

Review Article

Diet Quality Impacts Mental Health Aspects of University Students

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Received: September 13, 2021; **Accepted:** October 11, 2021; **Published:** October 18, 2021**Abstract****Introduction:** Mental health problems, especially depression and anxiety, among university students are widespread, and begin pre-matriculation. Diet is among the factors contributing to mental health in all age groups.**Aim:** The present review aims to critically summarize the observational studies and clinical trials that have investigated the association between mental health and diet quality in university student populations.**Methods:** PubMed was comprehensively searched to identify studies that explore the role of aspects of diet quality on quality of life, depression, and anxiety in university students.**Results:** Healthy dietary patterns, such as the Mediterranean and the DASH diet, diets with high intakes of antioxidants and antioxidant vitamins, folate, Zinc and Calcium are associated with less depressive symptoms. Higher alcohol and salt intake have also been associated with depression.**Conclusion:** Healthy dietary patterns, with adequate micronutrient and antioxidant intakes are associated with better mental health status. However, further randomised controlled clinical studies are needed in order to clarify the cause and the effect of the observed associations.**Keywords:** Diet; Anxiety; Depression; University students; Dietary patterns

Introduction

Mental health problems among undergraduate and postgraduate university students are widespread [1]. University students present with a significant number of mental health problems and high rates of psychological distress [2], which can affect college attrition and academic achievement [3,4], as well as students' emotional and behavioural skills and social life [2].

Two recent studies, part of the WHO Mental Health Surveys [3,4] investigated the mental health status of university students. An earlier paper examined the associations between mental health disorders and college entry and attrition by comparing college students and non-students in the same age range (18-22 years old) in 21 countries, around the world, with low, middle and high incomes. One in five college students had mental health disorders the past year, but just 16.4% of those students received treatment [3]. Another one investigated the mental health problems among freshmen in an e-survey of students in Belgium. One in three new students reported mental health problems in the past year [4]. Notably, the WHO Survey [3] and the systematic review by Storrie et al. [2] found that the vast majority of the students with mental health disorders were diagnosed before college entry (83.1% and 51%, respectively), highlighting the importance of mental health during adolescence.

Several studies have focused on medical students, and have shown that medical students have high levels of various mental health disorders, from depression to sleep disorders and burnout [5], which impair personal and occupational functioning. About one fourth of medical students had a mental health condition before

attending medical school, and one in three consulted a mental health professional. Anxiety and stress were quite common [6], while the fear of stigmatization was also evident in this group of students [7].

The association between mental health and diet is being investigated [8-10]. Diet can affect mental health aspects of university students, as well. University students have turned away from healthy dietary patterns [11], while diet quality is important for adolescent mental health, and most university students have been diagnosed with mental health problems pre-matriculation. Taking into account the above, the present review aims to critically summarise the observational studies and clinical trials that have investigated the association between mental health and diet quality in university student populations.

In this aspect, PubMed database was comprehensively searched, using relevant keywords in order to identify observational studies and clinical trials that have investigated the role of diet quality on quality of life, depression and anxiety in university students. The keywords used were combinations of the following: depression, anxiety, stress, diet, probiotics, mental health, quality of life, university students, Mediterranean diet. We also hand-searched the reference list of the studies, as well as the reference list of relevant reviews.

Diet and Mental Health in the General Population

Substantial evidence points towards an association between nutrients [12], healthy dietary patterns and better mental health [8-10]. The effect of diet on mental health may also be mediated

by gut microbiota [13], while other biological mechanisms [14] have also been proposed, including inflammation, oxidative stress, neuroplasticity and epigenetic modifications [15,16]. Concerning DNA methylation, nutrients such as folate, vitamins B6 and B12, choline and betaine [17] have the potential to impact DNA methylation. Nutritional deficiencies in utero and during infancy can influence brain development and possibly negatively impact behaviour [18-20]. In addition to this, diet has been implicated to mediate the relationship between inflammation, depression [21] and brain function [22], while low anti-oxidant capacity [23] and low antioxidant levels have been observed in patients with depression [24].

