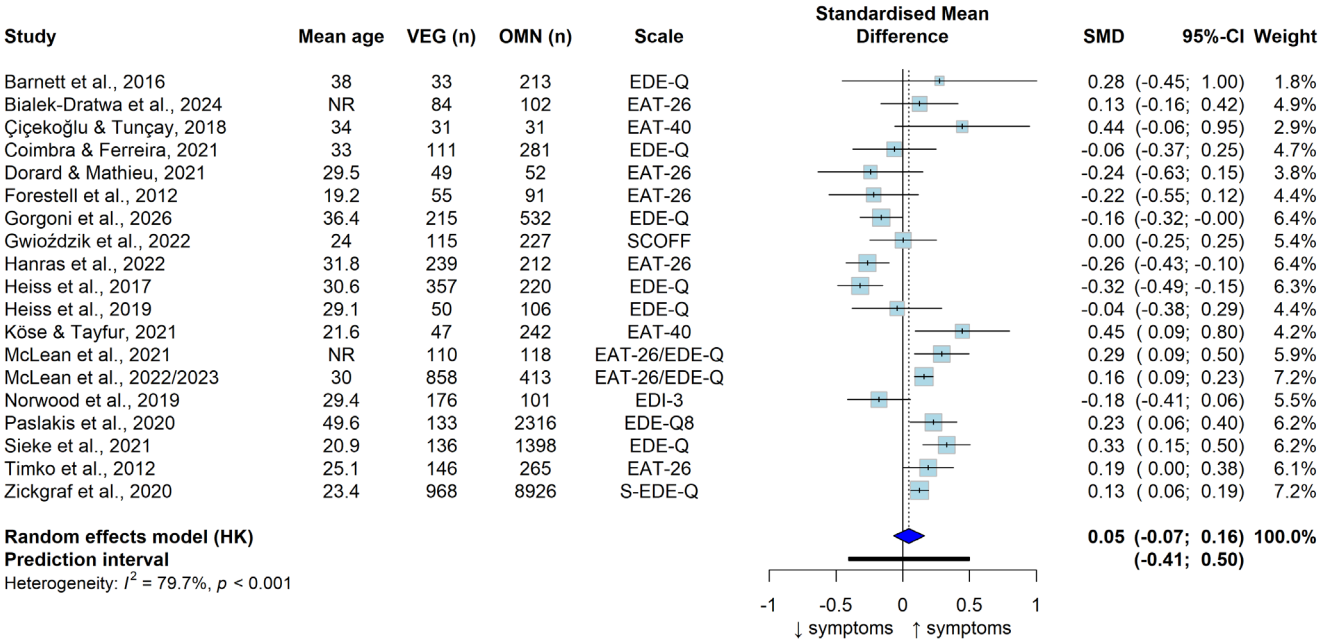
Covariates		***Coefficients***			***Heterogeneity***			***Residual heterogeneity***	
Adolescents and adults	**n**	**β**	**SE**	***p***	***I*² (%)**	**H²**	**R² (%)**	**Q**	***p***
Age (mean, years)	21	-0.006	0.008	0.478	88.3	8.5	0	103.7	<0.001
Sex (% female)	23	-0.004	0.004	0.311	87.1	7.8	0	96.1	<0.001
Total sample size (n)	23	0.000	0.000	0.726	84.9	6.6	0	107.5	<0.001
BMI (mean, kg/m²)	16	0.033	0.054	0.551	85.3	6.8	0	86.3	<0.001
Underweight status (%)	10	0.041	0.022	0.105	75.6	4.1	24.5	20.8	0.004
Publication year	23	-0.017	0.008	0.057	85.7	7.01	13.44	108.2	<0.001
Adults	**n**	**β**	**SE**	***p***	***I*² (%)**	**H²**	**R² (%)**	**Q**	***p***
Age (mean, years)	17	-0.002	0.008	0.855	86.2	7.3	0	81.9	<0.001
Sex (% female)	19	-0.008	0.003	0.028	81.2	5.3	20.6	72.1	<0.001
Total sample size (n)	19	0.000	0.000	0.499	81.6	5.4	0	84.7	<0.001
BMI (mean, kg/m²)	15	0.045	0.055	0.432	85.1	6.7	0	76.0	<0.001
Underweight status (%)	9	0.062	0.031	0.095	74.9	4.0	28.9	14.6	0.023
High educational level (%)	13	0.002	0.002	0.483	84.5	6.5	0	48.1	<0.001
Publication year	19	0.002	0.016	0.929	85.3	6.8	0	88.5	<0.001

Notes: Results are presented separately for studies including adolescent and adult populations and for studies restricted to adult populations. Univariate random-effects meta-regression models were used to estimate the proportion of between-study heterogeneity explained by each covariate, as well as the change in the effect size estimate for each 1-unit change in the characteristic included as predictor in the model. n represents the number of studies included in each meta-regression model. Abbreviations: BMI, body mass index; H^2, unaccounted variability; I^2, residual heterogeneity; Q, Cochran's Q statistic; SE, standard error; R^2, proportion of heterogeneity explained.

Supplementary Table 7. Sensitivity analyses excluding studies one by one.

Reference removed	*SMD*	*LL*	*UL*	I^2 *(%)*
All studies	0.074	-0.044	0.192	80.3
Barnett et al. (2016)	0.0709	-0.0506	0.1925	81.2
Białek-Dratwa et al. (2024)	0.0725	-0.0513	0.1963	81.2
Çiçekoğlu & Tunçay (2018)	0.0632	-0.0559	0.1823	80.9
Coimbra & Ferreira (2021)	0.0806	-0.0424	0.2036	81.1
Collins & Quinton (2020)	0.0885	-0.0324	0.2094	79.3
Dorard & Mathieu (2021)	0.0854	-0.0344	0.2053	80.8
Forestell et al. (2012)	0.086	-0.0343	0.2062	80.7
Gwiozdzik et al. (2022)	0.0874	-0.0342	0.2089	79.5
Gorgoni et al. (2026)	0.0783	-0.0456	0.2022	81.1
Hanras et al. (2022)	0.0924	-0.0259	0.2107	77.5
Heiss et al. (2017)	0.0948	-0.0212	0.2108	76.5
Heiss et al. (2019)	0.0796	-0.0435	0.2027	81.1
Köse & Tayfur, (2021)	0.0588	-0.0594	0.1771	80.5
Lindeman, Stark & Latvala (2000)	0.0552	-0.0565	0.1669	80.2
Lindeman M. (2002)	0.0528	-0.0614	0.1669	79.8
McLean et al. (2021)	0.0629	-0.0591	0.1849	80.5
McLean et al. (2022/2023)	0.0698	-0.0547	0.1942	80.0
Norwood et al. (2019)	0.0867	-0.0344	0.2078	80.4
Paslakis et al. (2020)	0.0661	-0.0571	0.1893	80.7
Perry et al. (2001)	0.074	-0.0487	0.1967	81.2
Sieke et al. (2021)	0.0602	-0.0609	0.1813	79.8
Timko et al. (2012)	0.0686	-0.0552	0.1923	81.0
Zickgraf et al. (2020)	0.0717	-0.053	0.1964	80.8

Notes: Results are presented for studies including both adolescent and adult populations. Abbreviations: LL, low limit; SMD, standardized mean differences; UL, upper limit.

