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Lifestyle behaviors associated with dietary quality in higher education students: A systematic review

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Abstract

Background: During the transition from secondary school into higher education many lifelong health-related behaviors are established. Evidence suggests that unhealthy diet and lifestyle behaviors correlate, causing an increase in co-morbidities, affecting overall health.

Objective: The aim of this review was to identify the relationship between dietary quality and lifestyle behaviors among higher education students.

Methods: A systematic search was performed online, in accordance with PRISMA guidelines. Inclusion criteria were studies conducted among higher education students, dietary intake assessment and its association with a lifestyle behavior, use of validated tools, and published in English from 2000-2021. One researcher screened abstracts and two independently screened the full text of retrieved papers. One researcher extracted data in consultation with a second researcher. Risk of bias was assessed by the first author and two independent assessors.

Results: Forty-five papers, from forty-five countries, with a total of 185,148 participants met the eligibility criteria. Causal relationships could not be established due to cross-sectional design of studies. Three dietary categories were used: i) total dietary intake, ii) dietary patterns, and iii) fruit and vegetable consumption. Lifestyle behaviors assessed were physical activity (PA), sleep, alcohol, and smoking. Twenty-one of twenty-four (88%) studies that assessed the relationship between PA and diet found a significant positive relationship. Six of ten (60%) papers that examined the relationship between sleep and diet found a significant positive association. Higher alcohol use was significantly associated with diet in five out of seven (71%) studies. Seven of eighteen (39%) studies that tested for an association

between smoking status and diet found a significant relationship.

Conclusions: There was evidence of a correlation between higher diet quality and both higher PA levels and lower alcohol consumption. Smoking status and sleep both had an inconclusive relationship with diet. Future research is needed to clarify these relationships inform healthy campus committees when planning services for students.

Keywords: Dietary Intake, Dietary Quality, Dietary Patterns, Fruit & Vegetable Consumption, Lifestyle Behaviors, Higher Education Students

1.Introduction

Since the inception of the World Health Organization Ottawa Charter for Health Promotion[1] in 1986, health has been viewed holistically, highlighting that, within everyday life, there is an interconnectedness between individuals, health and their environments such as home, work and educational settings. The number of higher education students across the globe has risen from 99 million in 2000 to 216 million in 2016, a number that is forecasted to rise to 594 million by the year 2040.[2] The introduction of the Okanagan Charter[3] in 2015 detailed the importance of higher education settings for health promotion. Students are set to be future decision and policymakers, and be role models to others, therefore, they may be seen as a growing population of considerable importance for promoting a healthy diet and lifestyle.[4]

During the transition from secondary school into higher education many lifelong health-related behaviors are established.[5,6] During this transition, a decrease in physical activity (PA) levels,[7] an increase in alcohol consumption[8], and an increase in poor dietary habits is evident; habits that are likely to be maintained throughout life, affecting future health status.[9-11] This may be a result of a change to environment and living arrangements that coincide with higher education commencement,[12-14] potentially causing, for these students, a higher risk later in life of type two diabetes and cardiovascular disease (CVD).[11] If identified early, modifying health risk behaviors can reduce the likelihood of disease later in life.[15]

Although there is no scientific consensus on how to define health-related lifestyle behaviors,[16] they can be considered as daily behavioral choices that affect the overall health status of an individual.[17] An early study of lifestyle behaviors conducted by Mulder et al,[18] studied four modifiable behaviors: PA, diet, smoking, and alcohol consumption. These four remain the most commonly studied health behaviors and have been found to be associated with all-cause mortality.[16,19-21] A healthy diet is often defined as consuming food in a pattern that is beneficial to health, or at least not harmful.[22] Although diet quality definitions have changed over time,[23] common features include a higher proportion of plant-based foods, fruit and vegetables (F&V), whole grains, legumes, seeds, nuts and omega-3 polyunsaturated fatty acids while containing lower amounts of animalbased foods, processed meats, refined sugars, and saturated fats.[24-26] It has been found that a high percentage of students do not meet the recommended daily amounts for whole grains[27,28] and F&V,[29-32] increasing the likelihood of obesity and other non-communicable diseases (NCDs).[33] Lack of PA and the sedentary nature of being a student is the secondary cause of increasing weight and associated co-morbidities after diet.[34-37] Regular alcohol consumption,[8,38] and the presence of excess or lack of sleep[39,40] have been demonstrated to affect the health of higher education students, as has smoking, screen time, other substance use, weight status and stress.[24,41-47]

A meta-analysis of over half a million adults aged from 20-84 with a follow up of 13.24 years (7.8–24), found that a combination of healthy lifestyle behaviors is associated with a 66% reduction in mortality.[16] A multicohort analysis of

over 100,000 adults (non-higher education students) with a mean age of 43.7±10.1 years and a mean follow-up duration of 12.5 (4.9–18.6) years, found that the more healthier lifestyle behaviors someone engages in, the higher the number of disease-free years a person has.[48] Other recent reviews and large studies reported an association between unhealthy lifestyle behaviors and an increased risk of cancer,[49] higher CVD prevalence,[50] long-term weight gain[51] and increased prevalence of obesity in children.[52] A systematic review of children and adolescents found a positive association between Mediterranean Diet (MD) adherence and higher PA levels.[53] A prospective study of almost 40,000 adults concluded that there was an association between an unhealthy diet and lifestyle behaviors.[54] It is, therefore, becoming evident that diet and lifestyle behaviors correlate with each other, and both are of great importance for overall health.[11]

A recent systematic umbrella review of the prevalence and determinants of modifiable health factors in higher education students found 81 review articles, comprising of 2,703 original articles.[55] The review included studies focusing on PA,[56,57] alcohol consumption,[8,58] substance use,[59,60] tobacco consumption,[61,62] and sleep[63] of higher education students. The most commonly found reviewed topics by Dietz et al,[55] were on substance use, namely alcohol, and in the area of mental health, particularly stress. Topics such as media consumption, sleep, nutrition and PA were deemed understudied. Six reviews were found by Dietz et al,[55] focusing on diet and nutrition in the areas of eating disorders, food insecurity, nutrition labels and the effects of dietary intervention with none assessing the correlation between diet and other lifestyle behaviors.

Other reviews were found that assessed the food intake of university students[28] and its relationship with academic achievement,[64] stress[65] and obesity traits.[66] In a review by Bernardo et al,[28] it was found that the majority of students had unhealthy dietary intakes. Elshurbjy & Ellulu,[65] found that stress affects dietary intake in two ways, causing under- or overeating, potentially explaining why stress is found to be associated with both weight gain and weight loss.[66] In the review by Burrows et al,[64] it was found that improved dietary intake was associated with higher academic achievement and, therefore, a higher education setting health-promoting initiative may be beneficial to students and the institute. Intervention studies described in the review by Dietz et al,[55] found environmental strategies were not commonly used and the majority were focused on individual behaviors; the authors reported a need for more setting-based health interventions, which is in agreement with the Okanagan Charter,[3] and noted as important for this population group.[28,64,66]

These reviews have created an overview of modifiable health behaviors in a student population and these results may create and improve diet and lifestyle behavior resources and environments in higher education settings. Although multiple reviews assessed the diet and lifestyle behaviors of higher education students singularly, none have assessed their correlation.[55] Therefore, this systematic review aimed to identify the relationship between dietary quality and lifestyle behaviors in higher education students.

2.Methods

The current systematic review procedure was registered in PROSPERO, the international prospective register of systematic reviews, ID: CRD42020176822: https://www.crd.york.ac.uk/PROSPERO/display_ecord.php?RecordID=176822. Transparency was ensured by conducting this review in adherence to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses - for Protocols (PRISMA-P) statement and the PRISMA 2020 checklist[67] which can be viewed in Supplementary Material 1.

Eligibility Criteria

The PICO (Population, Intervention, Comparison, and Outcome) format is a commonly used strategy for framing a research question. These four components enable the identification of relevant information.[68,69] The inclusion criteria for this review are detailed in Table 1. As previously noted, diet quality definitions have

Table 1. *Population, Intervention, Comparison and Outcomes (PICO) and study design*

Population	Students attending a higher education undergraduate, graduate course or equivalent, in any international location.
Intervention	Lifestyle behaviours associated with dietary quality in higher education students. Studies where dietary intake was measured by dietary assessment techniques (e.g., food diaries, 24-hour recalls, food frequency questionnaires) and have assessed the adequacy of dietary quality by reporting either: a. total dietary intake and comparing with food-based dietary guidelines, dietary reference values or validated indices (e.g., Healthy Eating Index); or, b. adherence to dietary patterns (e.g., Mediterranean diet); or c. scoring dietary intake frequency of fruit and vegetable intake. Recognised lifestyle behaviours (including, but not limited to, physical activity, sleep, smoking, and alcohol consumption), measured by validated tools. A single question regarding alcohol consumption has been found to be a time-efficient and clinically useful method for detecting hazardous drinking behaviour.[78,79] Presence of smoking habits will be included as a non-validated measure.
Comparison	No comparison groups. The question is about an issue of interest.
Outcome	Studies that find a significant or non-significant association between lifestyle behaviours and dietary quality of higher education students.
Study design	Systematic reviews and meta-analysis were excluded, all other study designs were deemed eligible, including cross-sectional, longitudinal (cohort), and intervention studies reporting baseline data.

changed over time[23] with the most common features being a higher proportion of plant-based foods, F&V, whole grains, legumes, seeds, nuts and omega-3 polyunsaturated fatty acids while containing lower amounts of animal-based foods, processed meats, refined sugars, and saturated fats.[24,26] Dietary intake indices explore adherence of individuals to dietary guidelines or established healthful dietary patterns such as the Mediterranean diet.[70,71] Additionally, F&V consumption also predicts diet quality.[72] Therefore, three markers of dietary quality were utilized in this review, outlined in Table 1.

Health-related lifestyle behaviors are considered as daily behavioral choices that affect individuals' overall health status.[17] Recent studies of higher education students have often measured limited lifestyle behaviors, however, the most frequently assessed are diet, smoking, alcohol, sleep, PA, screen time, substance use, weight status and stress.[43,45,47,73] Weight status and BMI are viewed as outcomes of diet and lifestyle behaviors,[73,74] therefore, not included. Similarly, measures of psychological stress have been viewed as a consequence of poor health-related lifestyle behaviors,[75,76] and therefore not included.

Studies were excluded if they did not report on nutritional intake, on the association between a lifestyle behavior and diet, focused solely on outcomes of diet, focused solely on a lifestyle behavior, did not use recognized validated meas uresor were studies that were not conducted using higher education students as participants. Studies written in English and published between 2000 and 2021 that meet the criteria have been included (Table 1).

Literature Search

A systematic search was performed from July to September 2020 in PubMed, Web of Science, EOLAS (via EBSCOhost), ScienceDirect (via EBSCOhost), and Eric (via EBSCOhost) databases to identify potential studies. A secondary search of these databases took place in July 2021 to update current findings. Keywords and MeSH (medical subject heading) terms were documented in a study protocol and conducted combining the following search terms:

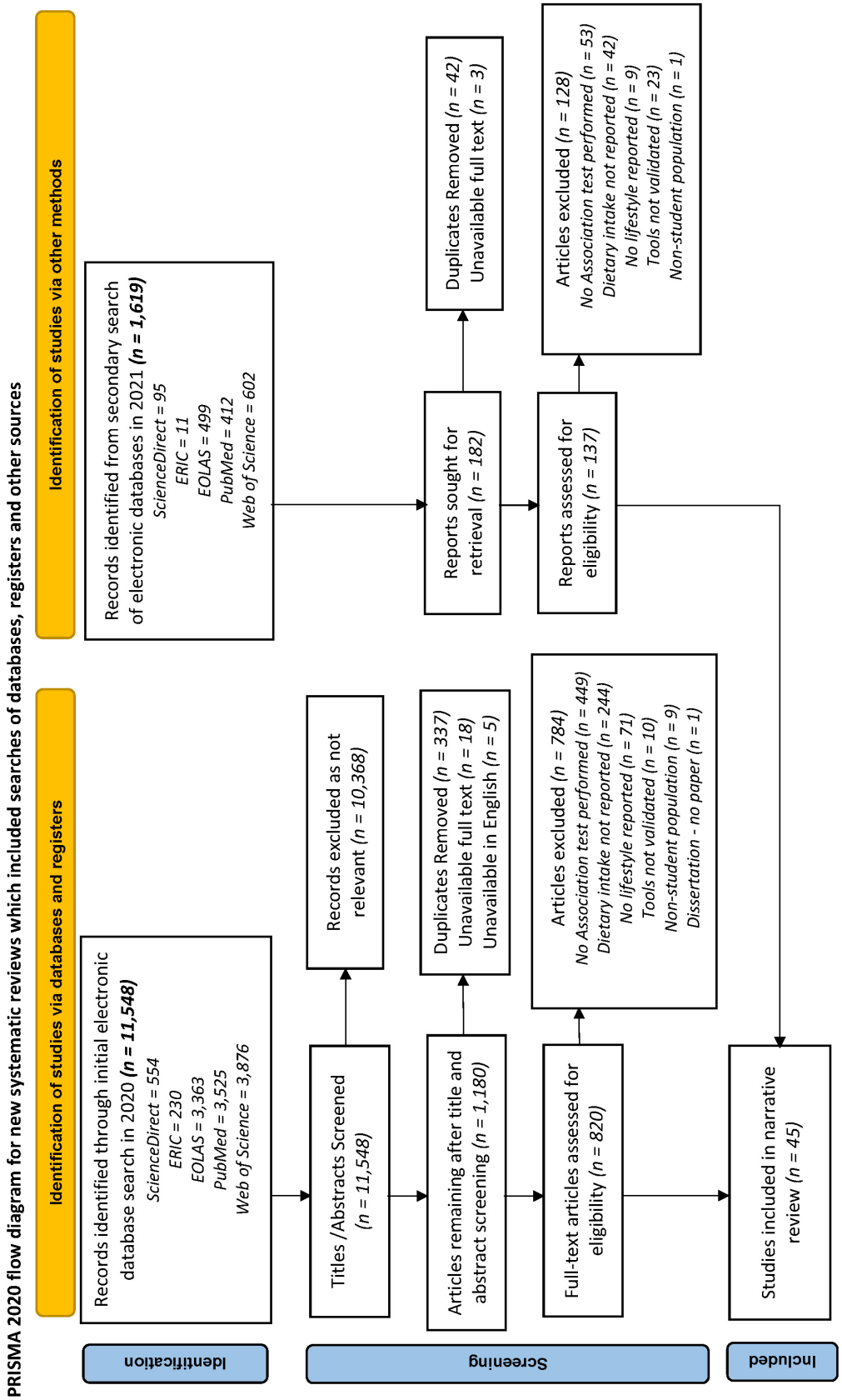
1. (Eating OR diet* OR food OR nutrition) AND
2. (University student OR college student OR undergraduate student OR graduate student OR tertiary student OR third level student OR postsecondary student OR higher education student) AND
3. (Determin* OR lifestyle OR factor OR associat* OR correlation OR cause)

Truncation was used to search word variants (symbolized by *) and terms were combined using the Boolean logic of AND or OR operators. Full terms available in Supplementary Materia l2.