In adults, a longitudinal study showed that low diet quality was associated with higher risk of depressive symptoms and the higher adherence of traditional diet was associated with a lower risk of depressive symptoms [25], while the SUN cohort showed that high fast-food and commercial baked foods intake [26], higher consumption of added sugars and lower quality carbohydrate rich foods consumption [27] were associated with higher depression risk. Conversely, higher fruit, vegetable and nut consumption has been positively associated with better mental health status [28,29]. Adherence to the Mediterranean Diet (MD) has been positively associated with better mental health status [30,31], while MD supplemented with nuts resulted in lower depression risk in the PREDIMED study [32]. In addition to this, in the elderly, higher adherence to the MD was independently associated with better cognitive status and less depressive symptoms [33]. Zinc, Magnesium and folate intakes have been negatively associated with depressive symptoms [12], and micronutrient supplementation has been shown to be effective, regarding improvements on psychiatric symptoms [34].

Systematic reviews [35-37] regarding the association between diet quality and mental health and depression in children and adolescents have found that those with worse mental health reported adherence to poorer dietary pat-terns, although confounding factors need to be controlled in future studies [37]. In children and adolescents around the world, adherence to a traditional [38] and a healthy diet [39] has been positively associated with better mental health measures. Studies in healthy populations and patients have observed an association between higher diet quality and higher quality of life [40-43]. MD adherence has also been associated with better quality of life both in adolescents [40] and adults [41], which could be attributed to the palatable, non-restrictive nature of this healthy diet and the high nutrient density, which could play a role on the prevention of mental health disorders, as discussed above. In addition to this, a healthy dietary pattern, such as the MD had a positive impact on physical health [42], thus patients who follow a healthy diet may observe improvements on their physical health, with positive impact on their quality of life.

Mental health scores

Studies use questionnaires in order to assess the mental health of the students. The most commonly used ones, according to the bibliography are the Center for Epidemiological Studies Depression Scale (CES-D scale) by L.S. Radloff [43], where a score of 16 points or more is considered depressed, and the Depression Anxiety Stress

Scales (DASS 21) by S.H. Lovibond, & P.F. Lovibond [44], which have cut-off points for anxiety, depression and stress. Additionally, the Beck Depression Inventory (BDI-II) [45].

Is used for the severity of depressive symptoms with scores of 0 to 13 indicating minimal depression, 14-19 mild depression, 20-28 moderate depression, and 29-63 indicating severe depression. The General Health Questionnaire (GHQ-12) [46] assesses Anxiety and Depression, Social Dysfunction, and Loss of Confidence. The GHQ-12 cut-off point has not been firmly set, and the most commonly used one is 2/3. Other studies use Zung's Self-Rating Anxiety Scale [47]. and Zung's Self-Rating Depression Scale. [48]. Lastly, the Positive and Negative Affect Schedule (PANAS) [49] has also been used. Studies use different scales, hence comparisons between studies should be done with caution [50,51].

Dietary Factors and Mental Health in University Students

Diet quality, depression and anxiety

Nine studies from the past 12 years have explored the relationship between diet quality and mental health in university students. The studies are summarised in Table 1. Unhealthy eating habits have been significantly associated with higher prevalence of anxiety, stress [52,53] and depression [52,54,55] scores in university students, according to relevant tools.

In 838 Applied Medical Sciences students in Jordan, a student population with high rates of mental health problems, Almdawi et al. [52] found that self-evaluation of diet as "unhealthy" was independently associated with higher depression and stress scores [52]. The important role of the self-evaluation of the diet quality on mental health, was also highlighted in the study by El Ansari et al. [56], in Egypt, where despite the fact that the Dietary Guideline Adherence Index was not associated with stress, when the subjective evaluation of healthy eating was taken into consideration it was negatively associated with stress, while stress was associated with lower stress-induced food intake [56].