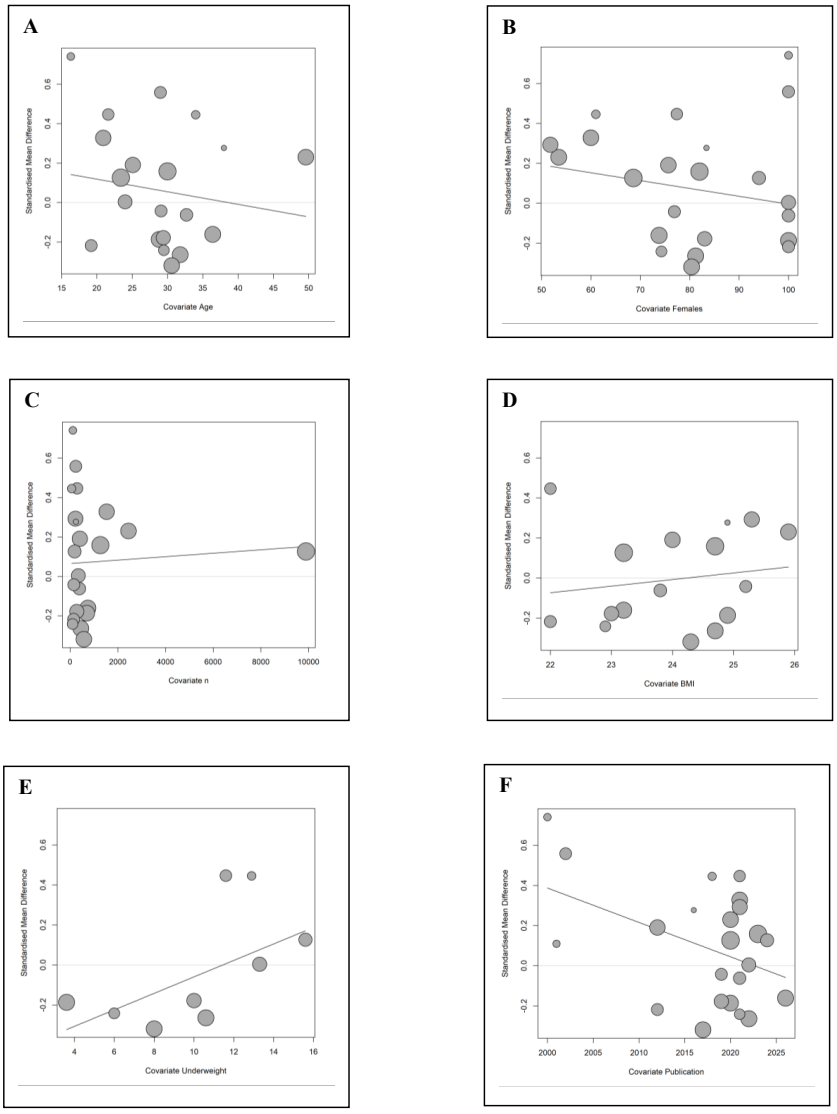


Study	Mean age	VEG (n)	OMN (n)	Scale	SMD	95%-CI	Weight
Barnett et al., 2016	38	33	213	EDE-Q	0.28	(-0.45; 1.00)	1.8%
Bialek-Dratwa et al., 2024	NR	84	102	EAT-26	0.13	(-0.16; 0.42)	4.9%
Çiçekoğlu & Tunçay, 2018	34	31	31	EAT-40	0.44	(-0.06; 0.95)	2.9%
Coimbra & Ferreira, 2021	33	111	281	EDE-Q	-0.06	(-0.37; 0.25)	4.7%
Dorard & Mathieu, 2021	29.5	49	52	EAT-26	-0.24	(-0.63; 0.15)	3.8%
Forestell et al., 2012	19.2	55	91	EAT-26	-0.22	(-0.55; 0.12)	4.4%
Gorgoni et al., 2026	36.4	215	532	EDE-Q	-0.16	(-0.32; -0.00)	6.4%
Gwioździk et al., 2022	24	115	227	SCOFF	0.00	(-0.25; 0.25)	5.4%
Hanras et al., 2022	31.8	239	212	EAT-26	-0.26	(-0.43; -0.10)	6.4%
Heiss et al., 2017	30.6	357	220	EDE-Q	-0.32	(-0.49; -0.15)	6.3%
Heiss et al., 2019	29.1	50	106	EDE-Q	-0.04	(-0.38; 0.29)	4.4%
Köse & Tayfur, 2021	21.6	47	242	EAT-40	0.45	(0.09; 0.80)	4.2%
McLean et al., 2021	NR	110	118	EAT-26/EDE-Q	0.29	(0.09; 0.50)	5.9%
McLean et al., 2022/2023	30	858	413	EAT-26/EDE-Q	0.16	(0.09; 0.23)	7.2%
Norwood et al., 2019	29.4	176	101	EDI-3	-0.18	(-0.41; 0.06)	5.5%
Paslakis et al., 2020	49.6	133	2316	EDE-Q8	0.23	(0.06; 0.40)	6.2%
Sieke et al., 2021	20.9	136	1398	EDE-Q	0.33	(0.15; 0.50)	6.2%
Timko et al., 2012	25.1	146	265	EAT-26	0.19	(0.00; 0.38)	6.1%
Zickgraf et al., 2020	23.4	968	8926	S-EDE-Q	0.13	(0.06; 0.19)	7.2%
Random effects model (HK)					**0.05**	**(-0.07; 0.16)**	**100.0%**
Prediction interval						**(-0.41; 0.50)**	

Heterogeneity: I^2 = 79.7%, p < 0.001

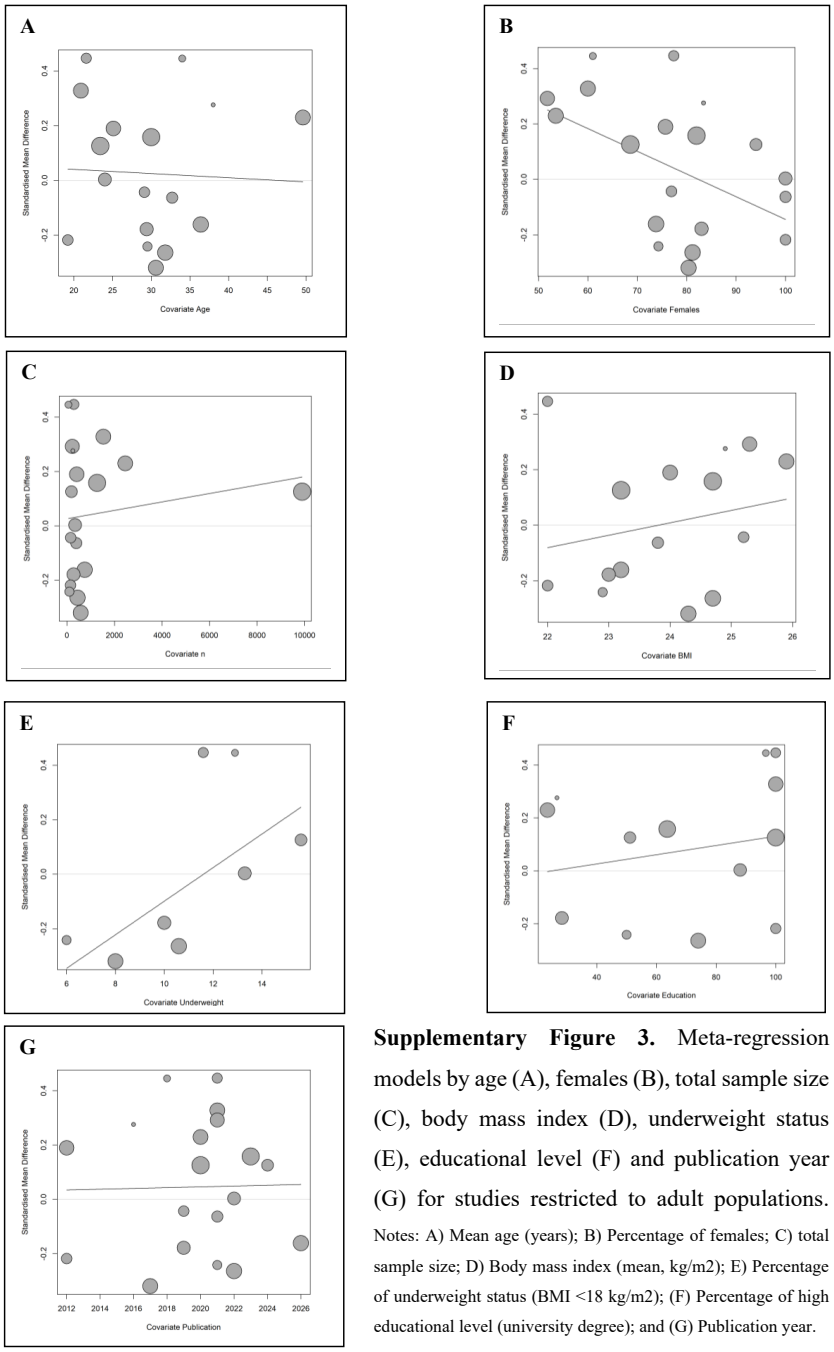
Supplementary Figure 1. Pooled standardized mean differences in eating disorder symptoms comparing vegetarian and vegan with omnivorous diets in studies including adult populations.

Abbreviations: CI, confidence interval; EAT, Eating Attitudes Test; EDE-Q, Eating Disorder Examination-Questionnaire; EDI, Eating Disorder Inventory; HK, Hartung-Knapp; OMN, omnivorous; SCOFF, Sick-Control-Fat-Food questionnaire; S-EDE-Q, Short-Eating Disorder Examination-Questionnaire; SMD, standardized mean difference; VEG, vegetarians and vegans.



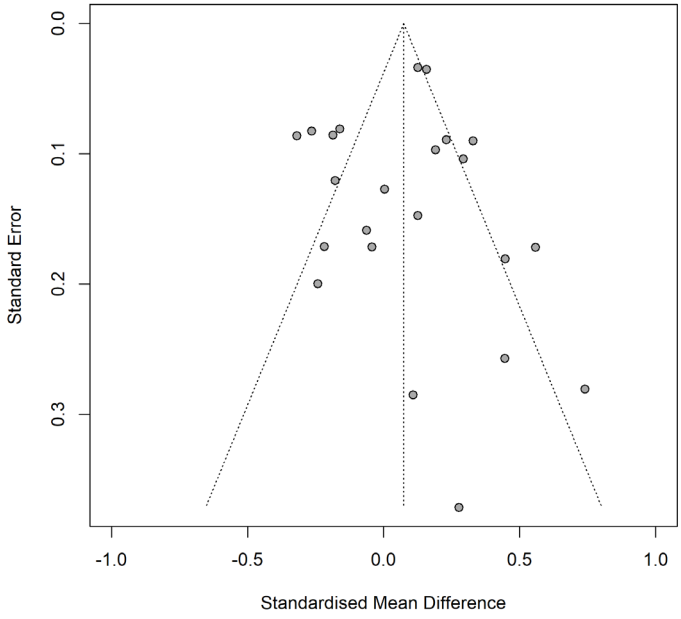
Supplementary Figure 2. Meta-regression models by age (A), females (B), total sample size (C), body mass index (D), underweight status (E), and publication year (F) for studies including both adolescent and adult populations.

Notes: A) Mean age (years); B) Percentage of females; C) total sample size; D) Body mass index (mean, kg/m^2); and E) Percentage of underweight status (BMI <18 kg/m^2).