Study Selection

The article selection process is shown in a flow diagram (Figure 1), predefined by inclusion and exclusion criteria (Table 1). The study selection process was performed in two steps. Firstly, all titles and abstracts were screened within all databases by one researcher (SD). Articles that met the inclusion criteria, or if it was unclear whether they could be excluded, were retrieved, and downloaded while duplicates were removed.

Figure 1. *PRISMA flow diagram*



Secondly, two researchers (SD, NOC) independently screened the full text of retrieved papers and determined their inclusion based on the predefined criteria. In the case of disagreement, a third reviewer (LK) was consulted. Microsoft Excel 2016, version 16.0 and Mendeley Reference Manager, version 1.19.8 were used to manage references and track paper selection.

Data Extraction

One reviewer (SD) completed data extraction, and this was checked for reliability by a second reviewer (LK). LK ensured reliability by ensuring valid tools were used and a high standard of statistical analysis was completed within included studies. There was consultation with a third and fourth reviewer (JK & JMK) to ensure extraction comparability and consistency. Data was extracted from papers that met the inclusion criteria using a data extraction tool developed by the authors. For studies that met the inclusion criteria, information about each study was extracted and organized into a descriptive table (Table 2) including general article information, study characteristics and participants' characteristics. Studies and their findings, including statistical associations between diet and lifestyle behaviors derived, were organized into three tables according to how diet was measured (i.e., total dietary intake, dietary patterns, and F&V consumption) (Tables 3-5).

Risk of Bias (Quality) Assessment

Risk of bias was assessed by three researchers, which included the first author (SD) and two independent assessors (DNC, MDH) using The Academy of Nutrition and Dietetics Quality Criteria Checklist for Primary Research.[79] A fourth reviewer (LK) evaluated the findings to ensure accuracy and discussed findings. In the case of disagreement, an open discussion took place with all authors, and a decision was made, based on consensus. This method of evaluating the validity of observational studies has been used in previous papers relating to dietary intake.[64,80,81]

The Quality Criteria Checklist for Primary Research evaluates ten items relating to validity, comprising of four key areas: sample selection methods, controlling of confounding factors, reliability of outcome, and statistical analysis, resulting in a quality rating that provides a systematic, reproducible, and quantitative means assessment, ensuring a sufficient and high standard systematic review.[82] Each item was answered "yes," "no" or "unclear,". Studies were deemed as positive quality or having minimal risk of bias if "yes" was the answer to all key validity questions and had a score of six or above. If the answers indicate some risk of bias within the study, it is designated neutral or medium quality. For studies where "no" was answered on five or more questions, it was considered negative or inferior quality with a considerable risk of bias. Results and the criteria checklist used can be seen in Supplementary Materials 3 and 4.

Data Synthesis

The studies included in this review, are from multiple nations, used a variety of study designs and measuring methods, resulting in significant

Table 2. *Study design and characteristics*

Author (Year)	Country	Study Design: (a) Study Type, (b) Recruitment Sampling, (c) Recruitment Method, (d) Response/ Participation/ Consent/ Completion Rate	Sample Size (% Female)	Participants Characteristics: (i) Age, (ii) Course or Department, (iii) Academic Year	Study Quality Rating
Adams & Colner, (2008)[83]	USA	a) Retrospective study b) N/A c) Students completed the assessment using either an online or paper-and-pencil version d) Response rate = 78% (paper), 21% (Web-based)	40209 (65%)	i) 20.3±1.37 ii) All faculty iii) First = 29.5%; Second = 22.5%; Third= 21.3%; Fourth = 17.5%; Fifth + = 6.2%; Graduate = 2.9%; Adult special = 0.1%; Other = 0.2%	Ø
Adams et al., (2020)[84]	USA	a) Cross-sectional b) N/A c) Recruited via flyers, newspaper advertisements, and class announcements during the academic year d) Completion rate = 75.3%	55 (100%)	i) Mean = 19 ii) Not reported iii) Not reported	Ø
Antoine-Jonville et al., (2010)[85]	French West Indies	a) Cross-sectional b) Random convenience sampling c) Students were approached on campus d) Consent rate = 79%; Completion rate = 72.1%	202 (100%)	i) Median (IQR) = 20 (19-21); Skewness = 1.64 ii) Several academic departments iii) Studying for more than one year	+
Aslan Çin, & Yardimci ,(2021)[86]	Turkey	a) Cross-sectional b) N/A c) Data collected using survey forms and face-to-face interview technique d) N/A	412 (100%)	i) 20.8±1.4 ii) Not reported iii) Not reported	+
Baydemir et al., (2018)[87]	Turkey	a) Cross-sectional b) Convenient random sampling c) Questions presented to students during class d) Response Rate = 58.8%	354 (55%)	i) 19.8±1.8 ii) School of medicine iii) First- and third-year students	Ø
Bennasar-Veny et al., (2020)[88]	Spain	a) Cross-sectional b) Randomized, multistage, conglomerate recruitment, stratified by academic majors c) N/A d) Completion rate = 94%	444 (67.8%)	i) 23.1±5.7 ii) All majors accounted for iii) Studying for more than one year	+
Bertsias et al., (2005)[89]	Greece	a) Cross-sectional b) Students registered in the third year of the clinical nutrition class were invited to participate c) N/A d) Participation rate = 98%	523 (42.8%)	i) 22.0±2.0 ii) Medical students iii) Third year	+

Author (Year)	Country	Study Design: (a) Study Type, (b) Recruitment Sampling, (c) Recruitment Method, (d) Response/ Participation/ Consent/ Completion Rate	Sample Size (% Female)	Participants Characteristics: (i) Age, (ii) Course or Department, (iii) Academic Year	Study Quality Rating
Borlu et al., (2019)[90]	Turkey	a) Cross-sectional b) Students attending the last grade c) N/A d) Response rate = 95.7%	246 (49.2%)	i) 24.6±1.7 ii) Medical students iii) Last grade	+
Carlos et al., (2020)[91]	Spain	a) Cross-sectional b) For convenience, a non-aleatory sample was used c) Data collected on paper and in person d) N/A	252 (75.8%)	i) 21.42±4.73 ii) Nursing, physiotherapy, and psychology iii) Not reported	+
Cena et al., (2021)[4]	International Study[a]	a) Cross-sectional b) N/A c) N/A d) Response rate varied from 4.3% to 100%	6222 (39.8% to 82.4%)	i) Median (IQR) varied between countries from 19.0(2.0) to 24.0(2.0) ii) Medicine, dentistry, nursing, pharmacy, sports and veterinary sciences, dietetics and economics iii) All years	+
Chacón-Cuberos et al., (2018)[92]	Spain	a) Cross-sectional b) Random sampling c) Collaboration requested using informative document d) Completion rate = 100%	775 (41.3%)	i) 22.2±3.8 ii) Physical education degrees iii) All years	Ø
Chacón-Cuberos et al., (2019)[93]	Spain	a) Cross-sectional b) Convenience sampling (younger than 30) c) N/A d) N/A	515 (49.2%)	i) 21.6±2.7 ii) Enrolled in educational sciences iii) Any enrolled during 2017–18 academic year.	Ø
Cobo-Cuenca et al., (2019)[94]	Spain	a) Cross-sectional b) Random convenience sampling – minimal 300 sample size, calculated using Epidat 4.2 c) N/A d) Response rate = 55.4%	310 (64.5%)	i) 20.9±2.5 ii) Faculties of Education, Nursing, Physiotherapy, Social Work and Polytechnic iii) First years	+
Deliens et al., (2018)[95]	Belgium	a) Cross-sectional b) A convenience sample c) Contacted face-to-face on campus and received a questionnaire invitation by email upon consent. d) Participation rate = 63.4%; Completion rate = 43.1%	185 (67%)	i) 20.8±1.7 ii) N/A iii) All years	+

Author (Year)	Country	Study Design: (a) Study Type, (b) Recruitment Sampling, (c) Recruitment Method, (d) Response/ Participation/ Consent/ Completion Rate	Sample Size (% Female)	Participants Characteristics: (i) Age, (ii) Course or Department, (iii) Academic Year	Study Quality Rating
de-Mateo-Silleras et al., (2019)[96]	Spain	a) Cross-sectional b) N/A c) N/A d) N/A	214 (75.2%)	i) Average = 22 (range 18–46 years old) ii) Health science = 52.8%; Engineering = 18.2%; Social & legal sciences = 11.7%; Sciences = 7.9%; Arts = 6.1%; PA = 3.3% iii) N/A	Ø
Di Benedetto et al., (2020)[97]	Australia	a) Cross-sectional b) N/A c) Participants recruited through various social media sites, e-mail, or psychology classes d) Completion rate = 92%	355 (80.6%)	i) 20.0±1.5 ii) Psychology = 54.4%, Other = 45.6% iii) N/A	Ø
Dinger et al., (2014)[29]	USA	a) Cross-sectional b) Surveyed all students/ random sampling c) N/A d) N/A	67861 (68%)	i) 18-20 = 60.4%, 21-24 = 39.6% ii) All iii) N/A	+
Du et al., (2021)[98]	USA	a) Cross-sectional b) Random convenience sampling c) Students recruited online via university research systems, during which time most areas had adopted "shelter in place" orders due to COVID-19 d) Completion rate = 84.6%	1280 (73%)	i) 22.5±4.8 ii) All courses iii) All years	+
Du et al., (2021)[99]	International Study[b]	a) Cross-sectional b) Random convenience sampling c) Students recruited online via university research systems, during which time most areas had adopted "shelter in place" orders due to COVID-19 d) Completion rate = 84.6%	2663 (66.7%)	i) 22.5±5.5 ii) All courses iii) All years	+
Eaves et al., (2017)[100]	USA	a) Cohort/ Cross-sectional b) Randomly administered at each university c) Two methods: instructors from randomly chosen classes asked students to take a paper-and-pencil version; or they were invited by email to participate online d) N/A	12512 **2003 –** (54.6%) **2007 –** (54.9%)	i) **2003:** 18-19 = 27.7%, 20-21 = 23.4%, 22-23 = 22.5%, >23 = 26.5% **2007:** 18-19 = 26.8%, 20-21 = 20.9%, 22-23 = 17.3%, >23 = 34.9% ii) N/A iii) **2003:** First and second year = 65.8%; Third and fourth year = 32.2%; Other = 2.0% **2007:** First and second year = 53.0%; Third and fourth year = 37.3%; Other = 9.7%	Ø

Author (Year)	Country	Study Design: (a) Study Type, (b) Recruitment Sampling, (c) Recruitment Method, (d) Response/ Participation/ Consent/ Completion Rate	Sample Size (% Female)	Participants Characteristics: (i) Age, (ii) Course or Department, (iii) Academic Year	Study Quality Rating
Elío et al., (2021)[101]	Spain	a) Cross-sectional b) Sample size calculated through the finite populations' formula and 95 was deemed a presentative size c) An invitation was sent to students as they enrolled d) Completion rate = 91%	100 (74%)	i) 36.6±10.5 ii) Postgraduate iii) All years	Ø
Fernández-Medina et al., (2020)[102]	Spain	a) Cross-sectional b) N/A c) Students were selected through the professors who taught that year and questionnaires sent online d) Response rate = 69.6%" for consistency	334 (79.6%)	i) 21.84 (DT=6.24) ii) Nursing iii) First year = 23.1%; Second Year = 31.4%. Third year = 38%; Fourth year = 7.2%	+
García-Meseguer et al., (2014)[103]	Spain	a) Cross-sectional b) Recruitment, including stratification, by enrolled students in each degree c) N/A d) Retention rate = 93%	284 (56%)	i) 21.3±5.8 ii) Any iii) Any enrolled during 2012-13 academic year	Ø
Gianfredi et al., (2018)[104]	Italy	a) Cross-sectional b) All Nursing students approached c) N/A d) Response rate = 63.2%	117 (70.1%)	i) 23.7±4.8 ii) Nursing students iii) First to third years	Ø
González et al., (2013)[105]	Puerto Rico	a) Cross-sectional b) Proportional sampling stratified by each school c) N/A d) Response rate = >10%; Compliance rate = 100%	274 (67.9%)	i) 21-30 years = 88%, 31-53 = 12% ii) Medical science campus iii) First and second year	+
González-Valero et al., (2019)[106]	Spain	a) Cross-sectional b) Random sampling c) Collaboration requested using informative document d) Completion rate = 100%	775 (41.3%)	i) 22.2±3.8 ii) Physical Education Degrees iii) All years	Ø
Landry et al., (2019)[107]	USA	a) Cross-sectional b) N/A c) Recruited via announcements in class, word of mouth, and electronic notice for in-person visits d) Completion rate = 92%	92 (51.1%)	i) 18.8±0.5 ii) Not reported iii) First year	+