Considering objective tools, "unhealthy eating", according to the Healthy Eating Index (modified by Norte et al. [57]) has been significantly associated with depression, anxiety and stress scores, according to the Depression Anxiety Stress Scales (DASS 21) in Spanish university students [53]. Another recent cross-sectional study from Poland, using the Beck Depression Inventory (BDI-II), found that increasing rates of healthy eating practices was associated with less depressive symptoms [54].

Few studies have investigated the association between MD adherence and mental health in this population group [11]. A follow-up study of the SUN Project explored the relationship between MD adherence and incidence of clinical depression in 10,094 healthy at baseline Spanish university graduates [58]. 4.4 years later, 480 depression cases were diagnosed. Higher MD adherence was significantly associated with lower risk of depression. Inverse dose-response relationships were found for foods that characterize MD, namely fruit and nuts intake, the monounsaturated-to-saturated-fatty-acids ratio, and legume intake and depression risk [58]. Concerning stress, students with low MD adherence had higher stress scores, regarding the communication of their ideas, in the

Table 1: Studies concerning dietary patterns and mental health in university populations.

Dietary pattern	Participants	Country	Findings	References	Ref number
Self-evaluation of diet as healthy or unhealthy	838 allied health professions students	Jordan	Self-evaluation of diet as unhealthy → ↑ depression and anxiety scores (DASS 21)	Almhdawi et al., 2018	[52]
Healthy Eating Index	1055 university students	Spain	Unhealthy eating → ↑ depression, anxiety and stress (DASS 21)	Ramon-Arbues et al., 2019	[53]
Eating practices	959 students	Poland	Healthy eating practices → ↓ depressive symptoms (BDI-II)	Oleszko et al., 2019	[54]
Mediterranean Diet	10,094 initially healthy students	Spain	↑ MD adherence → ↓ risk of depression	Sánchez-Villegas et al., 2009	[58]
Mediterranean Diet	515 university students	Spain	↓ MD adherence → ↑ stress	Chacon-Cuberos et al., 2019	[59]
DASH diet	240 university students	Iran	↑ DASH diet adherence → ↓ depression, anxiety, and stress scores (GHQ-12 & DASS-21 scales)	Faghih et al., 2020	[60]
Dietary Guideline Adherence Index/Self-evaluation of diet	2810 university students	Egypt	<ul style="list-style-type: none"> Dietary Guideline Adherence Index was not associated with stress Subjective evaluation of healthy eating negatively associated with stress Stress was related with ↓ stress-induced food intake 	El Ansari et al., 2015	[56]
Vegetarian diet	2991 German and 12,405 Chinese university students	Germany and China	<ul style="list-style-type: none"> Better mental health at baseline → non-vegetarian diet In Chinese students a vegetarian diet was an independent significant predictor of future mental health 	Velten et al., 2018	[62]
Vegetarian/Vegan diets	1608 German and 12,744 Chinese university students	Germany and China	No association, except for negative impact in Chinese students concerning anxiety & depression	Lavalle et al., 2019	[63]
Recommendations of the Spanish Society of Community Nutrition	117 students of a Faculty of Sciences	Spain	<ul style="list-style-type: none"> Macronutrients are associated with mood A healthy dietary pattern, with a high complex carbohydrate, high fibre, high aspartate, and a low cholesterol diet, may provide benefits improving the processing of social and affective information 	Ugartemendia et al., 2020	[72]

DASS-21: Depression; Anxiety and Stress Scale - 21; BDI-II: Beck Depression Inventory-II; MD: Mediterranean Diet; GHQ-12: General Health Questionnaire; DASH: Dietary Approaches to Stop Hypertension.

univariate, but not the multivariate analysis [59]. The multivariate analysis highlighted the fact that BMI and female sex were associated with higher academic stress scores, indicating a possible link between worse dietary habits during stressful periods [59]. Another healthy dietary pattern is the Dietary Approaches to Stop Hypertension (DASH) diet. Greater adherence to the DASH diet has been associated with better mental health, with lower depression, anxiety, and stress scores (General Health Questionnaire/GHQ-12 and DASS-21 scales) in Iranian university students [60].