Supplementary Figure 3. Meta-regression models by age (A), females (B), total sample size (C), body mass index (D), underweight status (E), educational level (F) and publication year (G) for studies restricted to adult populations.

Notes: A) Mean age (years); B) Percentage of females; C) total sample size; D) Body mass index (mean, kg/m2); E) Percentage of underweight status (BMI <18 kg/m2); (F) Percentage of high educational level (university degree); and (G) Publication year.



Supplementary Figure 4. Funnel plot of publication bias.

Notes: Egger's test for funnel plot asymmetry: t = –0.31, df = 21, p = 0.758. Results are presented for studies including both adolescent and adult populations.

APPENDIX VI. SUPPLEMENTARY MATERIAL MANUSCRIPT IV

Supplementary material: Plant-Based Diet Indices and Depression in University Students: The Nuts4Brain-Z Study

Table S1. Food components included in the 18 food groups used to construct the plant-based diet indices.

Plant food groups	**Food components**
Healthy	
Whole grains	Black or whole-grain bread, oat flakes, whole meal cookies.
Fruits	Orange, grapefruit, tangerines, bananas, apples, pears, strawberries, cherries, peaches, apricots, nectarines, watermelon, melons, kiwi, grapes, plums, peaches, apricots, nectarines, watermelon, melons, kiwi, grapes, dates, dried figs, raisins, prunes.
Legumes	Lentils, beans, chickpeas, peas, lima beans, broad beans.
Nuts	Almonds, peanuts, hazelnuts, pistachios, pine nuts, walnuts.
Tea and coffee	Coffee, decaffeinated coffee, tea.
Vegetables	Chard, spinach, cabbage, cauliflower, broccoli, lettuce, endive, escarole, raw tomato, carrots, pumpkin, green beans, eggplants, zucchini, cucumbers, peppers, asparagus, others: artichokes, leek, thistle, celery, onion, garlic, snow peas, chives, mushrooms.
Vegetable oils	Olive oil, virgin olive oil, olive pomace oil, corn oil, sunflower oil, soybean oil, blend of the above.
Less healthy	
Fruit juices	Natural orange juice, natural juices from other fruits.
Potatoes	Commercial potato chips, homemade potato chips, baked or boiled potatoes.
Refined grains	White rice, cereals, white bread, pasta.
Sugar sweetened beverages	Carbonated beverages with sugar, low calorie carbonated beverages, commercial fruit juices.
Sweets and desserts	Cookies, croissants, industrial bakery, homemade pastries, chocolates, donuts, muffins, cakes, nougat, fruits in syrup, cakes.
Animal food groups	
Animal fats	Lard, butter.
Dairy products	Whole, semi-skimmed and skimmed milk, condensed milk, cream, milk shakes, whole or skimmed yogurt, petit suisse, cottage cheese, cream cheese, cured or semi-cured cheeses, fresh cheese, custard, flan, pudding, ice cream.
Eggs	Eggs.

Fish and seafood	White fish, blue fish, salted fish, oysters, clams, mussels, squid, octopus, cuttlefish, shrimp, prawns, canned fish and shellfish, canned fish and shellfish in oil.
Meat	Chicken or turkey with or without skin, veal, pork, lamb, rabbit, liver, ham, processed meats, pates, hamburgers, bacon.
Miscellaneous	Croquettes, soupes, mayonnaise, snacks, pizza.

Note: Foods included in this table were derived from the food frequency questionnaire.

Table S2. Characteristics of the sample according to categories of adherence to plant-based diet indices.

	Tertiles of PDI			Tertiles of hPDI			Tertiles of uPDI		
	T1 (34–52)	**T2 (53–58)**	**T3 (59–70)**	**T1 (36–52)**	**T2 (38–73)**	**T3 (60–80)**	**T1 (36–53)**	**T2 (54–60)**	**T3 (61–76)**
Total sample, n (%)	144 (36.7)	130 (33.2)	118 (30.1)	142 (36.2)	125 (31.9)	125 (31.9)	138 (35.2)	124 (31.6)	130 (33.2)
Plant-based diet score, M ± SD	48.0 ± 3.9	55.4 ± 1.7	62.7 ± 3.0	47.5 ± 3.9	56.3 ± 2.0	64.6 ± 4.3	48.5 ± 3.9	56.8 ± 2.0	65.1 ± 3.5
Age (years), Median (Q1 - Q3)	20.5 (19.0 - 22.0)	20.0 (19.0 - 22.0)	21.0 (20.0 - 22.0)	20.0 (19.0 - 21.0)	21.0 (19.0 - 22.0)	21.0 (20.0 - 23.0)	21.0 (19.0 - 22.0)	20.5 (19.0 - 22.0)	20.0 (19.0 - 22.0)
Sex, n (%)									
Female	98 (68.1)	94 (72.3)	84 (71.2)	99 (69.7)	89 (71.2)	88 (70.4)	90 (65.2)	94 (75.8)	92 (70.8)
Male	46 (31.9)	36 (27.7)	34 (28.8)	43 (30.3)	36 (28.8)	37 (29.6)	48 (34.8)	30 (24.2)	38 (29.2)
Socioeconomic status, n (%)									
Low	24 (16.7)	23 (17.7)	18 (15.3)	24 (16.9)	24 (19.2)	17 (13.6)	21 (15.2)	19 (15.3)	25 (19.2)
Medium/high	120 (83.3)	107 (82.3)	100 (84.7)	118 (83.1)	101 (80.8)	108 (86.4)	117 (84.8)	105 (84.7)	105 (80.8)
BMI status (kg/m^2), n (%)									
BMI ≥ 25	38 (26.4)	28 (21.5)	33 (28.0)	27 (19.0)	34 (27.2)	38 (30.4)	36 (26.1)	23 (18.5)	40 (30.8)
BMI < 25	106 (73.6)	102 (78.5)	85 (72.0)	115 (81.0)	91 (72.8)	87 (69.6)	102 (73.9)	101 (81.5)	90 (69.2)
Tobacco smokers, n (%)									
Yes	31 (21.5)	19 (14.6)	15 (12.7)	28 (19.7)	16 (12.8)	21 (16.8)	20 (14.5)	22 (17.7)	23 (17.7)
No	113 (78.5)	111 (85.4)	103 (87.3)	114 (80.3)	109 (87.2)	104 (83.2)	118 (85.5)	102 (82.3)	107 (82.3)
Alcohol drinkers, n (%)									
Yes	56 (38.9)	41 (31.5)	39 (33.1)	58 (40.8)	38 (30.4)	40 (32.0)	45 (32.6)	48 (38.7)	43 (33.1)
No	88 (61.1)	89 (68.5)	79(66.9)	84 (59.2)	87 (69.6)	85 (68.0)	93 (67.4)	76 (61.3)	87 (66.9)
Physical activity levels, n (%)									
Low	22 (15.3)	17 (13.1)	18 (15.3)	23 (16.2)	20 (16.0)	14 (11.2)	12 (8.7)	14 (11.3)	31 (23.8)
Moderate/high	122 (84.7)	113 (86.9)	100 (84.7)	119 (83.8)	105 (84.0)	111 (88.8)	126 (91.3)	110 (88.7)	99 (76.2)
Sleep quality, n (%)									
Poor	75 (52.1)	68 (52.3)	67 (56.8)	81 (57.0)	60 (48.0)	69 (55.2)	58 (42.0)	77 (62.1)	75 (57.7)
Good	69 (47.9)	62 (46.7)	51 (43.2)	61 (43.0)	65 (52.0)	56 (44.8)	80 (58.0)	47 (37.9)	55 (42.3)

Total energy intake (kcal/d), Median (Q1 - Q3)	2089.6 (1602.7 - 2637.1)	2360.1 (1941.5 - 2947.9)	2909.1 (2493.6 - 3492.6)	2788.6 (2267.7 - 3378.5)	2313.1 (1765.7 - 3202.7)	2179.3 (1637.4 - 2584.8)	2828.5 (2366.7 - 3449.2)	2425.3 (1910.2 - 3102.4)	2006.9 (1532.0 - 2473.1)

Abbreviations: BMI, body mass index; hPDI, healthy plant-based diet index; PDI, plant-based diet index; uPDI, unhealthy plant-based diet index.

Table S3. Mean consumption of food groups across tertiles of adherence to plant-based diet indices.