Author (Year)	Country	Study Design: (a) Study Type, (b) Recruitment Sampling, (c) Recruitment Method, (d) Response/ Participation/ Consent/ Completion Rate	Sample Size (% Female)	Participants Characteristics: (i) Age, (ii) Course or Department, (iii) Academic Year	Study Quality Rating
Lenz, (2004)[108]	USA	a) Cross-sectional b) Random sample c) Survey was mailed (posted) to students d) Response rate = 31%	203 (60.6%)	i) 18 years old = 26%, 19 years old = 74% ii) N/A iii) First year = 65%; Second year = 35%	Ø
Lim et al., (2017)[109]	Singapore	a) Cross-sectional b) Proportional stratified random sampling was used c) Approached in tutorial classes d) Participation rate = 74.4%	884 (49.3%)	i) Median (IQR) = 21 (20 – 22) ii) Arts and social sciences, business, computing, dentistry, design and environment, law, engineering, medicine, music and science iii) All undergraduates	+
López-Nuevo et al., (2021)[110]	Spain	a) Cross-sectional b) N/A c) N/A d) Completion rate = 89%	55 (N/A)	i) 21±3 (APSA) and 23±2 (DPPA) years old ii) APSA and DPPA students (see footnotes) iii) Not reported	Ø
Martinez-Lacoba et al., (2018)[111]	Spain	a) Cross-sectional b) Representative sample of the study population c) An electronic survey, students could ask researchers for assistance d) Completion rate = 55%	593 (58%)	i) 20.2±3.2 ii) Health sciences or social sciences courses iii) N/A	+
Moreno-Gómez et al., (2012)[112]	Spain	a) Cross-sectional b) Random sampling of twenty-five lecture rooms c) Students present in the room were invited to complete the questionnaire d) Participation rate = 89.7%	987 (54.5%)	i) 21.5±3.3 ii) Even degree distribution of participants iii) Randomly selected from different faculties	+
Nelson et al., (2009)[113]	USA	a) Cross-sectional b) Random sampling c) Survey was mailed (posted) to students d) Response rate = 54.8%	3206 (61%)	i) 24.2±5.9 ii) N/A iii) First–second year = 22%; Third = 16%; ≥ Fourth = 25%; Graduate/ professional = 37%	Ø
Peltzer & Pengpid, (2014)[31]	International Study[cd]	a) Cross-sectional b) Stratified random sample procedure c) N/A d) Participation rate = >90%	17789 (58.7%)	i) 20.8±2.8 ii) A variety of majors including education, humanities and arts, social sciences, business and law, science, engineering and more iii) Undergraduates	+

Author (Year)	Country	Study Design: (a) Study Type, (b) Recruitment Sampling, (c) Recruitment Method, (d) Response/ Participation/ Consent/ Completion Rate	Sample Size (% Female)	Participants Characteristics: (i) Age, (ii) Course or Department, (iii) Academic Year	Study Quality Rating
Pengpid et al., (2015)[114]	International Study[c]	a) Cross-sectional b) Stratified random sample procedure c) N/A d) Participation rate = >90%	17928 (57.8%)	i) 20.8±2.8 ii) A variety of majors including education, humanities and arts, social sciences, business and law, science, engineering and more iii) All undergraduates	+
Quick et al., (2015)[115]	USA	a) Cross-sectional b) 18–24-year-olds with a BMI >18.5 kg/m2 recruited c) N/A d) Completion rate = 96.8%	1252 (58.9%)	i) 19.2 (Standard Error: 0.1) ii) N/A iii) N/A	+
Rodríguez-Muñozet et al., (2020)[116]	Spain	a) Cross-sectional b) Random total sampling c) Questionnaire emailed to students d) N/A	457 (66.7%)	i) 20.93±3.28 ii) All courses iii) All years	+
Silva et al., (2016)[117]	Brazil	a) Cross-sectional b) Random sampling c) Students invited and informed about the research d) N/A	204 (55%)	i) 21.6±3.9 ii) Law school iii) Students ≥3 months at college	+
Stuntz et al., (2015)[118]	USA	a) Cross-sectional b) Random sampling c) Invitation emails distributed to all students with reminder emails sent after the initial invitation d) Response rate = 47.8%; Completion rate = 80.6%	887 (65.5%)	i) 19.7±1.29 ii) All faculty iii) All undergraduates	+
Tassitano et al., (2016)[119]	Brazil	a) Cross-sectional b) Simple random sampling: stratification criteria were the gender density by class and year of each program c) N/A d) Response rate = 84.3%	717 (55.9%)	i) 20.6±1.9 ii) Multiple iii) First- or second-year students = 76.7%	+
Taylor et al., (2009)[120]	Canada	a) Cross-sectional b) A purposive sample c) Administered to ten classes during regular class time d) Participation rate = 89%	290 (71.4%)	i) 18-24 = 91%, >24 = 9% ii) All faculties iii) First year = 46.3%; Second to fourth year = 53.7%	Ø
Van den Bogerd et al., (2018)[121]	The Netherlands	a) Cross-sectional b) Random sampling c) Text sent with hyperlink to online questionnaire and an identical paper version via student webpage d) Completion rate = 70%	717 (63.7%)	i) ≥ 22 = 49.9%, < 22 = 50.1% ii) Health = 21.2%, Humanities/ social sciences = 31.9%, Economics/ law = 26.8%, Tech = 19.2% iii) N/A	Ø

Author (Year)	Country	Study Design: (a) Study Type, (b) Recruitment Sampling, (c) Recruitment Method, (d) Response/ Participation/ Consent/ Completion Rate	Sample Size (% Female)	Participants Characteristics: (i) Age, (ii) Course or Department, (iii) Academic Year	Study Quality Rating
Wilson et al., (2019)[122]	USA	a) Longitudinal b) All students meeting criteria c) Recruitment via direct e-mail d) Response rate: Timepoint (Tp) 1 = 15.7%; Tp 2 = 38.2%; Tp 3 = 25.1%	662 (62.5%)	i) 21.0±1.59 ii) Students enrolled in for credit PA classes iii) All undergraduates	Ø
Yamamoto et al., (2018)[123]	Japan	a) Cross-sectional b) Participants who took lectures related to food c) N/A d) Response rate = 81%	155 (49.7%)	i) 20.0±0.7 ii) Participants took lectures related to food iii) Not reported	Ø
Zurita-Ortega et al., (2018)[124]	Spain	a) Cross-sectional b) N/A c) Students enrolled in education or health-related degrees, aged 18 - 20 were approached d) Completion rate = 94%	597 (74%)	i) 19.0±0.6 ii) Social and health science courses iii) Mostly first year of study	+

Footnotes: a = *Croatia, Italy, Lebanon, Poland, Romania, Spain and Turkey;* b = *China, Ireland, Malaysia, South Korea, Taiwan, the Netherlands, and the United States;* c = *Barbados, Grenada, Jamaica, Colombia, Venezuela, Cameroon, Ivory Coast, Madagascar, Mauritius, Nigeria, South Africa, Turkey, Russia, Kyrgyzstan, Bangladesh, India, Pakistan, China, Indonesia, Laos, Philippines, Singapore, Thailand;* d = *Namibia, Egypt, Tunisia;* e = *Age reported as Mean ± Standard Deviation unless otherwise stated;* f = *Risk of bias was assessed using The Academy of Nutrition and Dietetics Quality Criteria Checklist for Primary Research tool; + = Study is deemed as positive quality or having minimal risk of bias; Ø = Study is deemed as neutral or medium quality;* IQR = *Interquartile range;* N/A = *Not available;* APSA = *Animation and Physical-Sports Activities;* DPPA = *Dental Pathology and the Prosthetic Anatomy*

Table 3. *Total Dietary Intake and Lifestyle Behaviors among Higher Education Students*

Author	Measure of Diet	Results of Diet	Measure of Lifestyle	Result of Lifestyle	Association Derived
Adams et al., (2020)[84]	24-hour diet recalls Data was converted to HEI - 2005 scores to assess diet quality. A higher score = higher quality diet (maximum 100).	Mean HEI = 61.5±13.1 Range = 28.0 - 89.3	Pittsburgh Sleep Quality Index (PSQI)	• 7.1±1.4 hours of sleep at night reported (range 5-10). • 41.8% = good quality sleep • Mean PSQI = 6.8±3.5 (range 1-17)	• Sleep and diet showed a small correlation (r55=−0.37, P=.005). • Sleep quality also predicted diet (β = −.38, P = .004), accounting for 14% of the variance. • In the mediation model, sleep quality and diet became non-significant (β = −.282, P = .064)
Antoine-Jonville et al., (2010)[85]	Food Frequency Questionnaire (FFQ) validated to assess coronary risk - graded from -17 to +19, a positive score is protective of CVD.	Mean score = -1 (-3 to 1), skewness = 0.33	One-year recall Modifiable Activity Questionnaire (MAQ) – Those with a PAL value greater than 1.7 are meeting the recommended PA threshold.	• 16.8% = PAL value greater than 1.7 • Median PAL = 1.58 (1.54-1.66), Skewness = 3.41	• PAL was not correlated with the FFQ score (r = –.01, p = .941). • The analysis of variance showed no significant difference in dietary score related to PAL (F = 1.18, p = .31)
Aslan Çin, & Yardimci ,(2021)[86]	24-hour diet recalls Data was converted to HEI - 2015 scores to assess diet quality.	Mean HEI = 39.6±12.4	Pittsburgh Sleep Quality Index (PSQI)	64.1% = poor sleep quality Mean PSQI = 7.5±3.1	Total diet quality was higher in those with good sleep quality (p<0.001)
Du et al., (2021)[98]	Dietary behaviors were assessed using an FFQ —Starting the Conversation (STC). The STC provides a score ranging from 0 to 16; higher the score = dietary behaviors not consistent with health	Mean STC score = 8.2±2.7	**A: Sleep** Pittsburgh Sleep Quality Index (PSQI) **B: Physical Activity** The International Physical Activity Questionnaire (IPAQ) – Long form	A. 78% = poor sleeper (8.6±3.0) 22% = good sleeper (3.0±1.0) B. METs minutes per week: 3330.5±4056.3	A. Poorer dietary behaviors (higher STC scores) were associated with poorer sleep quality (r=0.0164, p<0.001) B. Poorer dietary behaviors were correlated with less PA METs mins per week (r=−0.133, p>0.001)

Author	Measure of Diet	Results of Diet	Measure of Lifestyle	Result of Lifestyle	Association Derived
Du et al., (2021)[99]	Dietary behaviors were assessed using an FFQ —Starting the Conversation (STC).	Mean STC score = 7.8±2.8	**A: Sleep** Pittsburgh Sleep Quality Index (PSQI) **B: Alcohol** The Alcohol Use Disorders Identification Test (AUDIT-C)	A. Mean = 6.8±3.5 60.0% poor sleepers B. Mean = 3.1±2.7 22.8% females and 32.1% males alcohol misusers	A. Poorer dietary behaviors (higher STC scores) were associated with poorer sleep quality (r=0.018, p<0.0018) B. Poorer dietary behaviors were not correlated with alcohol misuse scores (r=0.08, p>0.001)
González et al., (2013)[105]	Diet Quality Index (DQI)—based on the 2010 USDA food pattern with scores from 0 to 65. Diet classified inadequate, if score is <33.	62% = Inadequate 38% = Adequate	Six questions related to the daily use of cigarettes. The data were dichotomized as "smoker" (> 1 cigarettes per day) or "non-smoker".	3% were considered smokers.	No significant associations between smoking and dietary pattern according to chi-square test (p<0.05)
Landry et al., (2019)[107]	24-hour dietary recalls Data was converted to Healthy Eating Index (HEI) - 2015 scores to assess diet quality.	• HEI >80 = 1% • HEI 51-80 = 51% • HEI <51 = 48% • Mean HEI = 54.9± 13.4	Accelerometers (wGT3X-BT, Actigraph, LLC) measured for seven consecutive days with data from all acceptable days averaged.	N/A	• Improvements in diet quality were linked with higher PA. • A 1-point increase in HEI was associated with 8.2 minutes per day higher light activity (P=0.008) and 107 more steps (P=0.002).
Moreno-Gómez et al., (2012)[112]	Global Diet Quality Score (GDQS) created by an average of the points obtained from three diet quality assessment scores including a modified Mediterranean diet score and a dietary guidelines score.	Mean GDQS = 5.0±1.3 Mean MDS = 5.1±1.8 Mean DGS = 2.1±1.3	Smoking habit (yes or no, age at start and number of cigarettes per day)	35.9% of participants were smokers	No significant associations were found between the diet quality scores and smoking: Mediterranean Diet Score; -0.081 Dietary Guidelines Score; -0.048 GDQS Score; -0.063
Yamamoto et al., (2018)[123]	A Food Guide score was calculated from the results of a diet history questionnaire - with a score range from 0 to 70, a higher score is more likely to show diet adherence.	Mean = 40.9 Range = 22 - 62	**A: Sleep** Pittsburgh Sleep Quality Index (PSQI) **B Smoking** Current smoker (yes or no)	A. 60% had poor sleep quality B. 7.1% of cohort were current smokers	A. A significant inverse association was found between the food guide and PSQI scores (p=0.015). B. No significant association (p> 0.05) found between the food guide score and smoking.