In summary, adherence to dietary patterns that are characterized as healthy patterns are associated with better mental health status scores.

Vegetarian and vegan diets and mental health

Two studies have investigated the role of vegan and vegetarian diets on mental health (Table 1). Vegan and vegetarian diets are on the rise [61], however, there is a lack of studies in student populations concerning their impact on mental health. A longitudinal study aimed to evaluate certain lifestyle choices as predictors of mental health in German and Chinese students. Vegetarian diets were associated with worse mental health status. Better mental health at baseline was predicted by a non-vegetarian diet among other factors, while in Chinese students a vegetarian diet was a significant predictor of future mental health, after adjusting for lifestyle choices, age, gender, and baseline mental health [62]. However, a recent study that also explored this association in multiple countries found no significant association between a vegetarian diet and mental health in US, Russian and German participants, but it was associated with anxiety and depression in Chinese students [63]. This effect could

be attributed to socio-economic factors that influence both mental health and the choice or need to adhere to a vegetarian diet in China. Hence, it is still unclear whether a plant-based diet can impact mental health in university students. Socio-economic factors and the reason behind choosing a vegetarian or vegan diet is an important factor to explore, as they can be used to mask disordered eating and eating behaviours [64,65].

Food groups and mental health

The impact of foods on mental health has been explored in sixteen studies (Table 2). Some studies show gender differences, which could be attributed to biological differences and sex differences regarding the relationship with food [66], as well as the female to male ratio in some studies. El Ansari et al. [67] found that consuming less nutritious ('un-healthy') foods (sweets, cookies, snacks, fast food) was significantly positively associated with perceived stress in females, and depressive symptoms in both men and women. Consumption of nutritious ('healthy') foods (fruits and vegetables) was significantly negatively associated with perceived stress and depressive symptoms for both men and women [67]. As symptoms of anxiety and depression increase, energy intake decreases and sugar intake increases [68]. Especially male university students consume more saturated fats, and less fruits and vegetables, as depressive symptoms increase [68], while fish and seafood consumption has been negatively associated with depressive symptoms [67]. Concerning stress, higher perceived stress score was significantly associated with less frequent fruit and vegetable intake, especially in males. Yet, no significant association was observed between the sweets, cakes and snacks intake and stress [56]. However, data from three countries, concerning male students, showed that food groups were not associated with perceived stress

Table 2: Food impact on mental health in university populations.