Plant food groups	Tertiles of PDI			Tertiles of hPDI			Tertiles of uPDI		
	T1	T2	T3	T1	T2	T3	T1	T2	T3
Healthy									
Whole grains	13.3±22.8	31.4±37.6	49.1±57.3	18.1±38.3	33.6±43.6	40.1±45.0	49.3±49.4	25.4±31.7	14.1±37.9
Fruits	213.0±161.8	287.9±195.3	464.1±260.5	273.2±191.5	320.0±240.0	352.6±255.2	422.2±250.9	290.7±185.7	219.6±199.0
Vegetables	138.2±102.2	243.1±168.3	293.7±180.2	184.0±136.7	204.6±170.9	275.7±174.2	316.1±184.6	198.8±112.4	137.6±130.1
Nuts	11.7±17.5	20.9±23.3	33.1±28.4	17.3±24.7	20.0±22.7	26.8±25.7	32.4±28.5	17.5±21.6	12.8±17.9
Legumes	18.8±13.6	29.0±24.8	40.4±29.9	28.9±27.1	28.5±24.8	28.5±22.0	38.7±29.3	27.0±21.9	19.6±17.4
Vegetable oils	10.1±12.2	15.6±14.4	20.2±16.1	12.7±13.8	15.0±15.4	17.5±14.8	19.8±15.1	15.9±16.7	8.9±9.5
Tea and coffee	29.3±36.2	44.8±49.2	64.1±60.3	36.1±44.4	41.0±48.5	58.9±56.7	65.9±56.7	40.8±48.0	26.6±36.6
Less healthy									
Fruit juices	28.8±44.7	50.9±59.5	81.3±111.6	67.7±89.0	54.3±73.8	31.6±63.4	44.9±71.2	41.6±62.3	69.3±94.3
Refined grains	66.1±46.1	83.3±50.5	105.5±71.2	97.4±64.3	89.5±58.7	62.4±42.9	88.3±55.2	82.6±60.7	79.7±59.0
Potatoes	51.3±40.5	67.0±51.2	93.6±67.0	92.4±63.1	61.5±52.2	50.9±39.1	72.6±63.4	71.9±53.0	63.2±49.1
Sweetened beverages	66.2±73.4	77.7±103.2	99.2±119.9	119.8±121.8	72.9±89.0	41.8±57.6	56.3±79.6	84.9±119.7	100.4±93.7
Sweets and desserts	53.9±63.6	59.3±40.6	72.9±51.6	87.5±67.8	57.2±39.4	35.9±29.3	54.9±43.0	69.3±67.1	60.8±48.7
Animal food groups									
Animal fat	0.8±1.7	0.9±1.9	0.7±1.4	1.4±2.0	0.6±1.6	0.4±1.2	0.9±1.8	0.9±1.7	0.7±1.7
Dairy products	354.7±239.2	372.6±274.4	312.2±196.7	393.6±262.2	357.4±244.2	286.3±196.6	429.1±249.9	361.4±239.4	248.6±193.7
Egg	30.9±26.1	27.4±15.2	28.5±25.8	31.9±23.9	28.3±24.2	26.5±20.1	38.0±26.8	28.0±24.0	20.3±11.0
Fish or seafood	89.8±60.6	96.8±62.2	99.1±60.8	100.8±59.6	93.0±64.2	90.3±59.7	120.0±65.8	100.3±59.0	63.1±41.3
Meat	210.9±107.1	207.3±98.0	206.2±109.7	244.1±104.1	201.2±94.0	174.8±103.8	242.1±110.9	210.3±97.8	170.6±91.7
Miscellaneous foods	42.2±28.4	40.3±30.1	42.6±31.0	58.8±33.0	38.1±25.7	25.9±16.9	38.8±29.1	44.6±31.6	42.0±28.3

Notes: Values are expressed as mean ± standard deviation (grams per day) for each food group. Abbreviations: hPDI, healthy plant-based diet index; PDI, plant-based diet index; uPDI, unhealthy plant-based diet index.

Table S4. Interaction analyses between plant-based diet indices and covariates in relation to depressive symptoms.

Plant-based diet indices	**PDI**	**hPDI**	**uPDI**
Covariates	***p*-for-interaction**		
Sex	0.317	0.551	0.644
Age	0.920	0.535	0.059
Socioeconomic status	0.976	0.386	0.105
BMI status	0.491	0.286	0.154
Tobacco use	0.317	0.117	0.876
Alcohol use	0.393	**0.002**	0.488
Physical activity levels	0.519	0.253	0.784
Sleep quality	0.086	0.285	0.265

Abbreviations: BMI: body mass index; hPDI, healthy plant-based diet index; PDI, plant-based diet index; uPDI, unhealthy plant-based diet index.

Table S5. Stratified linear and logistic regression analyses of the association between hPDI adherence and depressive symptoms according to alcohol drinking status.

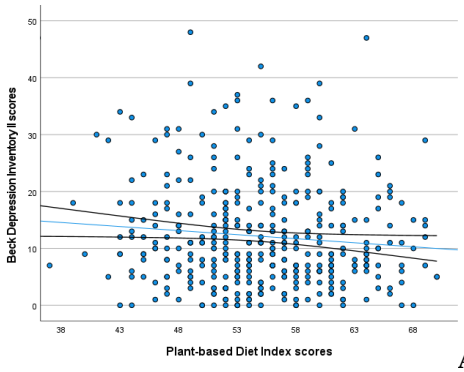
	Non-drinkers **(n=256)**		***Drinkers*** **(n=136)**	
Linear Regression	**B (95% CI)**	***p-value***	**B (95% CI)**	***p-value***
hPDI	−0.03 (−0.18, 0.11)	0.661	−0.31 (−0.48, −0.14)	<0.001
Logistic Regression	**OR (95% CI)**	***p-value***	**OR (95% CI)**	***p-value***
hPDI Low, T1	1.00		1.00	
hPDI Moderate, T2	0.41 (0.19–0.91)	0.029	0.43 (0.15–1.22)	0.113
hPDI High, T3	0.80 (0.37–1.72)	0.566	0.18 (0.05–0.59)	0.005

Notes: Values are presented as B coefficients (95% confidence intervals) from linear regression Model 3 and odds ratios (95% confidence intervals) from logistic regression Model 3. Model 3 was adjusted for age, sex, socioeconomic status, BMI, tobacco smoking, alcohol drinking, physical activity level, sleep quality and total energy intake. Abbreviations: CI, confidence interval; hPDI, healthy plant-based diet index; OR, odds ratio; T, tertile.

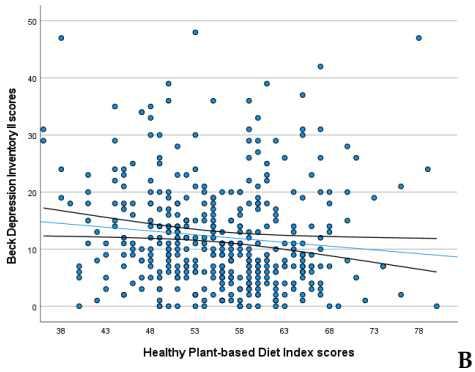
Table S6. Sensitivity analyses excluding participants with moderate-to-severe depression or receiving treatment, and those adhering to a strictly vegetarian diet.

Adherence to plant-based diets	**Without moderate-to-severe depression (n = 73)**		**Without a vegetarian diet[1] (n = 5)**	
	Total (n cases)	*OR (95% CI)*	*Total (n cases)*	*OR (95% CI)*
PDI				
Low, T1	114 (28)	1.00	143 (57)	1.00
Moderate, T2	107 (18)	0.56 (0.27–1.18)	129 (40)	0.62 (0.35–1.11)
High, T3	98 (22)	0.70 (0.32–1.53)	115 (39)	0.61 (0.33–1.15)
p-for-trend	319 (68)	0.361	387 (136)	0.113
hPDI				
Low, T1	111 (33)	1.00	140 (62)	1.00
Moderate, T2	109 (19)	**0.48 (0.24–0.99)**	124 (34)	**0.44 (0.24–0.82)**
High, T3	99 (16)	**0.36 (0.17–0.79)**	123 (40)	**0.51 (0.28–0.95)**
p-for-trend	319 (68)	**0.009**	387 (136)	**0.031**
uPDI				
Low, T1	114 (14)	1.00	136 (36)	1.00
Moderate, T2	99 (25)	**2.54 (1.15–5.60)**	122 (48)	1.58 (0.87–2.89)
High, T3	106 (29)	**3.50 (1.49–8.24)**	129 (52)	1.74 (0.91–3.35)
p-for-trend	319 (68)	**0.004**	387 (136)	0.096

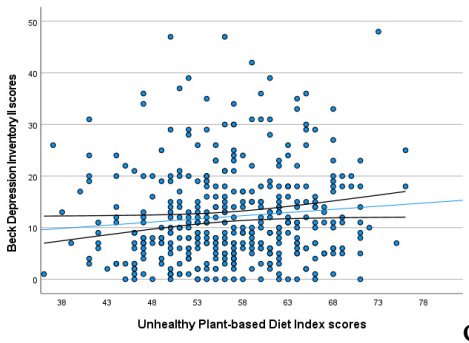
Notes: Values are odds ratios and their 95% confidence intervals from the fully adjustment model (Model 3). Bold values indicate statistical significance (p-value < 0.05). [1] Participants who did not consume red meat, white meat, or fish were excluded. Abbreviations: CI: confidence intervals; hPDI, healthy plant-based diet index; OR, odds ratio; PDI, plant-based diet index; T, tertile; uPDI, unhealthy plant-based diet index.