Footnotes: PA = *Physical activity;* CVD = *Cardiovascular disease;* PAL = *Physical activity level*

Table 4 *Diet Patterns and Lifestyle Behaviors among Higher Education Students*

Author	Measure of Diet	Results of Diet	Measure of Lifestyle	Result of Lifestyle	Association Derived
Baydemir et al., (2018)[87]	The Mediterranean Diet Quality Index (KIDMED) - used to assess adherence to the MD.	42.7% = Low MD 55.1% = Medium MD 2.3% = High MD	Smoking, Yes, or No?	20.3% = Yes 79.7% = No	No significant difference in smoking and KIDMED scores (First years P = 0.394; Third years P = 0.175)
Bennasar-Veny et al., (2020)[88]	MD adherence was evaluated using the PREDIMED index and the MD Score (MDS). The PREDIMED (Prevention with Mediterranean Diet) index results in a score of 0-14 with 9 or higher indicating acceptable adherence. The MDS is categorized as high adherence (≥5) or low adherence (<5).	Mean PREDIMED = 4.6±1.5 Mean MDS = 5.3±1.8	**A: PA** International Physical Activity Questionnaire - Short Form **B: Smoking** Asked if they smoked, and classified as smokers, non-smokers, or former smokers.	A. 66% reported performing weekly physical activity (PA). B. 19.5% were smokers and consumed an average of 7.1±7.0 cigarettes a day.	A. Higher PA = Higher adherence to MD (OR 1.61* 95% CI: 1.05–2.47), (aOR 1.75 * 95% CI: 1.09–2.80) *p<0.05 B. Tobacco consumption = Lower adherence to MD (OR 0.61 95% CI: 0.37–1.01), (aOR 0.52* 95% CI: 0.30–0.91) *p<0.05
Carlos et al., (2020)[91]	The Mediterranean Diet Quality Index (KIDMED)	20.7% = Poor diet; 63.7% = Needs improvement; 15.5% = Optimum	The Alcohol Use Disorder Identification Test was used to determine alcohol consumption habits.	80% = Low risk 17.6% = Risk of dependency 2.4% = Alcohol dependency	No association between MD adherence and alcohol consumption (r = 0.052, p > 0.05)
Cena et al., (2021)[4]	Mediterranean Diet Serving Score (MDSS) assessed the MD adherence. Scoring ranges from 0 to 24. Above 14 indicates good MD adherence	Median MDSS was below 14 in all study sites, ranging from 5 in Turkey to 10 in northern Italy and Spain.	International Physical Activity Questionnaire - Short Form	Spanish students had the highest total weekly METs (4072.8 (3829.8)); Turkey reported the lowest (1653.0 (2572.0))	The MDSS was correlated to total METs per week (r=0.16; p<0.001)
Chacón-Cuberos et al., (2018)[92]	The Mediterranean Diet Quality Index (KIDMED)	N/A	**A: PA** Physical Activity Questionnaire for Adolescents **B: Smoking** The Fagerström Test for Nicotine Dependence	N/A	A. A positive relationship between MD and PA in both males (p< 0.001; b = 0.27) and females (p< 0.001; b = 0.23), B. A negative association between smoking and MD in males (p< 0.01; b =−0.15). No association for females (p = 0.225, b = -0.07).

Author	Measure of Diet	Results of Diet	Measure of Lifestyle	Result of Lifestyle	Association Derived
Chacón-Cuberos et al., (2019)[93]	Mediterranean Diet Quality Index (KIDMED)	N/A	Physical Activity Questionnaire for Adolescents	N/A	A positive relationship can be observed between diet and physical activity ($p < 0.05$, $r = 0.228$)
Cobo-Cuenca et al., (2018)[94]	The Mediterranean Diet Adherence Screener (MEDAS) scored from 0–14 and categorized as low adherence (<9) and good adherence (>9).	24.6% = Good adherence 65.4% = Low adherence Mean = 7.0±2.0	GENE Active accelerometers (ActivInsights). Mean minutes/day of PA was estimated.	PA (min/day) = 223.1±65.3	No statistical significance between PA (min/day) and MD adherence P= 0.712
De-Mateo Silleras et al., (2019)[96]	The PREDIMED score was grouped in three categories: low (≤5), moderate (6-9) and high (≥10) points.	Median = 8 (6–9) MD adherence: 20.1% = High 69.2% = Average 10.7% = Low	The Global Physical Activity Questionnaire	75.7% = Light PA 5.1% = Intense activities.	PA and adherence to the MD was statistically significant ($p = 0.022$). Subjects who perform more PA have a greater adherence to MD.
Elío et al., (2021)[101]	3-day food diary and the MD pyramid (2010) used to classify diet into 3 groups: Poor diet quality = ≤3; Medium diet quality = 4-7; Optimal quality = ≥8	26% = Poor diet 68% = Medium diet 6% = Optimal diet quality	"Do you smoke?" (yes/no) and the number of cigarettes per day,	77% were non-smokers	No significant differences when comparing adherence with the MD and the number of cigarettes per day ($P = 0.168$)
Fernández-Medina et al., (2020)[102]	The PREDIMED score was grouped in three categories: low (≤5), moderate (6-9) and high (≥10) points.	10.5% = Good MD adherence 89.5% = Poor MD adherence	Pittsburgh Sleep Quality Index	45.7% = Good sleeper 54.3% = Poor sleeper	The correlations are significant and negative between the sleep quality index (higher score indicates poor sleep) and adherence to the MD ($r=-0.28$; $p<0.05$)
García-Meseguer et al., (2014)[103]	Health Eating Index (HEI) - scores: >80 = "good" diet, 51 to 80 = diet "needs improvement" and <51 = "poor" diet. MD pattern adherence: >6 = "high", 4-6 = "intermediate" and <4 = "low"	Mean HEI = 51.2±12.8 3.9% = "good", 57.4% "needs improvement", 38.7% = "poor", 5.3%, 44% and 50.7% of high, intermediate and low adherence	Smoking habit: yes/no, and ≤5 cigarettes or higher.	15.1% = Smokers 84.9% = Non-smokers	No associations found between smoking habits and HEI score ($P=0.774$) and MD adherence ($P=0.287$)
Gianfredi et al., (2018)[104]	The PREDIMED score was grouped in three categories: low (≤5), moderate (6-9) and high (≥10) points.	4.3% = High 48.7% = Moderate 47% = Low Mean = 5.9 ± 2.1	Smoking, Yes, or No?	42.7% = Yes 57.3% = No	A statistical association between PREDIMED score and smoking habit ($r = -0.2302$, $p = 0.0125$) was found.

Author	Measure of Diet	Results of Diet	Measure of Lifestyle	Result of Lifestyle	Association Derived
González-Valero et al., (2019)[106]	The Mediterranean Diet Quality Index (KIDMED)	N/A	Physical Activity Questionnaire for Adolescents	N/A	Adherence to MD and PA engagement were positively related ($r = -0.206$; $p<0.005$)
López-Nuevo et al., (2021)[110]	The Mediterranean Diet Quality Index (KIDMED)	APSA students = 8.00 (high MD adherence)	The Global Physical Activity Questionnaire	APSA students had higher total minutes of vigorous (405 vs 0) and moderate (297 vs 103) activity. DPPA students obtained higher sedentarism values (400 vs 120).	A moderate statistically significant correlation is observed between moderate ($r = 0.38$, $p <0.01$) and vigorous ($r = 0.50$, $p <0.01$) PA and adherence to KIDMED score.
Martinez-Lacoba et al., (2018)[111]	Food Frequency Questionnaire used to estimate MD adherence according to MEDI-LITE score (0 - 18) and deemed unhealthy if ≤9.	47.9% = Unhealthy diet	Do you smoke (yes/no)	16.36% smoked.	Tobacco use is not associated with diet. Tobacco use OR: 1.20 (95%CI: 0.76; 1.90)
Rodríguez-Muñozet et al., (2020)[116]	The Mediterranean Diet Quality Index (KIDMED)	15.8% = Low MD 46.6% = Medium MD 36.5% = High MD	International Physical Activity Questionnaire - Short Form	4465.26 (4486.99) = Low 4629.54 (5181.39) = Med 3675.68 (3722.09) = High	No relationship between PA (mean minutes) and KIDMED score ($p = 0.419$)
Zurita-Ortega et al., (2018)[124]	The Mediterranean Diet Quality Index (KIDMED)	0.5% = Low MD 21.9% = Medium MD 77.6% = High MD	Physical Activity Questionnaire for Adolescents	52.8% = Engaging in PA 47.2% = Not engaging in PA	There were significant associations between MD adherence and physical activity ($p = 0.014$).

Footnotes: MD = *Mediterranean diet;* APSA = *Animation and Physical-Sports Activities;* DPPA = *Dental Pathology and the Prosthetic Anatomy;* OR = *Odds ratio.*

Table 5. *Fruit and Vegetable Consumption and Lifestyle Behaviors among Higher Education Students*

Author	Measure of Diet	Results of Diet	Measure of Lifestyle	Result of Lifestyle	Association Derived
Adams & Colner, (2008)[83]	A one-item measure of typical daily F&V intake, with four response options: "N/A, 1–2, 3–4, or 5+ servings."	N/A	30 days cigarettes use.	N/A	Higher F&V intake was associated with a reduced likelihood of smoking, in males (Wald = 24.1, p = < .001, OR = 0.26 (95%CI: 0.00–0.98)) and females (Wald = 60.5, p = < .001, OR = 0.97 (95%CI: 0.96–0.97)).
Bertsias et al., (2005)[89]	24-hour dietary recall - recording the RDA or dietary reference intakes (DRI) of F&V	Meeting RDA: 41% of Males (370±275 g/day) 36% of females (354±283 g/day)	Smokers were classified as those who smoke more than one cigarette per day for at least three consecutive months.	Current smokers: 32% of males 27% of females	The mean consumption of F&V was 383±280 g/day among non/ex-smokers and 314±273 g/day among current smokers (p = 0.003). Among consumers, 41% of the non- or ex-smokers but only 31% of the smokers met F&V RDA (p = 0.050).
Borlu et al., (2019)[90]	F&V servings consumed in 24 hours was asked of the students	F&V = 4.10±2.90 Fruit = 1.67±1.58 Veg = 2.71±2.26 Inadequate intake: 61.2% of males and 61.6% of females	Tobacco Using Yes/No?	7.1% = Smokers 82.9% = Non-smokers	The rate of adequate F&V intake was significantly lower among smokers (X2=4.685, P= .036)
Deliens et al., (2018)[95]	A Food Frequency Questionnaire (FFQ) was used to calculate daily F&V consumption	Mean daily F&V = 192±146 grams Not meeting RDA = 90.3%	Smoking (% smokers; 0 = non-smoker,1 = smoker)	11.4% = Smokers 88.6% = Non-smokers	Univariate regression analysis of F&V and smoking showed a trend towards significance (P = < 0.1), α= 0.05, t = 1.7(a) β = 0.124.

Author	Measure of Diet	Results of Diet	Measure of Lifestyle	Result of Lifestyle	Association Derived
Di Benedetto et al., (2020)[97]	F&V consumption assessed separately, based on meeting Australian healthy eating guidelines	Fruit consumption meeting guidelines (≥2 servings per day) = 46.2% (164) Vegetable consumption meeting guidelines (≥5 servings per day) 7.6% (27)	**A: Physical Activity (PA)** Met Australian PA guidelines **B: Sleep** Pittsburgh Sleep Quality Index **C: Alcohol** Number of occasions students consumed 4+ alcoholic drinks in last the month = binge drinking	A. 45.9% = Meeting PA guidelines B. 35% = Good sleep quality C. 15.5% had alcohol binge occasions	Fruit consumption was positively related to meeting Australian PA guidelines (.13) and negatively to alcohol consumption (-.12). The magnitude of these relationships was small to moderate. Fruit consumption not related to sleep (0.03). Vegetable consumption was not related to sleep (0.01), alcohol consumption (0.04-), or meeting Australian PA guidelines (0.10).
Dinger et al., (2014)[29]	"How many servings of fruit and vegetables (F&V) do you usually have per day?"	5% meeting guidelines 95% not meeting guidelines	National College Health Assessment II. Those who reported ≥5 days MPA, ≥4 days VPA, or an accumulation of both were deemed as meeting MVPA recommendations.	49.9% = Meeting MVPA recommendation 50.1% = Not meeting MVPA recommendation	Students who consumed 5 or more servings of F&V per day had 2.81 (95% CI: 2.596, 3.041, p=<.001) greater odds of meeting MVPA recommendations than those who ate fewer F&V (β = 1.033, $\chi 2$ = 1779.23, df = 14). Statistically significant based on a Bonferroni-adjusted alpha (α = 0.0026).
Eaves et al., (2017)[100]	How often do you consume five F&V daily (rarely or never, 2-3 times per week, 4-6 times per week, or everyday)?	N/A	Behavioral Risk Factor Surveillance System's questions for VPA. Participants were classed as meeting VPA recommendations if they participate in 20+ minutes on 3 or more days per week.	57.9% = Sufficient VPA in 2003 48.6% = Sufficient VPA in 2007	The odds of meeting the VPA recommendation in 2003 and 2007 were 5.6 (95% CI: 4.14-7.47) and 3.1 (95% CI: 2.47-3.82) times higher, respectively among those students who ate 5+ servings of F&V daily, compared to those students who rarely or never consumed 5 servings of daily F&V.
Lenz, (2004)[108]	College Health Survey - Consumption of five servings of F&V a day	F&V consumption per day = Smokers: 4.9 (1–8); Non-smokers: 5.2 (1–8)	Tobacco consumption for the past year Tobacco consumption for the past month	29% = Used tobacco during the past year 32% = Used tobacco in the past month	In the univariate analysis findings indicates that as consumption of F&V decreased, tobacco use increased, but not significantly (p = 0.087).