Food group	Participants	Country	Findings	References	Ref number
Fruits and Vegetables	225 undergraduate US students	United States of America	Less fruit and vegetable intake with greater depressive symptoms in men	Keck et al., 2020	[68]
	3,706 university students	United Kingdom	Negative association with perceived stress and depressive symptoms for men and women	El Ansari et al., 2014	[67]
	696 German 489 Poland and 654 Bulgarian university students	Germany, Poland, Bulgaria	Negative association with perceived stress & depressive symptoms in women	Mikolajczyk et al., 2009	[66]
	1956 university students from Appalachia	United States of America	Negative association with depression in males	Wattick et al., 2018	[73]
	2810 university students	Egypt	Negative association with perceived stress, especially in males	El Ansari et al., 2015	[56]
	171 healthy young adults aged 18–25	New Zealand	<ul style="list-style-type: none"> No changes were found for depressive symptoms, anxiety, or mood after 14-day intervention Better well-being measures 	Conner et al. 2017	[76]
Fruits	60 male university students	Iran	Negative association with depression	Prohan et al. 2014	[70]
	2579 college students	China	Positive independent association with stress and depression	Liu et al. 2007	[71]
Meat	696 German 489 Poland and 654 Bulgarian university students	Germany, Poland, Bulgaria	Negative association with depressive symptoms in women	Mikolajczyk et al., 2009	[66]
Dairy	1055 university students	Spain	Negative association with prevalence of psychological and sleep disturbances	Ramon-Arbues et al., 2019	[53]
Legumes/Nuts/Seeds	60 male university students	Iran	Negative association with depression	Prohan et al. 2014	[70]
Fish and seafood	3,706 university students	United Kingdom	Negative association with depressive symptoms in men	El Ansari et al., 2014	[67]
Sweets/Snacks/Baked goods/ Fast food	3,706 university students	United Kingdom	Positive association with <ul style="list-style-type: none"> stress in females, depressive symptoms in both men and women 	El Ansari et al., 2014	[67]
	696 German 489 Poland and 654 Bulgarian university students	Germany, Poland, Bulgaria	Positive association with perceived stress in women	Mikolajczyk et al., 2009	[66]
	2579 college students	China	Positive independent association with stress and depression	Liu et al. 2007	[71]
Sweets	62 female university students	Japan	Positive association with worse mental health	Mochimasu et al. 2016	[69]
Added sugar	1956 university students from Appalachia	United States of America	Positive association with anxiety	Wattick et al., 2018	[73]
	225 undergraduate US students	United States of America	Higher intakes with increasing anxiety scores	Keck et al., 2020	[68]
Alcohol	2658 university students	Nigeria	Alcohol dependence, abuse and hazardous use positive association with major depressive disorder	Adewuya et al. 2006	[77]
	793 black students	South Africa	Positive association with depressive symptoms	Peltzer, 2003	[78]
	2991 German and 12,405 Chinese university students	Germany, China	↑ mental health in German and ↓ mental health in Chinese students	Velten et al. 2018	[62]
	475 nursing students	Australia	Alcohol score was associated with lower health related quality of life	Heidke et al. 2021	[79]

or depressive symptoms [66]. In females, perceived stress has been associated with higher consumption of sweets/fast foods and lower consumption of fruits and vegetables [66]. In female future dietitians, higher intake of sweets was independently associated with worse mental health in a pilot and cross-sectional study in Japan [69]. Although the authors did not describe a mechanism behind the association, their knowledge regarding diet quality and health could impact their relationship with food.

Excessive intake of sweets and low intake of dairy has recently been associated with higher prevalence of psychological and sleep disturbances in a university student population, with high rates of low diet quality [53]. Additionally, depressive symptoms were associated with less frequent consumption of fruits/vegetables and meat [66], while Prohan et al. found that students with depression exhibited lower intakes of fruits, legumes, nuts and seeds, than students without mental health problems [70].

High frequency of consumption of fresh fruit was associated with low levels of perceived stress and depression, while high frequency of ready-to-eat food and snack food was related with higher levels of perceived stress, and high intake of ready-to-eat and fast foods was positively associated with perceived depression [71]. Food choices are related to socio-economic status.

Furthermore, a recent Spanish study [72] also observed the negative impact on mental health of diets that defer from the traditional Mediterranean Diet, and the association between mental health aspects and macronutrients. The authors concluded that a healthy diet, rich in complex carbohydrates, insoluble fibre, and aspartate, and low in cholesterol could be beneficial for mental health [72].

Food insecurity has been related to worse mental health status [73-75]. A study in Appalachia [73] investigated the role of diet quality and food insecurity in university students. Concerning depression,

Table 3: Micronutrients and Antioxidants on mental health in university populations.