A

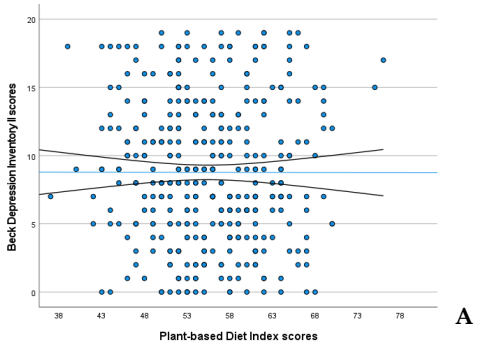


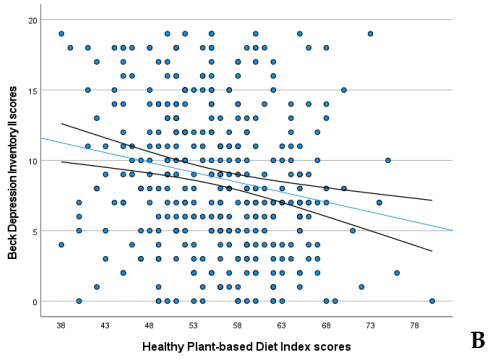
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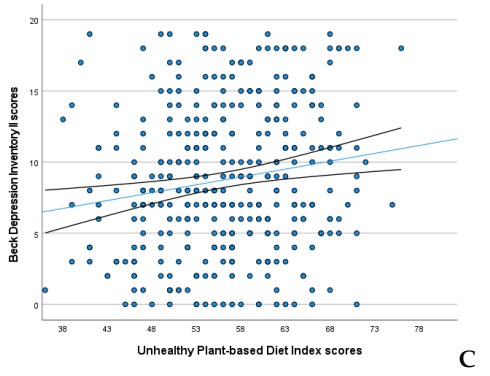


C

Supplementary Figure S1. Scatter plots illustrating the relationships between PDI, hPDI, and uPDI scores and BDI-II depressive symptom scores.
Notes: The blue line represents the fitted linear regression line, and the black lines represent the 95% confidence intervals.







Supplementary Figure S2. Scatter plots illustrating the relationships between PDI, hPDI, and uPDI scores and depressive symptom scores after excluding participants with moderate-to-severe depression and those receiving treatment for depression.
Notes: The blue line represents the fitted linear regression line, and the black lines represent the 95% confidence intervals.

15
OTHER SCIENTIFIC CONTRIBUTIONS



Academic Training

- 2022–2023. University master`s degree in Social and Health Care Research, Social and Health Care Centre, University of Castilla-La Mancha, Cuenca, Spain.

- 2013–2016. Graduate degree in Physical Education. Higher Institute of Physical Education, University of the Republic, Maldonado, Uruguay.

Research Stays

- 2025. Stay with a duration of three months at the Human Performance Analysis Research Group – PDU EFISAL *(Polo de Desarrollo Universitario Educación Física, Salud y Calidad de Vida)*, University of the Republic, Rivera, Uruguay.

Other peer review Publications

- Peraile-Huerta AM, Jiménez-López E, **Díaz-Goñi V**, Martins-de-Passos TO, Peral-Martínez F, Herráiz-Garrote S, Pérez-Moreno A, Mesas AE, Bizzozero-Peroni B. Animal-assisted therapy in patients with psychotic disorders: A systematic review and meta-analysis. Complement Ther Med. 2026 Mar;96:103322. doi: 10.1016/j.ctim.2026.103322. Epub 2026 Jan 12. PMID: 41534566.

- Mesas AE, Peral-Martínez F, Olivo-Martins-de-Passos T, Jiménez-López E, Beneit N, Martínez-Ortega IA, **Díaz-Goñi V**, Herraiz-Garrote S, Martínez-García I, Casanova-Rodríguez D, Rodríguez-Gutiérrez E, Bizzozero-Peroni B, Ballesta-Castillejos A, Cekrezi S, Marcilla-Toribio I, Núñez de Arenas-Arroyo S, Álvarez-Herraiz C, Maia CSC, Machado SP, Oliveira LFN, Serrano-Martínez S, Martínez-Madrid V, Calderón-Alva MC, López-Gil JF, Fernández-Rodríguez R, Cadenas-Sánchez C, Medrano M, Visier-Alfonso ME, Martínez-Vizcaíno V, Garrido-Miguel M. Nuts4Brain-RCT: Protocol for a Three-Arm Randomized Controlled Trial Examining the Dose-Response Effects of Nut Consumption on Mental Health in Young Adults. Healthcare (Basel). 2026 Feb 9;14(4):435. doi: 10.3390/healthcare14040435. PMID: 41753948; PMCID: PMC12940875.

- Bizzozero-Peroni B, **Díaz-Goñi V**, Fernández-Rodríguez R, Martínez-Vizcaíno V, Jiménez-López E, Visier-Alfonso ME, Garrido-Miguel M, Mesas AE. Plant-Based Diets and Mental and Neurocognitive Health Outcomes: A Systematic Review With Meta-

Analysis. Nutr Rev. 2025 Dec 1;83(12):2282-2295. doi: 10.1093/nutrit/nuaf080. PMID: 40720633.

- Sequí-Domínguez I, Sánchez-López M, Garrido-Miguel M, Solera-Martínez M, **Díaz-Goñi V**, de Arenas-Arroyo SN, Henriksson P, Herraiz-Adillo Á, Martínez-Vizcaíno V, Rodríguez-Gutiérrez E. Body Composition and Cardiometabolic Risk in Children. JAMA Netw Open. 2025 Oct 1;8(10):e2535004. doi: 10.1001/jamanetworkopen.2025.35004. PMID: 41037267; PMCID: PMC12492057.

- Rodríguez-Gutiérrez E, Martínez-Vizcaíno V, Bizzozero-Peroni B, **Díaz-Goñi V**, Martínez-García I, Sequí-Domínguez I, Núñez de Arenas-Arroyo S, Sánchez-López M, Pascual-Morena C, Torres-Costoso A. Daily steps, cardiorespiratory fitness, and remnant cholesterol in schoolchildren: mediation effects for cardiovascular prevention. Pediatr Res. 2025 Aug;98(2):672-679. doi: 10.1038/s41390-024-03779-z. Epub 2024 Dec 18. PMID: 39695264.

- Ballesta-Castillejos A, **Díaz-Goñi V**, Bizzozero-Peroni B, Jiménez-López E, López-Gil JF, Martínez-Ortega IA, Mesas AE, Garrido-Miguel M. Cross-Sectional Associations Between Depressive and Anxiety Symptoms and Disordered Eating Behaviors by Sex in University Students. J Clin Med. 2025 Jun 29;14(13):4611. doi: 10.3390/jcm14134611. PMID: 40648988; PMCID: PMC12250445.

- Visier-Alfonso ME, Sánchez-López M, Bizzozero-Peroni B, **Díaz-Goñi V**, Cekrezi S, Suazo I, Martínez-Vizcaíno V. The impact and perceptions of standing desk interventions on movement patterns and physical, mental, and academic outcomes in university students: a scoping review. BMC Public Health. 2025 May 9;25(1):1726. doi: 10.1186/s12889-025-22912-z. PMID: 40346487; PMCID: PMC12063225.

- Bizzozero-Peroni B, **Díaz-Goñi V**, Beneit N, Oliveira A, Jiménez-López E, Martínez-Vizcaíno V, Mesas AE. Nut consumption is associated with a lower risk of all-cause dementia in adults: a community-based cohort study from the UK Biobank. Geroscience. 2025 Apr;47(2):1721-1733. doi: 10.1007/s11357-024-01365-z. Epub 2024 Sep 30. PMID: 39343863; PMCID: PMC11979034.

- Fernández-Rodríguez R, Bizzozero-Peroni B, **Díaz-Goñi V**, Garrido-Miguel M, Bertotti G, Roldán-Ruiz A, López-Moreno M. Plant-based meat alternatives and cardiometabolic health: a systematic review and meta-analysis. Am J Clin Nutr. 2025 Feb;121(2):274-283. doi: 10.1016/j.ajcnut.2024.12.002. Epub 2024 Dec 7. PMID: 39653176.

- Bizzozero-Peroni B, Martínez-Vizcaíno V, Fernández-Rodríguez R, Jiménez-López E, Núñez de Arenas-Arroyo S, Saz-Lara A, **Díaz-Goñi V**, Mesas AE. The impact of the Mediterranean diet on alleviating depressive symptoms in adults: a systematic review and meta-analysis of randomized controlled trials. Nutr Rev. 2025 Jan 1;83(1):29-39. doi: 10.1093/nutrit/nuad176. PMID: 38219230.

- Rodríguez-Gutiérrez E, Torres-Costoso A, Jiménez-López E, Mesas AE, **Díaz-Goñi V**, Guzmán-Pavón MJ, Beneit N, Martínez-Vizcaíno V. Association Between Temperature, Sunlight Hours, and Daily Steps in School-Aged Children over a 35-Week Period. J Clin Med. 2024 Dec 17;13(24):7679. doi: 10.3390/jcm13247679. PMID: 39768602; PMCID: PMC11677288.

- Bizzozero-Peroni B, **Díaz-Goñi V**, Jiménez-López E, Rodríguez-Gutiérrez E, Sequí-Domínguez I, Núñez de Arenas-Arroyo S, López-Gil JF, Martínez-Vizcaíno V, Mesas AE. Daily Step Count and Depression in Adults: A Systematic Review and Meta-Analysis. JAMA Netw Open. 2024 Dec 2;7(12):e2451208. doi: 10.1001/jamanetworkopen.2024.51208. PMID: 39680407; PMCID: PMC11650418.

- Fernández-Rodríguez R, Martínez-Vizcaíno V, Reina-Gutiérrez S, Bizzozero-Peroni B, Torres-Costoso A, Rodríguez-Gutiérrez E, **Díaz-Goñi V**, Cadenas-Sánchez C. Sex Differences in Effects of Exercise on Physical Function in Aging: A Systematic Review with Meta-Analysis. World J Mens Health. 2024 Oct;42(4):694-711. doi: 10.5534/wjmh.230257. Epub 2024 Feb 7. PMID: 38449450; PMCID: PMC11439799.