Author	Measure of Diet	Results of Diet	Measure of Lifestyle	Result of Lifestyle	Association Derived
Lim et al., (2017)[109]	"How many servings of F&V do you eat on a typical day?" using the 24-hour dietary recall	Mean total F&V = 3.0 (95%CI 2.9-3.1) 13.6% and 27.1%, meet international and national F&V recommendations, respectively.	**A: PA** International Physical Activity Questionnaire - Short Form - Sufficient PA was defined as having at least MPA. **B: Smoking** Do you currently use one or more of the following tobacco products (cigarettes, snuff, chewing tobacco, cigars, etc)?	A. 62.7% = Sufficiently active 37.3% = Not sufficiently active B. 4% = Smokers 96% = Non-smokers	A. Univariable analysis showed those who had sufficient PA (PR: 1.33; 95%CI 1.01-1.76) were more likely to meet the F&V recommendations. B. No association found between those who did not smoke (PR: 0.95; 95%CI 0.50-1.7) meeting the F&V recommendations.
Nelson et al., (2009)[113]	F&V consumption classified as high risk if fewer than five daily servings	N/A	To assess binge drinking, students were asked: "Think back over the last 2 weeks. How many times have you had 5 or more drinks at a sitting?". High risk was characterized as binge drinking (ie, consuming 5+ drinks in a sitting) at least 1 time in the past 2 weeks.	31.3% = Binge drinking in the past two weeks	Adjusting for sociodemographic characteristics, binge drinking was associated with a wide <5 daily fruits/vegetables, RR: 1.07 (95% CI: 1.01-1.13). Effect modification: P-values of interaction terms Model 2 = 0.85 Model 3 = 0.39 Model 4 = 0.16

Author	Measure of Diet	Results of Diet	Measure of Lifestyle	Result of Lifestyle	Association Derived
Peltzer & Pengpid, (2014)[31]	'How many servings of fruit do you eat on a typical day?'' ''How many servings of vegetables do you eat on a typical day?''	82.8% = insufficient F&V consumption	**A: PA** Physical Activity Questionnaire—Short Form **B: Alcohol** Binge drinking was assessed with one item (from the AUDIT-C), ''How often do you have (for men) five or more and (for women) four or more drinks on one occasion?'' **C: Smoking** Tobacco use was assessed with the question: Do you currently use one or more of the following tobacco products (cigarettes, snuff, chewing tobacco, cigars, etc.)? - ''yes'' or ''no''	A. 45.6% = Low PA 54.4% = High/ moderate PA B. 12.2% = Binge drinking (at least once/month) C. 12.9% = Current tobacco use	In multivariate logistic regression analysis binge drinking and physical inactivity were associated with low prevalence of F&V intake: Current tobacco use = UOR: 1.08 (0.96 – 1.23), binge drinking = UOR: 1.19 (1.05–1.35)**, AOR: 1.18 (1.01–1.37)*, moderate/ high PA = UOR: 0.84 (0.78–0.91)***, AOR: 0.74 (0.68–0.81)*** In multivariate conditional logistic regression analysis not currently using tobacco [0.86 (0.77–0.96)**] and not binge drinking [0.82 (0.73–0.92)***] were associated with adequate fruits consumption: whereas none found for moderate/ high PA = 1.07 (0.99–1.15). Not currently using tobacco [0.83 (0.72–0.96)**] and moderate or high PA [1.23 (1.13–1.35)***] were found to be associated with adequate vegetable consumption. ***P<0.001; **P<0.01; *P<0.05, (95 % CI)
Pengpid et al., (2015)[114]	'How many servings of F&V do you eat on a typical day?'	81.8% = Not meeting F&V recommendations	Physical Activity Questionnaire—Short Form	PA Levels: 41.4% = Low 24.1% = Moderate 34.5% = High	F&V intake associated with higher PA levels (**P<0.01) Male UOR: (95 % CI) = 1.21 (1.06–1.38)**, AOR: (95 % CI) = 1.12 (0.95–1.33) Female UOR: (95 % CI) = 1.17 (1.06–1.31)**, AOR: (95 % CI) = 1.09 (0.95–1.24)

Author	Measure of Diet	Results of Diet	Measure of Lifestyle	Result of Lifestyle	Association Derived
Quick et al., (2015)[115]	National cancer institute daily F&V screener: daily cups of F&V categorised into three groups (< 1 cup, 1 to 2.5 cups, and ≥2.5 cups)	Fruit: 36.3% = < 1 cup 43.7% = 1-2.5 cups 20.0% = ≥ 2.5 cups Vegetables: 46.1 %= < 1 cup 37.8% = 1-2.5 cups 16.1% = ≥ 2.5 cups	Pittsburgh Sleep Quality Index	28% = inadequate sleep (< 7 hr/night) 36% = 7–8hr or 36% = ≥ 8 hours	F&V consumption was nonlinear with sleep duration and not significantly associated with sleep duration. Fruit consumption = F = 1.89, p = 0.390 Vegetable consumption = F = 0.31, p = 0.858
Silva et al., (2016)[117]	FFQ - participants were asked to indicate their daily consumption and serving size of F&V	FFQ - participants were asked to indicate their daily consumption and serving size of F&V	Perceived sleep debt was calculated as the difference between preferred weekday sleep duration and their self-reported actual sleep duration	Perceived sleep debt = 1:50±1.1	Perceived sleep debt Coefficient (β) Greens and vegetables = −0.05 Fruits and fruit juices = −0.01 Multiple regression analyses found no significant correlation between F&V and sleep

Author	Measure of Diet	Results of Diet	Measure of Lifestyle	Result of Lifestyle	Association Derived
Stuntz et al., (2015)[118]	"How many days per week do you eat at least 2 servings of fruit?", "How many days per week do you eat at least 3 servings of vegetables?"	Days per week meeting guidelines: Fruit = 4.67±2.09 Vegetables = 4.49±2.1	**A: PA** Godin Leisure Time questionnaire - a leisure activity score was calculated using strenuous, moderate and light levels of intensity. **B: Alcohol** How many times in the past two weeks the participant had five or more (four or more for women) drinks in a row. **C: Sleep** Health related survey for college students used to calculate the sleep schedule (i.e., weighted midpoint of sleep), sleep duration (i.e., weighted average time asleep), bedtime delay (i.e., difference in weekday and weekend bedtime), and oversleep.	A. Leisure-time physical activity (LTPA) = 61.23±32.60 B. Frequency of binge drinking = 1.59±1.76 C. Sleep schedule = 16.75±0.77 Sleep duration = 8.23±0.99 Bedtime delay = 1.77±0.87 Oversleep = 2.01±1.11	A. Mediation analyses indicates that consuming more F&V is significantly associated with higher levels of LTPA. Fruit = (R2 = 0.194***), Total effect = 3.77***, Direct effect = 2.35***, Total indirect effect = 1.41a, Veg = (R2 = 0.189***), Total effect = 2.80***, Direct effect = 1.90***, Total indirect effect = 0.90a Correlation coefficients show a correlation between LTPA and fruit (r = .24**) and vegetables (r = .17*). B. Correlation coefficients: frequency of binge drinking linked to lower fruit (r = −.11**) and vegetable (r = −.07*) consumption C. Sleep schedule linked to lower fruit consumption (r = −.19*), whereas no association between fruit consumption and sleep duration (r = -.00), bedtime delay (r = .06) and oversleep (r = -.06) Sleep schedule (r = −.12**) and oversleep (r = −.09*) linked to lower vegetable consumption whereas no association found between vegetable consumption and sleep duration (r= -.04) or bedtime delay (r= -.01) *p< .05., **p< .01., ***p< .001.,

Author	Measure of Diet	Results of Diet	Measure of Lifestyle	Result of Lifestyle	Association Derived
Tassitano et al., (2016)[119]	F&V intake was measured by a Food Frequency Questionnaire (FFQ)	Median F&V = 2.0 servings per day	Physical Activity Questionnaire—Short Form (IPAQ-SF) PA measured in minutes per week	Median (minutes per week): Male = 164.0±117.9 Female = 111.6±99.0	Correlation matrix between F&V and PA: (Male = 0.27*, Female = 0.23*). *p<0.05 Multiple linear regression: Male = (b=0.004, 95%CI 0.003-0.00, β=0.0.190, p=0.000, R^2 = 0.04), Female = (b=0.003, 95%CI 0.002-0.004, β=0.132, p=0.004, R^2 = 0.02) Thus, F&V intake would increase by one serving if males and females increased their moderate to intense PA by 35 minutes and 47 minutes per day, respectively.
Taylor et al., (2009)[120]	F&V servings consumed in 24 hours was asked of the students	41% consume five servings of F&V a day	The Youth Risk Behavior Survey = VPA for at least 20 minutes on 3 or more days and MPA for at least 30 minutes 5 or more days a week	55% = Not engaging in MPA on at least five of the last seven days or VPA on at least three of the last seven days	54% participating in VPA for at least 20 minutes on 3 or more days during the week and were more likely to consume five or more F&V servings a day compared to the 39% that reported lower levels of activity (39%) (X2 (1) =7.0, p<0.008).

Author	Measure of Diet	Results of Diet	Measure of Lifestyle	Result of Lifestyle	Association Derived
Van den Bogerd et al., (2018)[121]	Adherence to the daily Dutch F&V guidelines was calculated	Mean fruit = 1.37±1.00 portions a day Mean vegetable = 126.18±64.89 grams a day Adherence to guidelines: Fruit = 27.9% Vegetable = 6.8 %	**A: PA** Tested with adherence to the Dutch PA guidelines. **B: Alcohol** Considered heavy to excessive if females consumed four glasses and males consumed six glasses or more at least once a week. **C: Smoking** Do you smoke? 'yes/no	A. Adherence to PA guidelines: 64.7% = Yes 35.0% = No B. Alcohol intake 26.1% = None 51.7% = Moderate 21.5% = Heavy to excessive C. Smoking 20.5% = Yes 78.4% = No	A. Fruit and adherence to PA guidelines No = Univariate model (UM): (β: −0.34**, 95% CI: −0.48, −0.18) Final multivariable model (FMM): (β: −0.37**, 95% CI: −0.52, −0.22). Vegetable and adherence to PA guidelines No = UM: (β: −19.76**, 95% CI: −29.66, −9.85), FMM: (β: −18.32**, 95% CI: −28.32, −8.32) B. Fruit and alcohol heavy to excessive = UM: (β: −0.25*, 95% CI: −0.46, −0.04), FMM: (β: −0.38**, 95% CI: −0.60, −0.16) Vegetable and alcohol heavy to excessive – FMM: (β: −17.53*, 95% CI: −31.98, −3.06) β, regression coefficient; *P<0.05, **P<0.001. No significant association between F&V and others.
Wilson et al., (2019)[122]	Servings of F&V participants consume per day recorded	F&V T1 = 3.98±2.09 F&V T2 = 4.07±2.12 F&V T3 = 4.02±1.9	The Global Physical Activity Questionnaire: Participants were categorized based on whether they met the American College of Sports Medicine's PA recommendations	T1 VPA = 167.04±178.02 T1 MPA = 172.53±161.65 T2 VPA = 151.56±166.43 T2 MPA = 180.4±159.22 T3 VPA = 153.21±163.53 T3 MPA = 177.01±174.04	Significant correlation (**P<.01) was observed from a Bivariate Correlation between F&V and VPA at each time point, whereas no such relationship was observed with MPA. F&V T1 and VPA1 = .18**, and MPA1 = −.03 F&V T2 and VPA2 = .18**, and MPA2 = −.02 F&V T3 and VPA3 = .14**, and MPA3 = .05

Footnotes: T1 = *Timepoint 1;* T2 = *Timepoint 2;* T3 = *Timepoint 3;* MVPA: = *Moderate to vigorous physical activity;* MPA = *Moderate physical activity;* VPA = *Vigorous physical activity;* UOR = *Unadjusted odds ratio;* AOR = *Adjusted odds ratio;* RDA = *Recommended Daily Amount;* a = *CI does not include zero.*

heterogeneity, therefore, homogenizing results was not possible, and no meta-analysis was performed. Descriptive statistics were used to summarize study and sample characteristics, dietary intake assessment, reported lifestyle behavior(s) and the association between dietary intake and lifestyle behavior(s), using text and tables, in narrative form. Tables have been organized by type of dietary intake method used and alphabetically by author name.

3.Results

Study Characteristics

The initial database search found a total of 11,548 abstracts and 1,619 from a secondary search, totaling 13,167 articles. After the initial screening of titles and abstracts, 11,805 papers were excluded as not meeting criteria, resulting in 1,362 papers. A number of these were removed as duplicates and for not being available in English or full text format, therefore 957 papers were eligible for full-text article assessment. The full-text assessment resulted in the final sample of 45 studies included in this review. Figure 1 depicts the complete search process.