Micronutrients	Participants	Country	Findings	References	Ref number
Antioxidants/Dietary Inflammatory Index	134 female university students	Turkey	Positive association between Dietary Inflammatory Index score & depression	Açik et al., 2019	[81]
Antioxidants-lutein & zeaxanthin	60 male university students	Iran	Students with depression had: <ul style="list-style-type: none"> • ↓ quality diet and lower antioxidants intake • ↓ Total Antioxidant Capacity 	Prohan et al. 2014	[70]
Calcium	56 female college students with depression and 122 female students without depression	Korea	Positive association with depression score (CES-D scale)	Park et al., 2019	[83]
Zinc	308 female university students	Iran	<ul style="list-style-type: none"> • ↓ Zinc levels & intake in students with depression • Zinc intakes and concentration were correlated with the Beck questionnaire scores 	Amani et al., 2010	[82]
Folic Acid	56 female college students with depression and 122 female students without depression	Korea	Positive association with depression score (CES-D scale)	Park et al., 2019	[83]
	425 post graduate students	Iran	Intake was related to the total score of Depression Scale CES-D & the subscales depressive affect and interpersonal difficulties	Yary, 2013	[84]
Vitamins A and C	60 male university students	Iran	Students with depression had: <ul style="list-style-type: none"> • ↓ quality diet and lower antioxidants intake • ↓ Total Antioxidant Capacity 	Prohan et al. 2014	[70]
	56 female college students with depression and 122 female students without depression	Korea	Positive association with depression score (CES-D scale)	Park et al., 2019	[82]
Salt	20222 university students from 26 countries	various	Positive association with depression score (CES-D scale)	Peltzer et al., 2015	[86]
Omega 3 fatty acids	68 medical students received either 2.5 g omega-3 /day (2085 mg eicosapentaenoic acid and 348 mg docosahexanoic acid) or placebo	United States of America	↓ anxiety after intervention and lower inflammation (reductions in stimulated IL-6 and tumour necrosis factor alpha production)	Kiecolt-Glaser et al. 2011	[87]
Tryptophan	25 healthy university students cross-over study	United States of America	<ul style="list-style-type: none"> • ↑ tryptophan diet → ↑ mood (PANAS scale) ↓ anxiety scores (Zung's Self-Rating Anxiety Scale), • ↓ tryptophan diet → borderline depression scores (Zung's Self-Rating Depression Scale) 	Lindseth et al.	[88]

CES-D: Center for Epidemiological Studies-Depression; PANAS: Positive and Negative Affect Schedule.

food insecurity was an independent factor in both males and females, while and fruit and vegetable intake was independent predictors for depression in males only. Concerning anxiety, food insecurity and added sugar intake were significant predictors of anxiety [73]. Regarding fruit and vegetable intake, Conner et al. [76] undertook a 14-day clinical trial aiming to increase fruit and vegetable intake of 171 young adults aged 18-25, who had low intakes of fruits and vegetables. Participants were randomly assigned into either: a) Their usual diet; b) Their usual diet plus text message reminders to increase their fruit and vegetable consumption and a voucher to purchase fruits and vegetables; or c) A fruit and vegetable intervention where participants were given two additional daily servings of fresh fruits and vegetables to consume on top of their usual diet. The participants, who were given fruits and vegetables to consume, had improved their mental well-being (vitality, flourishing and motivation). However, no changes were found for depressive symptoms, anxiety, or mood, possibly due to the fact that the study participants were mentally healthy and the fact that the study was short-termed. The authors state that the benefits were not due to vitamin C, carotenoids, or mental expectations. This study highlights that improvements in food quality can positively impact mental health, even in healthy populations.

Sex differences and socio-economic factors do play a role on both food choice and mental health. Consumption of more nutritious is associated with better mental health status and lower depression and anxiety scores.

Alcohol use has also been investigated in four studies in relation

to mental health in university students. In Nigeria, compared with those who do not drink, students who present alcohol dependence, abuse and hazardous use were at higher risk for major depressive disorder (according to the Mini International Neuropsychiatric Interview). However, normal alcohol use was not associated with depression [77]. In black South-African students, alcohol drinking was associated with depressive symptoms (according to the 13-item short Beck Depression Inventory) [78], and in Australian nursing students alcohol score was associated with lower health related quality of life [79]. However, the effect of alcohol intake may be cultural. The frequency of alcohol consumption predicted better mental health in German and poorer mental health in Chinese students [62], while the levels of alcohol intake play a role on its impact on mental health.

Nutrients and antioxidants on mental health

Anti-Inflammatory diet patterns and mental health: Lately, the inflammatory and anti-inflammatory effects of dietary patterns interest health professionals, while oxidative stress and inflammation have been observed in individuals with depression [80]. Two studies have explored relative associations in university students (Table 3).