- Visier-Alfonso ME, Jiménez-López E, Rodríguez-Gutiérrez E, Mesas AE, Núñez de Arenas-Arroyo S, **Díaz-Goñi V**, Álvarez-Bueno C, Martínez-Vizcaíno V. Internal Consistency and Validity of a Short Spanish Version (10-Items) of the Center for Epidemiological Studies Depression Scale for Children and Adolescents (CES-DC). Depress Anxiety. 2024 Sep 25;2024:5409747. doi: 10.1155/2024/5409747. PMID: 40226705; PMCID: PMC11918615.

- Martins-de-Passos TO, Mesas AE, Beneit N, **Díaz-Goñi V**, Peral-Martinez F, Cekrezi S, Martinez-Vizcaino V, Jimenez-Lopez E. Are Sleep Parameters and Chronotype Associated with Eating Disorder Risk? A Cross-Sectional Study of University Students in Spain. J Clin Med. 2024 Sep 15;13(18):5482. doi: 10.3390/jcm13185482. PMID: 39336969; PMCID: PMC11432122.

- Cavero-Redondo I, Saz-Lara A, Bizzozero-Peroni B, Núñez-Martínez L, **Díaz-Goñi V**, Calero-Paniagua I, Matínez-García I, Pascual-Morena C. Accuracy of the 6-Minute

Walk Test for Assessing Functional Capacity in Patients With Heart Failure With Preserved Ejection Fraction and Other Chronic Cardiac Pathologies: Results of the ExIC-FEp Trial and a Meta-Analysis. Sports Med Open. 2024 Jun 18;10(1):74. doi: 10.1186/s40798-024-00740-6. PMID: 38886304; PMCID: PMC11183033.

- Fernández-Rodríguez R, Garrido-Miguel M, Bizzozero-Peroni B, **Díaz-Goñi V**, Rodríguez-Gutiérrez E, Guzmán-Pavón MJ, Meseguer-Henarejos AB, Torres-Costoso A. Time-Restricted Eating and Bone Health: A Systematic Review with Meta-Analysis. Nutrients. 2024 Mar 18;16(6):876. doi: 10.3390/nu16060876. PMID: 38542787; PMCID: PMC10974430.

- **Díaz-Goñi V**, Cavero-Redondo I, Bizzozero-Peroni B, Rodríguez-Gutiérrez E, Pascual-Morena C, Sequí-Domínguez I, Lucas-Torres ML, Arenas-Arroyo SN, Saz-Lara A. Comparative effect of different types of physical exercise and intensity levels on low birth weight: A systematic review and network meta-analysis. Womens Health (Lond). 2024 Jan-Dec;20:17455057241276253. doi: 10.1177/17455057241276253. PMID: 39320857; PMCID: PMC11425745.

- Cavero-Redondo I, Saz-Lara A, Martínez-García I, Bizzozero-Peroni B, **Díaz-Goñi V**, Díez-Fernández A, Moreno-Herráiz N, Pascual-Morena C. Comparative Effect of Two Types of Physical Exercise for the Improvement of Exercise Capacity, Diastolic Function, Endothelial Function and Arterial Stiffness in Participants with Heart Failure with Preserved Ejection Fraction (ExIC-FEp Study): Protocol for a Randomized Controlled Trial. J Clin Med. 2023 May 18;12(10):3535. doi: 10.3390/jcm12103535. PMID: 37240641; PMCID: PMC10218785.

- Bizzozero-Peroni B, Brazo-Sayavera J, Martínez-Vizcaíno V, Fernández-Rodríguez R, López-Gil JF, **Díaz-Goñi V**, Cavero-Redondo I, Mesas AE. High Adherence to the Mediterranean Diet is Associated with Higher Physical Fitness in Adults: a Systematic Review and Meta-Analysis. Adv Nutr. 2022 Dec 22;13(6):2195-2206. doi: 10.1093/advances/nmac104. PMID: 36166848; PMCID: PMC9776663.

- Bizzozero-Peroni B, Fernández-Giménez S, Pintos-Toledo E, Corvos CA, **Díaz-Goñi V**, Brazo-Sayavera J. Physical activity-related indicators in children and adolescents in Uruguay: A scoping review based on the Global Matrix initiative. Front Public Health. 2022 Sep 7;10:954621. doi: 10.3389/fpubh.2022.954621. PMID: 36159259; PMCID: PMC9490234.

- Bizzozero-Peroni B, Brazo-Sayavera J, Martínez-Vizcaíno V, Núñez de Arenas-Arroyo S, Lucerón-Lucas-Torres M, **Díaz-Goñi V**, Martínez-Ortega IA, Mesas AE. The associations between adherence to the Mediterranean diet and physical fitness in young, middle-aged, and older adults: A protocol for a systematic review and meta-analysis. PLoS One. 2022 Jul 8;17(7):e0271254. doi: 10.1371/journal.pone.0271254. PMID: 35802597; PMCID: PMC9269745.

Research Project Participation

- Project on Cannabis Use and Mental Health in Adolescents and Young Adults: Exploring Epidemiological Gaps from the Perspectives of Gender, Socioeconomic Status, and the Role of BDNF – EpidCANNABIS Project. IP: Estela Jiménez López. Ministry of Health, Consumer Affairs, and Social Welfare, (Ref. 2024I091). 01/01/2025-present.

- Effectiveness of the MOVI-PlayandLearn intervention in reducing sedentary behavior, increasing physical activity, and improving physical and mental health through active video games in schoolchildren. PI: Andrés Redondo Tébar. Regional Government of Castilla-La Mancha, Ministry of Education, Culture and Sports, (SBPLY/24/180225/000264). 01/11/2025 - 31/10/2028.

- Impact of Nut Consumption on Mental Health in Young Adults: A Randomized Controlled Trial. IP: Arthur Eumann Mesas. Regional Government of Castilla-La Mancha, (SBPLY/23/180225/000177). 01/05/2024-present.

- Effectiveness of the UNI-UP intervention on improving the body composition, cardiometabolic risk and mental health in university students. IP: Ana Isabel Torres Costoso. Ministry of Science and Innovation and Carlos III Health Institute, (PI23/00962). 01/01/2024-31/12/2026.

- Effectiveness of the MOVI-steps and MOVI-up interventions on improving physical and mental health in the university students from Castilla-La Mancha, Spain (SBPLY/21/180501/000122). IP: Vicente Martínez Vizcaíno. Regional Government of Castilla-La Mancha. 01/09/2022- 31/08/2025.

- Nuts4Brain project: The relationship between nut consumption and mental health throughout adulthood. IP: Arthur Eumann Mesas. Carlos III Health Institute, (PI21/01898). 24/01/2023–31/12/2024.

- e-MOVI: a comprehensive school- and family-based intervention to improve body fat, cardiometabolic risk, and cognitive function by increasing physical activity and improving diet among schoolchildren. IP: Vicente Martínez Vizcaíno. Ministry of Science and Innovation, Carlos III Health Institute, (PI19/01126). 01/04/2023-31/07/2023.

- ExIC-FEp Study: Comparison of the Effects of Two Types of Physical Exercise on Exercise Capacity, Diastolic Function, Endothelial Function, and Arterial Stiffness in Patients with Heart Failure with Preserved Ejection Fraction. IP: Iván Cavero Redondo. Department of Education, Culture, and Sports of the Regional Government of Castilla-La Mancha. 01/04/2023-01/10/2023.

- EvasCu study: Validity of an accelerated vascular aging model as an index of cardiovascular risk in healthy adults: confirmatory factor analysis. IP: Alicia Saz-Lara. Comillas Pontifical University. 22/04/2022–22/04/2023.

Research dissemination Project Participation

- *Concurso fotográfico y evento divulgativo científico coordinado: Nutre-Activa tu Mente*. IP: Miriam Garrido Miguel. University of Castilla-La Mancha. IV Dissemination Plan "UCLMdivulga". Ministry of Science and Innovation. 2022/2023.

Contributions in Congresses

- **Valentina Díaz-Goñi**, Fernando Peral-Martínez, Tomás Olivo-Martins-de-Passos, María Eugenia Visier-Alfonso, André Luiz Martins, Isabel Antonia Martínez-Ortega, Sandra Herraiz-Garrote, Nuria Beneit-Redondo, Arthur E. Mesas, Bruno Bizzozero-Peroni. Cardiorespiratory fitness and risk of mental disorders and dementia: a systematic review and meta-analysis. I Congreso Iberoamericano en Actividad Física, Estilo de Vida y Salud. Centro de Estudios Sociosanitarios. Cuenca- Spain, 2026.

- Eva Rodríguez-Gutiérrez, Valeria Reynolds-Cortez, Cristina Gallego-Gómez**,** **Valentina Díaz-Goñi**, Manale Majdoub, Irene Martínez-García, Héctor Martínez-Martínez, Tomás Olivo-Martins-de-Passos, Belén Sánchez-Rojo Huertas, Irene Sequí-Domínguez. Daily steps and hypertension: a dose-response meta-analysis. I Congreso Iberoamericano en Actividad Física, Estilo de Vida y Salud. Centro de Estudios Sociosanitarios. Cuenca- Spain, 2026.

- Fernando Peral-Martínez, Tomás Olivo-Martins-de-Passos, **Valentina Díaz-Goñi**, Ana María Peraile-Huerta, Antonio Fernández-Caballero Elvira, André Luiz Martins, Claudia Quezada-Bascuñán, Shkelzen Cekrezi. Association between cannabis use and suicidal thoughts and behaviors in the Spanish population aged 15-64 years. I Congreso Iberoamericano en Actividad Física, Estilo de Vida y Salud. Centro de Estudios Sociosanitarios. Cuenca- Spain, 2026.