The key characteristics of included studies are presented in Table 2. Forty-five papers with a total of 185,148 participants (median = 457, mean = 4114±11987, range = 55 - 67,861) met the eligibility criteria and were included. Studies were from a total of forty-five countries across six continents, with the highest number of studies from Spain (n=16) and the USA (n=12). The study including Irish students was conducted as part of an international study during the COVID-19 pandemic and involved some authors of this systematic review. The age range of participants varied from 18.8±0.5 to 36.6±10.5 with some studies reporting a median (n=4) or an age range (n=6) of students. The majority of papers were published in the past five years (n=31, 69%), and had a higher response rate from females (n=34, 76%), with three studies including female students only. A variety of courses, faculties, and study years were represented. Causal relationships could not be established as all, but two studies had a cross-sectional design.

Assessment of Diet and Lifestyle Behaviors

Table 1 depicts the inclusion criteria for this review and studies were included if they measured dietary quality in one of three different ways. Therefore, to conveniently report results, three tables were created to organize studies by the method used to report dietary quality (Tables 3-5). Three dietary categories were used: i) total dietary intake (n=9), dietary indices, ii) dietary patterns (n=17), of which all are assessed by the MD, therefore, renamed MD dietary patterns and iii) F&V consumption, assessed by servings consumed (n=19). Lifestyle behaviors assessed included: physical activity (n=24), sleep (n=10), alcohol (n=7), and smoking (n=18). Some papers tested for the association of diet and multiple lifestyle behaviors (n=10), whereas the majority assessed a singular lifestyle (n=35), resulting in fifty-nine associations tested.

Methods Used to Assess Diet and Lifestyle Behaviors

Dietary quality was measured by a variety of methods, with food frequency question-

naires (FFQ) (n=9)[85,95,98,99,105,111,117,119,121] being the most frequently used. The next most common tools were used multiple times each to record dietary quality: the Mediterranean Diet Quality Index – KIDMED (n=8),[87,91-93,106,110,116,124] 24-hour diet recalls (n=6)[84,86,89,103,107,109] and papers with a single item question similar to "*How many servings of F&V do you eat on a typical day?*" (n=5).[31,90,97,113,114] Four more studies used a single item question regarding F&V within a larger survey design (College Health Survey; Health Risk Behavior Survey; Higher Education Health Behavior Survey and the Survey of Health-Related Variables among College Students).[100,108,118,120] The PREDIMED (Prevention with Mediterranean Diet) (n=4)[88,96,102,104] and the National College Health Assessment II (NCHA) (n=3)[29,83,122] were also used in multiple papers. The remaining methods were used singularly: The Mediterranean Diet Adherence Screener (MEDAS),[94] Diet History Questionnaire,[108] Mediterranean Diet Serving Score (MDSS),[4] 3-day food diary,[101] a National Cancer Institute Daily F&V Screener[115] and one paper used a combination of three dietary measurements (Diet Diversity Score, Mediterranean Diet Score, Dietary Guidelines Score).[112]

Physical Activity Questionnaire—Short Form (IPAQ-SF) (n=7),[4,31,88,109,114,116,119] Physical Activity Questionnaire for Adolescents (PAQ-A) (n=4),[92,93,106,124] Global Physical Activity Questionnaire (GPAQ) (n=3)[96,110,122] and Accelerometers (n=2)[94,107] were the main instruments used to assess PA. The remaining methods were used singularly: Godin Leisure Time Questionnaire,[118] Physical Activity Questionnaire—LongForm (IPAQ-LF),[98] Modifiable Activity Questionnaire (MAQ),[85] National College Health Assessment II (NCHA),[29] The Youth Risk Behavior Survey,[120] Behavioral Risk Factor Surveillance System's questions[100] and comparison to Australian and Dutch PA Guidelines.[97,121]

Sleep was assessed in 10 studies. The Pittsburgh Sleep Quality Index (PSQI) was used in most papers (n=8).[84,86,97-99,102,115,123] Two other studies used a combination of questions relating to chronotype, social jetlag, and perceived sleep debt assessment within validated questionnaires.[117,118] A single item question regarding binge drinking prevalence was used in most papers that assessed alcohol consumption (n=5)[31,97,113,118,121] and the Alcohol Use Disorders Identification Test – AUDIT-C was used in the two other studies.[91,99] Smoking status was assessed using a single item question like: Smoking Status - Yes/No? (n=17)[31,83,88-90,95,101,103-105,107-109,111,112,121,123] and one other study used The Fagerström Test for Nicotine Dependence (FTND).[92]

Dietary Quality of Students and Associations with Lifestyle Behaviors

Before looking at the relationship between diet and lifestyle behaviors it is important to acknowledge and identify students' dietary quality. Dietary quality was reported in a variety of methods and as can be seen in Tables 3-5, results were heterogenous. In studies that measured total dietary intake, the Healthy Eating Index (HEI) results ranged from 39.6±12.4 to 61.5±13.1. One paper found 62% of students' diet was inadequate and others finding less ambiguous results. Papers that

assessed MD dietary patterns found a range of 2.3 to 77.6% MD adherence (Table 4). Those studies that assessed F&V consumption found that those meeting current F&V guidelines ranged from 5% to 41% (Table 5).

i) Total dietary intake and its relationship with lifestyle behaviors

A total of nine papers assessed the relationship between total dietary intake and lifestyle behaviors and are summarized in Table 3. PA (n=3), sleep quality (n=5), alcohol consumption (n=1), andsmoking status (n=3) were measured for association with diet deriving a total of twelve associations. Three papers assessed the relationship between diet and PA. Two of these studies found a significant relationship between higher PA and healthier eating[98,107] while one found none.[85] Four papers found that diet quality was higher in those with good sleep quality.[86,98,99,123] One paper found that better sleep and a higher diet score showed a small correlation, however, when a mediation model was created this relationship became nonsignificant.[84] No significant association was found between diet scores and alcohol misuse scores,[99] or current smoking status[105,112,123] in the papers reviewed.

ii) MD dietary patterns and its relationship with lifestyle behaviors

A total of seventeen papers assessed the relationship between MD dietary patterns and lifestyle behaviors and are summarized in Table 4. PA (n=10), smoking status (n=7), sleep quality (n=1) and alcohol consumption (n=1) were measured for association with a total of nineteen associations derived. There was a significant association between MD adherence and PA: students who performed more PA had a greater adherence to a MD in most studies (n=8)[4,88,92,93,96,106,110,124] while two found no statistical significance.[94,116] Smoking was associated with lower adherence to the MD in two papers[88,104] while four papers found no association.[87,101,103,111] One paper found a negative association between MD adherence and tobacco consumption in male, but not female students.[92] One paper found a significant correlation between higher MD adherence and good sleep quality.[102] There was no association found between MD scores and alcohol use.[91]

iii) Fruit and vegetable consumption and its relationship with lifestyle behaviors

A total of nineteen papers assessed the relationship between F&V consumption and lifestyle behaviors and are summarized in Table 5. PA (n=11), sleep quality (n=4), alcohol consumption (n=5), and smoking status (n=8) were measured for association with a total of twenty-eight associations derived. Of the nineteen papers measuring F&V consumption, the majority defined what was considered a portion within the paper (n=12), and three papers referenced a source that defined portion size (e.g., 80g of carrots or a handful of grapes). Four papers referred to F&V as portions but did not define a portion size within the text and a questionnaire source could not be found.

Students who consume higher amounts of F&V were more likely to report higher levels of PA in most studies.[29,100,109,114,118-122] One study found a significant correlation between vigorous PA and consumption of F&V, whereas no such relationship was observed between moderate PA.[31] Another study found that fruit consumption was positively related to meeting PA guidelines while vegetable consumption was not.[97] F&V consumption was not significantly associated with sleep duration.[97,115,117] One study assessed consumption of F&V separately and found a significant relationship between F&V and sleep schedule while only vegetable consumption was linked to oversleeping.[118] Neither F&V consumption were associated with sleep duration or bedtime delay.[118] Binge drinking alcohol was found to be associated with low F&V intake.[31,113,118,121] One study found higher fruit consumption had a significant relationship with lower alcohol consumption, whereas vegetable consumption did not.[97] Higher F&V intake was associated with a reduced likelihood of cigarette smoking in four papers.[31,83,89,90] Other papers found no significant correlation between smoking and F&V consumption.[108,109,121] One study found being a smoker and lower consumption of F&V showed a trend towards significance.[95]

Summary of Results

To summarize, 21 of 24 studies (88%) that examined the relationship between PA and dietary intake found a significant relationship between higher diet quality and higher PA levels.[4,29,31,88,92,93,96-98,100,106,107,109,110,114,118-122,124] Six of ten (60%) papers that examined the association between sleep and diet found a significant association between better sleep quality and higher quality diet.[84,86,98,99,102,123] Five out of seven (71%) papers found an association between higher diet quality and lower alcohol use.[31,97,113,118,121] Seven of the eighteen studies (39%) that tested for association between smoking status and diet found a significant relationship between having a poor diet quality and being a smoker.[31,83,88-90,92,104]

Study Quality

Three researchers agreed independently that all studies were eligible for either a plus or neutral designation in the risk of bias assessment, as summarized in Table 2 and detailed in Supplementary Material 3. Discrepancies between the reviewers' initial quality assessment focused on questions related to whether the selection of study subjects was free from bias, and if the measurements used were valid and reliable. These differences were discussed by the research team, and outcomes agreed upon. Twenty-six studies were rated as positive quality, and the remaining nineteen were neutral. Studies were rated neutral quality for not reporting the study outcomes clearly, not using valid, or reliable measurement tools (e.g., valid and reliable tool used to measure diet and physical activity, but not sleep and alcohol consumption) or the selection of study subjects were not evidently clear from bias (e.g., students enrolled in for credit PA classes, or those who took lectures related to food). Several studies did not clearly report on withdrawals of participants from the study, representativeness of

the population, limitations, funding sources or the statistical analysis may not have been appropriate for the study design; blinding was not reported in any paper as it was not deemed relevant for the topic of interest and methods used. However, these did not affect quality ratings.

4.Discussion

The aim of this study was to identify the relationship between dietary quality and lifestyle behaviors in higher education students. The association between diet (categorized as either total dietary intake, dietary patterns, or F&V consumption) and lifestyle behaviors (PA, sleep, alcohol, and smoking) was examined. Results of associations were consistent across each measure of diet for PA and smoking. Sleep quality is associated more with overall diet intake/ patterns but not F&V consumption, whereas alcohol consumption is associated with F&V consumption but not total diet intake/ patterns. The results of studies included in this review highlight that dietary intake is sub-optimal among students and needs to be addressed through interventions. Low consumption of F&V has also been reported in many studies of higher education students.[27,28,32,125] Adherence to the MD within this review varies hugely between studies; previous studies of students have reported that as a population group they are abandoning the traditional MD diet within Mediterranean nations.[126,127] Poor dietary choices are common among student cohorts, as they tend to prioritize fast food,[128] and convenience foods[129] over healthier options, even if they have good nutrition knowledge[27,32] and are aware of what they "should" be eating.[130] With a variety of measurements and results utilized across studies it is difficult to compare findings from this review with other population groups.

sub- optimalamong

Physical Activity and its relationship with diet

Most studies within this review found a significant positive association between PA and diet quality ($P< 0.05$).[4,29,31,88,92,93,96-98,100,106,107,109,110,114,118-122,124] These results concur with previous systematic reviews and meta-analysis of over half a million youths and another review of 137,846 twenty-two-year olds, including some higher education students, which found that those with higher adherence to the MD are more likely to be physically active and have a less sedentary lifestyle.[53,131]A systematic review of over half a million non-higher education individuals found a positive correlation between higher PA levels and healthier dietary habits.[132] However, a narrative review of systematic reviews about the correlates of PA for children and adolescents found that results were inconclusive when assessing PA's relationship with diet.[133] A review by Choi et al,[134] found that only one paper of four that tested for an association between dietary habits and PA found a correlation between higher PA and higher quality diet whereas three were inconclusive. These mixed results correspond with the 12% of papers within the current review that assessed the relationship between diet and PA and which were also inconclusive.[85,94,116]

Sleep and its relationship with diet

A recent systematic review assessing the current evidence of association between diet and sleep quality found that F&V consumption was consistently reported to be linked to higher sleep quality.[135] However, studies that measured diet using dietary indices or MD patterns were less conclusive with some finding an association and some not.[135] Studies have found that an adherence to the MD,[136,137] F&V consumption[138] and a higher quality diet[139,140,141] are all associated with higher sleep quality, with most of these studies using the PSQI tool to measure sleep. However, it has been noted that additional research, in this emerging area, to determine this relationship, is vital to gain more conclusive evidence.[139,142,143] Di Benedetto et al, noted that other studies found no association between quality of sleep and F&V consumption, however, they did find an association between the total HEI score and sleep quality,[97] indicating that dietary assessment used as a tool that assesses overall food consumption may yield more conclusive results, which was similar to what was also found in this review. Only ten papers met our inclusion criteria of using validated measures to assess the relationship between sleep quality and diet and with four studies[97,115,117,118] testing for correlation between F&V consumption. More in-depth research is warranted to understand this relationship further. The papers that did find an association were all published within the past three years,[84,86,98,99,102,123] potentially indicating that this is an emerging area of study, and more studies may be published in the coming years.