The association between the Dietary Inflammatory Index and depression was explored by Açik et al. [81] in female university students. Students were found to follow a “pro-inflammatory” diet and a significant positive association between Dietary Inflammatory Index score and depressive symptoms was observed. A case-control study on 60 male university students, examined the association between diet and the Beck Depression Inventory-II, the dietary and

serum total antioxidant capacity and high-sensitive C-reactive protein concentrations. Students with depressive symptoms had a lower quality diet, lower Total Antioxidant Capacity and lower antioxidant intake [70]. Hence, a dietary pattern that could be characterized as anti-inflammatory, such as the Mediterranean Diet, may play a role in depression.

Nutrients and antioxidants on mental health: Studies concerning specific nutrients have also been undertaken. Five studies explored micronutrient intake and one randomised controlled clinical trial was undertaken concerning omega-3 fatty acids, while another one examined the role of tryptophan on mental health (Table 3). Nutrient intake can impact mental health in university students, highlighting the role of a healthy diet that provides adequate intakes of all the essential nutrients.

In female university students, a series of studies explored the association between Zinc intake, Zinc status and depression. Zinc intake and serum Zinc concentrations were by two thirds lower in the students with depression than in healthy controls, while Zinc intake and concentration were correlated with the Beck Depression Inventory scores. Students with depression also had lower consumption levels of red meat and chicken, which are main food sources of Zinc [82].

Moreover, in Korean female college students, depression score (Center for Epidemiological Studies Depression Scale- CES-D scale) was positively associated with life stress and negatively associated with vitamin A, folic acid, vitamin C and calcium intakes, healthy diet and healthy dietary behaviours [83]. In post-graduate students in Iran, vita-min B9 intake was related with the total score of CES-D scale and the depressive affect and interpersonal difficulties of the two subscales of the CES-D (depressive affect and interpersonal difficulties) [84]. Moreover, Prohan et al. found that students with depression had lower intakes of the following antioxidants: vitamin C, beta-carotene, lutein, and zeaxanthin [70].

Considering carotenoids, Stringham et al. [85] undertook a randomised controlled trial regarding the mental health impact of macular carotenoids. 59 US participants were randomised to receive either placebo, 13mg, or 27mg per day macular carotenoids for 1 year, and were assessed at baseline, at 6 months and at the end of the trial. At baseline, Macular Pigment Optical Density (MPOD) was negatively associated with the Beck Anxiety Inventory score and the Brief Symptom Inventory score, while serum cortisol and psychological stress scores were also positively associated. Over the study period, improvements were observed on mental and physical health scores of both intervention groups versus the control group, indicating a positive impact of macular carotenoids in this healthy young adult population.

In undergraduate students with high depression rates, from 26 countries with high, medium and low-income countries [86] various factors were independently associated with depressive symptoms (assessed via the CES-D scale). Apart from socio-demographic factors, and traumatic events, unhealthy behaviours, such as smoking, irregular sleep, infrequent meals, and increased salt intake were independently associated with severe depressive symptoms [86].

The role of the omega-3 and omega-6 polyunsaturated fatty

acids on depression and anxiety was investigated in a parallel group, placebo-controlled, double-blind 12-week randomised controlled clinical trial that compared omega-3 supplementation and placebo. 68 medical students provided serial blood samples during lower-stress periods, as well as on days before an exam. The students received either 2.5g omega-3/day, or placebo capsules in the proportions of the fatty acids in the typical American diet. Compared to control group, the intervention group had a 14% decrease in inflammation and a 20% reduction in anxiety scores, but not in depressive symptoms. Decreasing ratios of the plasma omega-6:omega-3 ratio led to lower anxiety scores and lower inflammation [87].