- Fernando Peral-Martínez, **Valentina Díaz-Goñi**, Tomás Olivo-Martins-de-Passos, André Luiz Martins, Isabel Antonia Martínez-Ortega, Ana María Peraile-Huerta, Bruno Bizzozero-Peroni, Silvana Patiño Cardona, Belén Sánchez Rojo-Huertas, Valeria Reynolds-Cortez. The relationship between adherence to the Mediterranean diet and academic performance in university students: a systematic review and meta-analysis. I Congreso Iberoamericano en Actividad Física, Estilo de Vida y Salud. Centro de Estudios Sociosanitarios. Cuenca- Spain, 2026.

- Silvana Patiño-Cardona, Carlos Pascual-Morena, Irene Martínez-García, Mar de Miguel Brox, María Molina-Sánchez, Irene Marcilla-Toribio, Nuria Jiménez-Rubio, **Valentina Díaz-Goñi**, Antonio Fernández-Caballero Elvira, Héctor Martínez-Martínez, Elena Moreno Charco. Association between physical activity and mortality in chronic kidney disease: a meta-analysis. I Congreso Iberoamericano en Actividad Física, Estilo de Vida y Salud. Centro de Estudios Sociosanitarios. Cuenca- Spain, 2026.

- Tomás Olivo-Martins-de-Passos, Fernando Peral-Martínez, **Valentina Díaz-Goñi**, Silvana Patiño-Cardona, Elena Moreno-Charco, Ana María Peraile-Huerta, Nuria Jiménez-Rubio, Antonio Fernández-Caballero-Elvira. Association between evening chronotype and depressive symptoms in children and adolescents: A systematic review and meta-analysis. I Congreso Iberoamericano en Actividad Física, Estilo de Vida y Salud. Centro de Estudios Sociosanitarios. Cuenca- Spain, 2026.

- Tomás Olivo-Martins-de-Passos, David Parra-Camacho, Carlos Pérez-Campos, Fernando Peral-Martínez, Arthur E. Mesas, Sergio Aguado-Berenguer, Estela Jiménez-López, André Luiz Martins, Antonio Fernández-Caballero Elvira, **Valentina Díaz-Goñi**. Evaluation of an educational intervention in Physical Education classes to improve sleep knowledge in adolescents. I Congreso Iberoamericano en Actividad Física, Estilo de Vida y Salud. Centro de Estudios Sociosanitarios. Cuenca- Spain, 2026.

- Nuria Jiménez Rubio, Ana Pérez Moreno, Miriam Garrido Miguel, **Valentina Diaz-Goñi**, María Molina Sánchez, Isabel Antonia Martínez Ortega, Antonio Fernández Caballero Elvira, Cristian Marcelo Jaque Gallardo, Silvana Patiño Cardona, Irene

Marcilla Toribio. Dietary Inflammatory Index and Quality of Life: a systematic review. I Congreso Iberoamericano en Actividad Física, Estilo de Vida y Salud. Centro de Estudios Sociosanitarios. Cuenca- Spain, 2026.

- Ana María Peraile-Huerta, Fernando Peral-Martínez, Ana Pérez-Moreno, **Valentina Díaz-Goñi,** Antonio Fernández-Caballero, Nuria Jiménez-Rubio, Noemí Oriola-Martínez, Bruno Bizzozero-Peroni, Estela Jiménez-López. Examining the Associations of Screen Time and Social Media Addiction with Memory Performance: A Cross-Sectional Study in Spanish University Students. XIII Jornadas Doctorales de la Universidad de Castilla-La Mancha. Universidad de Castilla-La Mancha. Ciudad Real-Spain, 2026.

- **Valentina Díaz-Goñi**, Tomás Olivo Martins-De-Passo, Fernando Peral-Martínez, Ana María Peraile-Huerta, Nuria Jiménez-Rubio, Irene Marcilla-Toribio, Ana Pérez-Moreno, Arthur Eumann Mesas, Bruno Bizzozero-Peroni. Plant-based diet index and depression in young adults: a cross sectional study. XIII Jornadas Doctorales de la Universidad de Castilla-La Mancha. Universidad de Castilla-La Mancha. Ciudad Real-Spain, 2026.

- Nuria Jiménez-Rubio, Tomás Olivo-Martins-de-Passos, **Valentina Díaz-Goñi**, Ana Pérez Moreno, Manale Majdoub, Elena Moreno Charco, Silvana Patiño Cardona, Pilar Martínez Sánchez, Miriam Garrido Miguel, Bruno Bizzozero Peroni. The relationship between the dietary inflammatory index and the muscle strength index and health-related quality of life: a cluster analysis. XIII Jornadas Doctorales de la Universidad de Castilla-La Mancha. Ciudad Real- Spain, 2026.

- Álvaro Hernández-Galán, María Eugenia Visier-Alfonso, **Valentina Díaz-Goñi**, Sergio Núñez de Arenas-Arroyo, Eva Rodríguez-Gutiérrez, Mairena Sánchez-López, Vicente Martínez-Vizcaíno. The relationship between physical fitness and cognition in university students: the Uni-Up Project study. Symposium EXERNET. Sevilla-Spain, 2025.

- Bruno Bizzozero-Peroni, **Valentina Díaz-Goñi**, Fernando Peral Martínez, Irene Sequí Domínguez, Shkelzen Cekrezi, Miriam Garrido-Miguel, Eva Rodríguez-Gutiérrez, Mairena Sánchez-López. Associations between cardiorespiratory fitness and risk of common mental disorders: a systematic review and meta-analysis. Symposium EXERNET. Sevilla-Spain, 2025.

- Shkelzen Cekrezi, María Eugenia Visier-Alfonso; Mairena Sánchez-López; Vicente Martínez-Vizcaíno, **Valentina Díaz-Goñi**, Montserrat Solera-Martínez, Miriam Garrido-Miguel. University students' perceptions of the use of standing desks to reduce sedentary behaviour: a qualitative study as part of the Uni-UP project. Symposium EXERNET. Sevilla-Spain, 2025.

- Mairena Sánchez-López, María Eugenia Visier-Alfonso, Héctor Martínez-Martínez, Belén Sánchez Rojo-Huertas, **Valentina Díaz-Goñi**, Vicente Martínez-Vizcaíno. Reducing sedentary behaviour at university: students' perceptions, acceptance and satisfaction regarding an intervention involving standing desks: the Uni-UP Project. Symposium EXERNET. Sevilla-Spain, 2025.

- Andrés Redondo-Tébar; Irene Sequí-Domínguez, **Valentina Díaz-Goñi**, Álvaro Hernández-Galán, Gemma Martínez-Torremocha, Raquel Aparicio-Mera. Association Between Meeting Physical Activity Guidelines Through Active Transportation To/From University And Psychological Well-Being. II Congresso Internacional Riidass – O Deslocamento Ativo Como Motor De Mudança: Ciclo De Vida, Saúde, Sustentabilidade E Políticas Públicas. Porto- Portugal, 2025.

- Tomas Olivo-Martins de Passos, **Valentina Díaz-Goñi**, Shkelzen Cekrezi, Suzana Menezes-Guariente, Irene Marcilla-Toribio, Fernando Peral-Martínez, Sandra Herraiz-Garrote; Estela Jiménez-López. Are Sleep Parameters and Chronotype Associated with Eating Disorder Risk? A Cross-Sectional Study of University Students in Spain. XII Jornadas Doctorales de la Universidad de Castilla-La Mancha. Escuela Internacional de Doctorado. Cuenca- Spain, 2025.

- Sofia Alfaro-Gonzales, **Valentina Díaz-Goñi**, Tomas Olivo-Martins de Passos Álvaro Hernández Galán, Héctor Martínez Martínez, Rubén Fernández Rodríguez, José Alberto Martínez Hortelano, Sergio Núñez de Arena Arroyo, Miriam Garrido Miguel. Association between adherence to the Mediterranean diet and symptoms of depression and anxiety in university students: the mediating role of lean body mass and muscle strength index. XII Jornadas Doctorales de la Universidad de Castilla-La Mancha. Escuela internacional de Doctorado. Cuenca- Spain, 2025.

- **Valentina Díaz-Goñi**, Tomas Olivo-Martins de Passos, Shkelzen Cekrezi, Valeria Reynold-Cortez, Ruben Fernández-Rodríguez, Fernando Peral-Martínez, Sandra Herraiz-Garrote, Bruno Bizzozero-Peroni. Associations between vegetarian/vegan vs. Omnivorous diets and symptoms of orthorexia nervosa: a systematic review and meta-

analysis. XII Jornadas Doctorales de la Universidad de Castilla-La Mancha. Cuenca-Spain, 2025.

- Ana María Paraile-Huerta, Ana Pérez-Moreno, Claudia Andrea Quezada-Bascuñán, Sofía Alfaro González, Suzana María Menezes Guariente, **Valentina Díaz-Goñi**, Pilar Martínez Sánchez, Bruno Bizzozero Peroni, Estela Jiménez López. Effects of animal-assisted therapy on patients with psychotic disorders: a systematic review. XII Jornadas Doctorales de la Universidad de Castilla-La Mancha. Cuenca- Spain, 2025.