Alcohol Consumption and its relationship with diet

Due to the lack of validated measures being used to assess alcohol consumption in studies of students, a vast number did not meet the inclusion criteria. Seven papers were included, five of which tested for an association with F&V consumption using a single item question regarding binge-drinking prevalence. Each of these five papers found an association between lower alcohol consumption and higher fruit consumption[31,97,113,118,121] with all, but one, finding higher vegetable consumption was related with lower alcohol consumption.[31,113,118,121] Only 7.6% (n=27) of students from the Di Benedetto et al, study were meeting vegetable guidelines. The low prevalence of produce consumption might explain why no association was found.[97] These results are similar to previous studies of non-higher education students that found those who consumed higher levels of alcohol and/ or binge drink had poorer diet quality, higher calorie intake and inadequate F&V consumption than non-drinkers.[144-149] However, two studies using the AUDIT tool found alcohol consumption did not correlate with dietary quality[91,99] which may be due to alcohol being a commonly consumed societal norm to the extent that it may be independent of other factors.[150] Therefore, the current evidence of the relationship between alcohol consumption and diet quality coincides with other population groups and is a potential target for health promoting interventions.

Smoking Status and its relationship with diet

Over a third of the studies within this review

found a significant relationship between poor diet quality and being a smoker.[31,83,88-90,92,104] These results are inconclusive, similar to a study of American adolescents (aged 14-18 years) that found that, although low fruit consumption was associated with smoking frequency, vegetable consumption was not.[151] Other studies have found that an inverse association between diet quality and smoking exists.[146,152] Studies have found that although smokers tend to have a lower quality diet, the relationship between these may be dependent on the intensity of tobacco consumption.[153,154] For this systematic review, the majority of studies did not assess frequency of smoking, potentially a reason as to why non-significant associations were found. It is believed that participants tend to overreport lifestyle behaviors that can be viewed as socially desirable (e.g., PA) while underreporting undesirable social behaviors, including smoking and alcohol consumption, because of an uneasiness around the topic, stigma attached to their use and attempts to conceal these behaviors.[155]

Summary of Diet and Lifestyle Behaviours

The sedentary nature of being a student has been identified as the second most common contributor to increasing weight and associated co-morbidities after diet among this cohort.[34] The key enablers of healthy eating in students include friend and family encouragement, self-motivation, weight management, self-regulation, a desire to improve health and self-esteem and attract potential partners.[156] A socio-ecological model developed by Deliens et al, states that students can be influenced by individual factors, their social networks, physical environment and macroenvironment.[157] This model can help higher education communities understand how and why students make dietary choices, potentially empowering and supporting improvement of dietary intake.[158] Studies have found that a higher quality diet and PA together are associated with improved general health status,[159] mitigate the risk of overweight and obesity,[160] and reduce age-associated cognitive decline.[161] A relationship has also been found between poor diet and higher alcohol consumption,[149] poor sleep,[162] and smoking[163] therefore interventions targeting multiple behaviors may be beneficial to improve the health of higher education students. It appears that those who engage in unhealthy lifestyle behaviors, identified in this review, tend to choose less healthy food options and could be a reason such relationships exist.[24,41,45-47,145,162]

These unhealthy behaviors are increasing the risk of students developing NCDs, such as obesity,[33] type 2 diabetes and CVD.[11] If identified early, modifying these health risk behaviors can reduce the likelihood of disease later in life.[15] Thereby, results are of interest to health promotion practitioners based in higher education, as they have the potential to guide development of diet and lifestyle behavior interventions for students.

Limitations

A limitation of this review is that the included studies used a variety of methodologies, making it difficult to compare and interpret results. Another limitation is that only studies in the Eng-

lish language were included. Furthermore, grey literature and research theses were not included. A meta-analysis could not be performed with a small number of papers investigating each specific relationship; the variety of methods (e.g., FFQ, 24-Hour diet recalls, self-reported) and statistical analysis used (e.g., chi-square, regression models) meant that the strength of associations found could not be determined. Some studies found in the initial literature search tested for an association between dietary quality and illicit drug use, which has been shown to have an association with the consumption of more calories in American adults.[164] Underreporting of illicit drug use is common due to specification errors[155,165] and there is a lack of available and quality data to assess its use among students,[166,167] therefore, excluded from this study. As most of the studies had a cross-sectional design, a causality or directional relationship could not be identified as they only report relationships present at one point in time.

Future Use of Findings

Higher education students are attending institutions that often have high quality facilities, technology, and highly educated staff across a spectrum of health disciplines that can be used and potentially be ideal for health promotion campaigns and interventions.[168] Recent systematic reviews have been conducted to assess the effectiveness of health interventions in a higher education setting with the majority focusing on a singular health outcome[169,170,171]; topics such as sleep, nutrition and PA were deemed understudied among students.[55] Most studies describing healthy campuses are theoretical with very few published interventions.[172] Effective interventions for students preventing unhealthy behaviors include in-person interventions, media approaches and nutrition labelling.[55] Encouraging positive health-promoting communication between students and their parents and peers[173-175] and increased self-esteem[176] have been shown to increase students' healthy behaviors and may be affordable, convenient interventions. Students tend to consume high amounts of food on campus, therefore, HEIs are responsible for ensuring healthy options are available, affordable and promoted to students.[177-180] If HEIs provide an educational program on time management and health-promoting skills such as budget financing, and cooking while staggering course schedules students may be more able to live a healthy lifestyle while on campus.[181,182] When PA is added to the curriculum of students both overall health and academic achievement improve.[183]

The most effective sleep intervention for students is cognitive behavioral therapy for insomnia (CBTi), which can work through online delivery[55,99,184] such as SilverCloud, a service promoted by the Irish health service, and includes stress management too.[185,186]Sleep hygiene education, mindfulness, relaxation, and hypnotherapy are also shown to improve the sleep quality of students.[99,184,87] Web-based and face-to-face programs have been shown to reduce hazardous alcohol consumption among students, however, long-term data is not available.[55] Research indicates that strict, comprehensive policies in relation to smoking, including prevention and cessa-

tion are reducing rates among students.[61] Teaching mindfulness and relaxation techniques to students has shown to reduce students stress levels and improve lifestyle behaviours.[65,188,189] Interventions that combine all health behaviors are likely to benefit students' health, decrease obesity levels and reduce the likelihood of future NCDs.[51,190,191] Integrating health courses into the curriculum is highly proposed to improve students' health and well-being.[192-195]

Future studies with a prospective design are needed which will allow for the assessment of temporal sequence, eliminate recall bias and enable comparison of diet and multiple lifestyle behaviors.[197] Future research could benefit from not using only self-reported measures to reduce the likelihood of over- or underestimation and misinterpretation of diet and lifestyle behaviors.[155,198] The development and piloting of interventions that add to what has been described, integrating diet and lifestyle behaviors together could be a beneficial approach with long-term effects.[55,170,196] These interventions will need to be tested for their feasibility and measured for their effectiveness on student engagement, improving or maintaining their health, both in the short and long term.

5.Conclusion

There is evidence of a correlation between higher diet quality and both higher PA levels and lower alcohol consumption. A relationship between sleep and diet appears to be trending towards correlation while smoking status had an inconclusive relationship with diet in this review. Additional research and clarity of the relationship between diet and lifestyle behaviors are warranted in this population group. Future research can help clarify these relationships and help inform healthy campus committees and students' unions when planning interventions, health, and well-being support and services for higher education students to create healthier institutes.

Availability of Data, Code and other Materials

Template data collection forms, data extracted from included studies, data used for all analyses, analytic code, and any other materials used in the revie ware available upon reasonable request from the author.

Supplementary Material 1: The PRISMA 2020 Checklist

Section and Topic	Item No.	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	Title Page: Page 15
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	Abstract: Page 15
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	Introduction: Page 17-18
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	Introduction: Page 18
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	Methods: Table 1.
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	Methods: Page 19
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	Supplementary Material 2
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	Methods: Pages 19-20
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	Methods: Page 19-20
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	Methods & Results: Pages 22 and Tables 2-5
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	Methods & Results: Pages 21-23 & Tables 2-5

Section and Topic	Item No.	Checklist item	Location where item is reported
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	Methods: Pages 22 and Supplementary material 3 and 4
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	N/A
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	Methods & Results: Page 43 and tables 2-5
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	Methods & Results: Page 43 and tables 2-5
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	Methods & Results: Page 43 and tables 2-5
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	N/A
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	N/A
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	N/A
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	N/A
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	N/A
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	Results: Figure 1.
Study characteristics	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	Results: Figure 1.
	17	Cite each included study and present its characteristics.	Results: Table 2.
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	Supplementary Material 3: Table 2
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	Results: Tables 2-5. Pages 43-47

Section and Topic	Item No.	Checklist item	Location where item is reported
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	Results & Supplementary Material: Tables 2-5 and Supplementary Marerial 3: Table 2.
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g., confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	Results: Tables 2-5. Pages 43-47
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	N/A
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	N/A
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	N/A
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	N/A
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	Discussion: Pages 47-49
	23b	Discuss any limitations of the evidence included in the review.	Discussion: Page 49
	23c	Discuss any limitations of the review processes used.	Discussion: Page 49
	23d	Discuss implications of the results for practice, policy, and future research.	Discussion: Page 50-51
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	Methods: Page 19
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	Methods: Page 19
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	Methods: Page 19
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	Title Page: Page 82
Competing interests	26	Declare any competing interests of review authors.	Title Page: Page 82
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	Conclusion: Page 51

Supplementary Material 2: Literature Search

EOLAS Library Database Search

(Eating OR diet* OR food OR nutrition) AND (University student OR college student OR undergraduate student OR graduate student OR tertiary student OR third level student OR postsecondary student OR higher education student) AND (determin* OR lifestyle OR factor OR associat* OR correlation OR cause)

Check any limit that may pertain to your search:

Age: Any

Language: English

Year of publication: 2000-Present

Total Results: 3,363

Science Direct Database Search via EOLAS Library

(Eating OR diet* OR food OR nutrition) AND (University student OR college student OR undergraduate student OR graduate student OR tertiary student OR third level student OR postsecondary student OR higher education student) AND (determin* OR lifestyle OR factor OR associat* OR correlation OR cause)

Check any limit that may pertain to your search:

Age: Any

Language: English

Year of publication: 2000-Present

Total Results: 554

ERIC Database Search via EOLAS Library

(Eating OR diet* OR food OR nutrition) AND (University student OR college student OR undergraduate student OR graduate student OR tertiary student OR third level student OR postsecondary student OR higher education student) AND (determin* OR lifestyle OR factor OR associat* OR correlation OR cause)

Check any limit that may pertain to your search:

Age: Any

Language: English

Year of publication: 2000-Present

Total Results: 230

PubMed Database Search

((((("Students"[Mesh]) OR ((university student[Text Word] OR college student[Text Word] OR undergraduate student[Text Word] OR graduate student[Text Word] OR tertiary student[Text Word] OR third level students[Text Word] OR postsecondary student[Text Word] OR higher education students[Text Word])))) AND (("Life Style"[Mesh]) OR ((determin*[Text Word] OR lifestyle[Text Word] OR factor[Text Word] OR associat* OR correlation[Text Word] OR cause[Text Word])) AND ((humans[Filter]) AND (english[Filter])))) AND (((((("Food"[Mesh]) OR ("Diet"[Mesh])) OR ("Nutritional Status"[Mesh])) OR ("Eating"[Mesh])) OR ((eating[Text Word] OR diet*[Text Word] OR food[Text Word] OR nutrition)[Text Word]) AND ((humans[Filter]) AND (english[Filter])))) AND ((humans[Filter]) AND (english[Filter]) AND (2000:2020[pdat])) Filters: Humans, English Sort by: Most Recent

("Students"[MeSH Terms] OR ("university student"[Text Word] OR "college student"[Text Word] OR "undergraduate student"[Text Word] OR "graduate student"[Text Word] OR "tertiary student"[Text Word] OR "third level students"[Text Word] OR "postsecondary student"[Text Word] OR "higher education students"[Text Word])) AND (("Life Style"[MeSH Terms] OR ("determin*"[Text Word] OR "lifestyle"[Text Word] OR "factor"[Text Word] OR "associat*"[All Fields] OR "correlation"[Text Word] OR "cause"[Text Word])) AND ("humans"[MeSH Terms] AND "english"[Language])) AND (("Food"[MeSH Terms] OR "Diet"[MeSH Terms] OR "Nutritional Status"[MeSH Terms] OR "Eating"[MeSH Terms] OR ("Eating"[Text Word] OR "diet*"[Text Word] OR "Food"[Text Word] OR ("nutrition s"[All Fields] OR "Nutritional Status"[MeSH Terms] OR ("nutritional"[All Fields] AND "status"[All Fields]) OR "Nutritional Status"[All Fields] OR "nutrition"[All Fields] OR "nutritional sciences"[MeSH Terms] OR ("nutritional"[All Fields] AND "sciences"[All Fields]) OR "nutritional sciences"[All Fields] OR "nutritional"[All Fields] OR "nutritionals"[All Fields] OR "nutritions"[All Fields] OR "nutritive"[All Fields]))) AND ("humans"[MeSH Terms] AND "english"[Language])) AND ("humans"[MeSH Terms] AND "english"[Language] AND 2000/01/01:2020/12/31[Date - Publication])

Translations

humans[Filter]: humans[MH]

english[Filter]: english [LA]

nutrition: "nutrition's"[All Fields] OR "nutritional status"[MeSH Terms] OR ("nutritional"[All Fields] AND "status"[All Fields]) OR "nutritional status"[All Fields] OR "nutrition"[All Fields] OR "nutritional sciences"[MeSH Terms] OR ("nutritional"[All Fields] AND "sciences"[All Fields]) OR "nutritional sciences"[All Fields] OR "nutritional"[All Fields] OR "nutritionals"[All Fields] OR "nutritions"[All Fields] OR "nutritive"[All Fields]