Lindseth et al. [88] examined the impact of dietary tryptophan on anxiety, mood and depression scores, in 25 healthy US university students, in a crossover study. A higher in tryptophan diet was associated with better mood (PANAS scale) and lower anxiety scores (Zung's Self-Rating Anxiety Scale), while they had borderline depression scores after a low tryptophan diet (Zung's Self-Rating Depression Scale) [88].

Probiotics and mental health

Two studies have been undertaken in university students, examining the role of probiotics on mental health. Nishida et al. [89] administered *Lactobacillus gasseri* CP2305 or placebo once daily for 24 weeks to 60 Japanese medical students before a stressful exam. The intake of the probiotic was successful in reducing anxiety and sleep disturbance (Spielberger State-Trait Anxiety Inventory and the Pittsburgh Sleep Quality Index) compared to placebo. Tran et al. [90] in their randomised, placebo-controlled trial with 86 healthy students found that probiotic administration for 28 days was successful on improving anxiety, especially in high distress students.

Conclusion

Mental health problems in university students begin before college enrolment, indicating the need for both timely prevention, early diagnosis, and accessible treatment. In accordance with other previous studies and reviews [91], our review findings point towards a positive association between healthy dietary patterns and university students' mental health, as indicated by the results of randomised controlled trials. In general, a high-quality dietary pattern, like the Mediterranean Diet and the DASH diet, may positively affect mental health in university students. Surprisingly, our findings also pointed towards an association between vegan/vegetarian diets and worse mental health in a limited population (Chinese students), a finding that was also observed in the recent systematic review and meta-analysis of high quality studies by Igacuel et al. [92], especially for anxiety, in participants under 26 years of age in high quality studies. However, a recent meta-analysis did not find any significant associations between vegetarian diets and depression or anxiety with data from observational studies [93]. Another systematic review [94] found that high quality data support the fact that people who avoid meat are at higher risk of depression, anxiety, as well as self-harming Disturbed Eating habits that could be characterized as unhealthy have also been explored in relation to mental health, as they are common in this age group. Disordered eating was common, while one-fifth of the students had moderate levels of depression and anxiety severity and almost half of the students engaged in at least one obsessive-compulsive disorder type behaviour [95]. Food avoidance, influenced

by non-experts on nutrition, was also associated with depressive symptoms [96].

Higher fruit and vegetable intake, as well as high legume, nuts and seeds intake are related with better mental health status. Conversely, higher intakes of fast food, sweets and ready-made baked goods are related to a worse mental health status. Alcohol and salt intake also impact depression symptoms, although the impact of alcohol intake may differ among countries. Concerning micronutrients, zinc, vitamin A, vitamin B9, vitamin C, and calcium intakes are related to depression scores, while pro-inflammatory diets, with low antioxidant intakes are also associated with depression scores.

In children, greater dietary variety was associated with lower risk of internalizing disorder in subsequent years [97]. In women of all ages, a healthy dietary pattern has been associated with lower odds for major depression or dysthymia and for anxiety disorders. Conversely, a “western” type diet has been associated with a higher GHQ-12 score. Diet quality is independently and inversely correlated with GHQ-12 [8], while intake of magnesium, folate, and zinc have been associated with mental health [12]. On the other hand, omega-3 fatty acid supplementation may not be an effective preventing measure against depression and anxiety symptoms [98], despite the positive findings in university students [87].

Concerning gut flora, the gut-brain axis is regulated by microbes [99] and their impact on pathophysiology of mental disorders has been investigated in animal models and humans. There is evidence for altered microbiota in animal models of depression [100] and patients with depression [101,102]. Limited studies [103] so far have explored the effectiveness of probiotics [104] and prebiotics [105] on mental health, and two studies have been undertaken in university students, with positive results within one month.

It is important to note that the associations between diet and mental health are not well studied in university students, and randomised controlled clinical trials are still scarce. There are literature gaps concerning the impact of special diets on mental health problems in this population. Further studies, especially randomised trials are strongly recommended to clarify the causes behind the observed associations between diet, depression, and anxiety, and whether these associations may be due to reverse causality.

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