- Bruno Bizzozero-Peroni, Eva Rodríguez-Gutiérrez, **Valentina Díaz-Goñi**, Sergio Núñez De Arenas-Arroyo, Irene Sequí-Domínguez, Maribel Lucerón-Lucas-Torres, Santiago Mula-Muñoz, Ana Torres Costoso, Arthur Eumann Mesas, Vicente Martínez-Vizcaíno. Effects of a 29-week mHealth intervention to promote daily steps in schoolchildren. ICAMPAM. ISMPB Conference Secretariat. Rennes- France, 2024.

- Eva Rodríguez-Gutiérrez, Bruno Bizzozero-Peroni, **Valentina Díaz-Goñi**, Sergio Núñez De Arenas-Arroyo1, Irene Sequí-Domínguez1, Maribel Lucerón-Lucas-Torres1, Santiago Mula-Muñoz1, Ana Torres Costoso, Vicente Martínez-Vizcaíno. The physical activity patterns in children: an analysis of differences and agreement between weekdays and weekends. ICAMPAM. ISMPB Conference Secretariat. Rennes- France, 2024.

- **Valentina Díaz-Goñi**, Bruno Bizzozero-Peroni, María Eugenia Visier-Alfonso, Estela Jiménez López, Nuria Beneit Redondo, Tomás Olivo-Martins-de-Passos, Isabel Antonia Martínez Ortega, Eva Rodríguez Gutiérrez, María Isabel Lucerón Lucas-Torres, Miriam Garrido Miguel, José Francisco López Gil, Rubén Fernández Rodríguez, Arthur Eumann Mesas. Mediterranean diet interventions for depressive symptoms in adults with depression: a systematic review and meta-analysis of randomized controlled trials. XI Jornadas Doctorales de la Universidad de Castilla-La Mancha. Escuela Internacional de Doctorado de la Universidad de Castilla-La Mancha. Toledo- Spain, 2023.

- Maribel Lucerón-Lucas-Torres, Irene Martínez-García, Irene Sequí-Domínguez, Sergio Núñez de Arenas-Arroyo, **Valentina Díaz-Goñi**, Bruno Bizzozero-Peroni, Eva Rodríguez-Gutiérrez. The effect of wine consumption and triglycerides: a systematic review and meta-analysis of clinical trials. XI Jornadas Doctorales de la Universidad de Castilla-La Mancha. Escuela Internacional de Doctorado de la Universidad de Castilla-La Mancha. Toledo- Spain, 2023.

- Eva Rodríguez-Gutiérrez, Sergio Núñez De Arenas-Arroyo, Irene Sequí-Dominguez, Bruno Bizzozero-Peroni, Maribel Lucerón-Lucas-Torres, Carlos Pascual-Morena, Irene Martínez-García, **Valentina Díaz-Goñi**, Ana Torres-Costoso, Vicente Martínez-Vizcaíno. Association between physical activity based on steps per day and all-cause mortality: A systematic review and meta-analysis. VIII Simposio EXERNET: "Ejercicio físico para la salud a lo largo de la vida". Red Española de Investigación en Ejercicio Físico y Salud. Almería- Spain, 2023.

- Sergio Núñez de Arenas-Arroyo, Eva Rodríguez-Gutiérrez, Irene Sequí-Domínguez, Bruno Bizzozero-Peroni, María Isabel Luceron Lucas Torres, Irene Martínez García, Carlos Pascual Morena, **Valentina Díaz-Goñi**, Vicente Martínez-Vizcaino, Ana Torres-Costoso. Increment of 1000 steps/day and all-cause mortality: a systematic review and meta-analysis. VIII Simposio EXERNET: "Ejercicio físico para la salud a lo largo de la vida". Red española de Investigación en Ejercicio Físico y Salud. Almería- Spain, 2023.

- Maribel Lucerón-Lucas-Torres, María Dolores Gómez-Guijarro, Marta González-Molinero, **Valentina Diaz-Goñi**, Irene Martínez García, Irene Sequí Domínguez, Bruno Bizzozero Peroni, Sergio Núñez de Arenas Arroyo, Sara Reina Gutiérrez, Nacho García-Miralles. Association Between Wine Consumption And Coronary Heart Disease: A Systematic Review And Meta-Analysis. IX Congreso Internacional de Investigación en Salud y Envejecimiento y VII Congreso Internacional de investigación en Salud. Sociedad Científica Española para la Investigación y Formación en Ciencias de la Salud. Murcia- Spain, 2022.

- Nacho García-Miralles, Maribel Lucerón-Lucas-Torres, Marta González-Molinero, Eva Rodríguez Gutiérrez, **Valentina Diaz-Goñi**, Irene Martínez García, Irene Sequí-Domínguez, Sergio Núñez de Arenas Arroyo, Bruno Bizzozero-Peroni, María Dolores Gómez-Guijarro. The effect of strength training on maximum oxygen consumption in heart failure: a systematic review. IX Congreso Internacional de Investigación en Salud y Envejecimiento y VII Congreso Internacional de investigación en Salud. Sociedad Científica Española para la Investigación y Formación en Ciencias de la Salud. Murcia-Spain, 2022.

- Sara Reina-Gutiérrez, Carlos Pascual-Morena, María Eugenia Visier-Alfonso, Nacho García Miralles, Eva Rodríguez Gutiérrez, Sergio Núñez de Arenas Arroyo, Marta González Molinero, **Valentina Diaz-Goñi**, Irene Martínez García, Irene Sequí-Domínguez. Effect of physical exercise on cardiorespiratory fitness in people with multiple sclerosis: a meta-analysis. IX Congreso Internacional de Investigación en Salud y Envejecimiento y VII Congreso Internacional de investigación en Salud.

Sociedad Científica Española para la Investigación y Formación en Ciencias de la Salud. Murcia- Spain, 2022.

- Eva Rodríguez-Gutiérrez, **Valentina Díaz-Goñi**, Irene Sequí-Domínguez, Sara Reina Gutiérrez, Bruno Bizzozero Peroni, Maribel Lucerón Lucas-Torres, Sergio Núñez de Arenas Arroyo, Marta González Molinero, María Dolores Gómez Guijarro, Nacho García-Miralles. Effectiveness of HIIT on BDNF in adults: a systematic review and meta-analysis. IX Congreso Internacional de Investigación en Salud y Envejecimiento y VII Congreso Internacional de investigación en Salud. Sociedad Científica Española para la Investigación y Formación en Ciencias de la Salud. Murcia- Spain, 2022.

- **Valentina Díaz-Goñi**, Irene Sequí-Domínguez, Sergio Núñez de Arenas-Arroyo, Sara Reina Gutiérrez, Nacho García Miralles, Carlos Pascual Morena, María Eugenia Visier Alfonso, Maribel Lucerón Lucas-Torres, Eva Rodríguez Gutiérrez, Bruno Bizzozero Peroni. Mediterranean diet and motor skills in older adults: a systematic review with meta-analysis. IX Congreso Internacional de Investigación en Salud y Envejecimiento y VII Congreso Internacional de investigación en Salud. Sociedad Científica Española para la Investigación y Formación en Ciencias de la Salud. Murcia- Spain, 2022.

- Bruno Bizzozero-Peroni, Irene Sequí-Domínguez, Carlos Pascual-Morena, Sergio Núñez de Arenas Arroyo, Maribel Lucerón Lucas-Torres, Eva Rodríguez Gutiérrez, María Dolores Gómez Guijarro, Marta González Molinero, Nacho García Miralles, **Valentina Díaz-Goñi**. Nut consumption and quality of life in young adults: the mediating role of specific nutrients and cardiorespiratory fitness. IX Congreso Internacional de Investigación en Salud y Envejecimiento y VII Congreso Internacional de investigación en Salud. Sociedad Científica Española para la Investigación y Formación en Ciencias de la Salud. Murcia- Spain, 2022.

- María Eugenia Visier-Alfonso, Maribel Lucerón-Lucas-Torres, Eva Rodríguez-Gutiérrez, María Dolores Gómez Guijarro, Marta González Molinero, **Valentina Diaz-Goñi**, Irene Martínez García, Irene Sequi Dominguez, Bruno Bizzozero-Peroni, Sergio Núñez de Arenas-Arroyo. Parents' perceptions of the use of electronic devices for physical activity in children and adolescents. IX Congreso Internacional de Investigación en Salud y Envejecimiento y VII Congreso Internacional de investigación en Salud. Sociedad Científica Española para la Investigación y Formación en Ciencias de la Salud. Murcia- Spain, 2022.

Dissemination of the Research Findings

- *No todas las dietas basadas en plantas son saludables para el cerebro*. Article from The Conversation, Spain. Accessible at: https://theconversation.com/no-todas-las-dietas-basadas-en-plantas-son-saludables-para-el-cerebro-275040.

- *What vegan and vegetarian diets can and can't tell us about eating disorders*. Article from The Conversation, UK. Accessible at: https://theconversation.com/what-vegan-and-vegetarian-diets-can-and-cant-tell-us-about-eating-disorders-287256

- *Una buena condición física puede ayudar a prevenir la demencia, la depresión y los trastornos psicóticos*. Interview conducted by the University of Granada, Spain. Accessible at: https://canal.ugr.es/noticia/una-buena-condicion-fisica-puede-ayudar-a-prevenir-la-demencia-la-depresion-y-los-trastornos-psicoticos/

"…No te rindas, por favor no cedas,
aunque el frío queme,
aunque el miedo muerda,
aunque el sol se esconda,
y se calle el viento,
aún hay fuego en tu alma
aún hay vida en tus sueños…"

No te rindas – Mario Benedetti

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