Total Results: 3,525

Web of Science Search

29th September 2020

# 8	3,876	#7 AND #6 AND #5 *Indexes=SCI-EXPANDED, SSCI, A&HCI, ESCI Timespan=2000-2020*
# 7	10,964,123	(AB=(determin* OR lifestyle OR factor OR associat* OR correlation OR cause)) *AND* **LANGUAGE:** (English) *Indexes=SCI-EXPANDED, SSCI, A&HCI, ESCI Timespan=2000-2020*
# 6	182,455	(AB=(university student OR college student OR undergraduate student OR graduate student OR tertiary student OR third level student OR postsecondary student OR higher education student)) *AND* **LANGUAGE:** (English) *Indexes=SCI-EXPANDED, SSCI, A&HCI, ESCI Timespan=2000-2020*
# 5	975,842	(AB =(eating OR diet* OR food OR nutrition)) *AND* **LANGUAGE:** (English) *Indexes=SCI-EXPANDED, SSCI, A&HCI, ESCI Timespan=2000-2020*

Total Results = 3,876

Supplementary Material 3: Bias Report Table: Academy of Nutrition and Dietetics Quality Criteria Checklist

Author (Year	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	Overall Quality Rating
Adams & Colner, (2008)[83]	Yes	Yes	Yes	No	No	Yes	Unclear	Yes	Yes	No	Ø
Adams et al., (2020)[84]	Yes	Unclear	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Ø
Antoine-Jonville et al., (2010)[85]	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Unclear	Yes	+
Aslan Çin, & Yardimci, (2021)[86]	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Unclear	+
Baydemir et al., (2018)[87]	Yes	Yes	Yes	Yes	No	Yes	Unclear	Unclear	Yes	Yes	Ø
Bennasar-Veny et al., (2020)[88]	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	+
Bertsias et al., (2005)[89]	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	+
Borlu et al., (2019)[90]	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Unclear	No	+
Carlos et al., (2020)[91]	Yes	Yes	Yes	Unclear	No	Yes	Yes	Yes	Yes	Yes	+
Cena et al., (2021)[4]	Yes	Yes	Yes	Unclear	No	Yes	Yes	Yes	Yes	Yes	+
Chacón-Cuberos et al., (2018)[92]	Yes	Yes	Yes	Unclear	No	Yes	Unclear	Yes	Yes	Yes	Ø
Chacón-Cuberos et al., (2019)[93]	Yes	Yes	Yes	Unclear	No	Yes	Unclear	Yes	Yes	Yes	Ø
Cobo-Cuenca et al., (2019)[94]	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	+
Deliens et al., (2018)[95]	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	+
de-Mateo-Silleras et al., (2019)[96]	Yes	Unclear	Yes	Unclear	No	Yes	Yes	Yes	Yes	Unclear	Ø
Di Benedetto et al., (2020)[97]	Yes	Yes	Yes	Yes	No	Yes	Unclear	Unclear	Yes	Unclear	Ø
Dinger et al., (2014)[29]	Yes	Yes	Yes	Unclear	No	Yes	Yes	Yes	Yes	Yes	+

Author (Year	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	Overall Quality Rating
Du et al., (2021)[98]	Yes	Yes	Yes	Unclear	No	Yes	Yes	Yes	Yes	Yes	+
Du et al., (2021)[99]	Yes	Yes	Yes	Unclear	No	Yes	Yes	Yes	Yes	Yes	+
Eaves et al., (2017)[100]	Yes	Yes	Yes	Unclear	No	Yes	Unclear	Yes	Yes	Unclear	Ø
Elio et al., (2021)[101]	Yes	Unclear	Yes	Unclear	No	Yes	Yes	Yes	Yes	Yes	Ø
Fernández-Medina et al., (2020)[102]	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	+
García-Meseguer et al., (2014)[103]	Yes	Yes	Yes	Yes	No	Yes	Unclear	Yes	Unclear	Unclear	Ø
Gianfredi et al., (2018)[104]	Yes	Yes	Yes	Yes	No	Yes	Unclear	Unclear	Yes	Yes	Ø
González et al., (2013)[105]	Yes	Yes	Yes	Unclear	No	Yes	Yes	Yes	Yes	Unclear	+
González-Valero et al., (2019)[106]	Yes	Yes	Yes	Unclear	No	Yes	Unclear	Yes	Yes	Yes	Ø
Landry et al., (2019)[107]	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	+
Lenz, (2004)[108]	Yes	Yes	Yes	Yes	No	Yes	Unclear	Unclear	Yes	No	Ø
Lim et al., (2017)[109]	Yes	Yes	Yes	Yes	No	Yes	Yes	Unclear	Yes	Yes	+
López-Nuevo et al., (2021)[110]	Yes	Unclear	Yes	No	No	Yes	Yes	Yes	Yes	No	Ø
Martinez-Lacoba et al., (2018)[111]	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	+
Moreno-Gómez et al., (2012)[112]	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	+
Nelson et al., (2009)[113]	Yes	Yes	Yes	Yes	No	Yes	Unclear	Yes	Yes	Unclear	Ø
Peltzer & Pengpid, (2014)[31]	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	+
Pengpid et al., (2015)[114]	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	+

Author (Year	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	Overall Quality Rating
Quick et al., (2015)[115]	Yes	Yes	Yes	Unclear	No	Yes	Yes	Yes	Yes	Unclear	+
Rodríguez-Muñozet et al., (2020)[116]	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	+
Silva et al., (2016)[117]	Yes	Yes	Yes	Unclear	No	Yes	Yes	Yes	Yes	Unclear	+
Stuntz et al., (2015)[118]	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Unclear	+
Tassitano et al., (2016)[119]	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	+
Taylor et al., (2009)[120]	Yes	Yes	Yes	Yes	No	Yes	Unclear	No	Yes	No	Ø
Van den Bogerd et al., (2018)[121]	Yes	Yes	Yes	Yes	No	Yes	Unclear	Yes	Yes	Yes	Ø
Wilson et al., (2019)[122]	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Ø
Yamamoto et al., (2018)[123]	Yes	Unclear	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Ø
Zurita-Ortega et al., (2018)[124]	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	+

Footnotes: 1. *Was the research question clearly stated? 2. Was the selection of study subjects free from bias? 3. Were study groups comparable? 4. Was the method of handling withdrawals described? 5. Was blinding used to prevent the introduction of bias? 6. Were intervention procedure and comparison(s) described in detail? Where intervening factors described? 7. Were outcomes clearly defined and the measurements valid and reliable? 8. Was the statistical analysis appropriate for the study design and type of outcome indicators? 9. Are conclusions supported by results with biases and limitations taken into consideration? 10. Is bias due to study's funding or sponsorship unlikely? + = Positive: Indicates that the report has clearly addressed issues of inclusion/exclusion, bias, generalizability, and data collection and analysis; - = Negative: Indicates that these issues have not been adequately addressed; Ø Neutral: Indicates that the report is neither exceptionally strong nor exceptionally weak.*

Supplementary Material 4: Bias Reporting Tool: Academy of Nutrition and Dietetics Quality Criteria Checklist for Review Articles - Primary Research

RELEVANCE QUESTIONS					
1.	Would implementing the studied intervention or procedure (if found successful) result in improved outcomes for the patients/clients/population group? (NA for some Epi studies)	Yes	No	Unclear	N/A
2.	Did the authors study an outcome (dependent variable) or topic that the patients/clients/population group would care about?	Yes	No	Unclear	N/A
3.	Is the focus of the intervention or procedure (independent variable) or topic of study a common issue of concern to dietetics practice?	Yes	No	Unclear	N/A
4.	Is the intervention or procedure feasible? (NA for some epidemiological studies)	Yes	No	Unclear	N/A
If the answers to all of the above relevance questions are "Yes," the report is eligible for designation with a plus (+) on the Evidence Quality Worksheet, depending on answers to the following validity questions.					
VALIDITY QUESTIONS					
1.	**Was the research question clearly stated?**	Yes	No	Unclear	N/A
	1.1 Was the specific intervention(s) or procedure (independent variable(s)) identified?				
	1.2 Was the outcome(s) (dependent variable(s)) clearly indicated?				
	1.3 Were the target population and setting specified?				
2.	**Was the selection of study subjects/patients free from bias?**	Yes	No	Unclear	N/A
	2.1 Were inclusion/exclusion criteria specified (e.g., risk, point in disease progression, diagnostic or prognosis criteria), and with sufficient detail and without omitting criteria critical to the study?				
	2.2 Were criteria applied equally to all study groups?				
	2.3 Were health, demographics, and other characteristics of subjects described?				
	2.4 Were the subjects/patients a representative sample of the relevant population?				
3.	**Were study groups comparable?**	Yes	No	Unclear	N/A
	3.1 Was the method of assigning subjects/patients to groups described and unbiased? (Method of randomization identified if RCT)				
	3.2 Were distribution of disease status, prognostic factors, and other factors (e.g., demographics) similar across study groups at baseline?				
	3.3 Were concurrent controls used? (Concurrent preferred over historical controls.)				
	3.4 If cohort study or cross-sectional study, were groups comparable on important confounding factors and/or were preexisting differences accounted for by using appropriate adjustments in statistical analysis?				
	3.5 If case control study, were potential confounding factors comparable for cases and controls? (If case series or trial with subjects serving as own control, this criterion is not applicable. Criterion may not be applicable in some cross-sectional studies.)				
	3.6 If diagnostic test, was there an independent blind comparison with an appropriate reference standard (e.g., "gold standard")?				
4.	**Was method of handling withdrawals described?**	Yes	No	Unclear	N/A
	4.1 Were follow up methods described and the same for all groups?				
	4.2 Was the number, characteristics of withdrawals (i.e., dropouts, lost to follow up, attrition rate) and/or response rate (cross-sectional studies) described for each group? (Follow up goal for a strong study is 80%.)				
	4.3 Were all enrolled subjects/patients (in the original sample) accounted for?				
	4.4 Were reasons for withdrawals similar across groups?				

	4.5	If diagnostic test, was decision to perform reference test not dependent on results of test under study?	
5.	**Was <u>blinding</u> used to prevent introduction of bias?**		Yes No Unclear N/A
	5.1	In intervention study, were subjects, clinicians/practitioners, and investigators blinded to treatment group, as appropriate?	
	5.2	Were data collectors blinded for outcomes assessment? (If outcome is measured using an objective test, such as a lab value, this criterion is assumed to be met.)	
	5.3	In cohort study or cross-sectional study, were measurements of outcomes and risk factors blinded?	
	5.4	In case control study, was case definition explicit and case ascertainment not influenced by exposure status?	
	5.5	In diagnostic study, were test results blinded to patient history and other test results?	
6.	**Were <u>intervention</u>/therapeutic regimens/exposure factor or procedure and any comparison(s) described in detail? Were <u>intervening factors</u> described?**		Yes No Unclear N/A
	6.1	In RCT or other intervention trial, were protocols described for all regimens studied?	
	6.2	n observational study, were interventions, study settings, and clinicians/provider described?	
	6.3	Was the intensity and duration of the intervention or exposure factor sufficient to produce a meaningful effect?	
	6.4	Was the amount of exposure and, if relevant, subject/patient compliance measured?	
	6.5	Were co-interventions (e.g., ancillary treatments, other therapies) described?	
	6.6	Were extra or unplanned treatments described?	
	6.7	Was the information for 6.4, 6.5, and 6.6 assessed the same way for all groups?	
	6.8	In diagnostic study, were details of test administration and replication sufficient?	
7.	**Were <u>outcomes</u> clearly defined and the <u>measurements valid and reliable</u>?**		Yes No Unclear N/A
	7.1	Were primary and secondary endpoints described and relevant to the question?	
	7.2	Were nutrition measures appropriate to question and outcomes of concern?	
	7.3	Was the period of follow-up long enough for important outcome(s) to occur?	
	7.4	Were the observations and measurements based on standard, valid, and reliable data collection instruments/tests/procedures?	
	7.5	Was the measurement of effect at an appropriate level of precision?	
	7.6	Were other factors accounted for (measured) that could affect outcomes?	
	7.7	Were the measurements conducted consistently across groups?	
8.	**Was the <u>statistical analysis</u> appropriate for the study design and type of outcome indicators?**		Yes No Unclear N/A
	8.1	Were statistical analyses adequately described the results reported appropriately?	
	8.2	Were correct statistical tests used and assumptions of test not violated?	
	8.3	Were statistics reported with levels of significance and/or confidence intervals?	
	8.4	Was "intent to treat" analysis of outcomes done (and as appropriate, was there an analysis of outcomes for those maximally exposed or a dose-response analysis)?	
	8.5	Were adequate adjustments made for effects of confounding factors that might have affected the outcomes (e.g., multivariate analyses)?	
	8.6	Was clinical significance as well as statistical significance reported?	
	8.7	If negative findings, was a power calculation reported to address type 2 error?	
9.	**Are <u>conclusions supported by results</u> with biases and limitations taken into consideration?**		Yes No Unclear N/A
	9.1	Is there a discussion of findings?	
	9.2	Are biases and study limitations identified and discussed?	
10.	**Is bias due to study's <u>funding or sponsorship</u> unlikely?**		Yes No Unclear N/A
	10.1	Were sources of funding and investigators' affiliations described?	
	10.2	Was there no apparent conflict of interest?	

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STATEMENT OF POTENTIAL CONFLICT OF INTEREST

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SD, LK, JMM and JMK conceptualized and designed the study. SD and LK drafted the introduction section. SD and NOC conducted a database search and extracted the data. SD and LK drafted the methods, results, discussion and conclusion section. All authors contributed to the writing and editing of the manuscript. All authors read and approved the final manuscript.