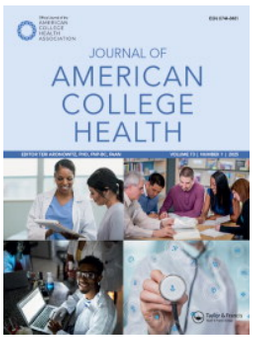

Journal of American College Health

ISSN: 0744-8481 (Print) 1940-3208 (Online) Journal homepage: www.tandfonline.com/journals/vach20

Are health behaviors associated with mental health among tertiary education students? A systematic review of cohort studies

Melinda Hutchesson, Megan Whatnall, Sasha Fenton, Lee Ashton, Amanda Patterson, Jordan Smith, Mitch J. Duncan, Frances Kay-Lambkin & Tracy Burrows

To cite this article: Melinda Hutchesson, Megan Whatnall, Sasha Fenton, Lee Ashton, Amanda Patterson, Jordan Smith, Mitch J. Duncan, Frances Kay-Lambkin & Tracy Burrows (2025) Are health behaviors associated with mental health among tertiary education students? A systematic review of cohort studies, Journal of American College Health, 73:1, 111-123, DOI: 10.1080/07448481.2023.2201865

To link to this article: https://doi.org/10.1080/07448481.2023.2201865

Published online: 27 Apr 2023.

JOURNAL OF AMERICAN COLLEGE HEALTH
2025, VOL. 73, NO. 1, 111–123
https://doi.org/10.1080/07448481.2023.2201865

Routledge
Taylor & Francis Group

MAJOR ARTICLE

Are health behaviors associated with mental health among tertiary education students? A systematic review of cohort studies

Melinda Hutchesson, BND (Hons), PhD[a,b], Megan Whatnall, BND (Hons), PhD[a,b], Sasha Fenton, BND (Hons), PhD[a,b], Lee Ashton, BSc (Hons), MSc, PhD[a,c,d], Amanda Patterson, BSc, MND, PhD[a,b], Jordan Smith, BTech (HPE) (Hons), PhD[c,d], Mitch J. Duncan, BHMSc (Hons), PhD[d,e], Frances Kay-Lambkin, PhD[e] and Tracy Burrows, BND, PhD[a,b]

[a]School of Health Sciences, College of Health, Medicine, and Wellbeing, University of Newcastle, Newcastle, Australia; [b]Food and Nutrition Research Program, Hunter Medical Research Institute, Newcastle, Australia; [c]School of Education, College of Human and Social Futures, University of Newcastle, Newcastle, Australia; [d]Active Living Research Program, Hunter Medical Research Institute, Newcastle, Australia; [e]School of Medicine and Public Health, College of Health, Medicine and Wellbeing, University of Newcastle, Newcastle, Australia

ABSTRACT

Objective: To evaluate the association between health behaviors with mental health among tertiary education students.

Methods: Six databases were searched until September 2021 for prospective cohort studies evaluating the association between health behavior(s) (dietary intake, physical activity, sedentary behavior, alcohol intake, sleep, smoking or illicit drug use) and mental health. Two independent reviewers screened records for inclusion, extracted data and completed risk of bias assessments.

Results: 33 studies were included (14 assessed sleep, 14 alcohol intake, 13 physical activity, 8 smoking, 6 sedentary behavior, 4 diet, 1 illicit drug use). A consistent association between poor sleep, and physical inactivity with increased risk of poor psychological wellbeing, and between poor sleep and increased mental ill-health related outcomes was demonstrated.

Conclusion: Findings suggest interventions to address poor sleep and physical inactivity among students may positively impact mental health. Further research of other health behaviors, and their association with mental health, is required.

ARTICLE HISTORY
Received 8 May 2022
Revised 19 March 2023
Accepted 5 April 2023

KEYWORDS
Mental health; college student; health behavior; systematic review

Introduction

Mental ill-health has global impacts, with approximately 10% of individuals experiencing a mental health disorder.[1] The onset of mental health disorders occurs before age 25 for approximately two thirds (62.5%) of cases,[2] and young adults experience the highest rates of mental ill-health than any other adult life stage. Tertiary education students, including university students, are particularly vulnerable to mental ill-health. Global data demonstrates that approximately one-third of students in their first year of university study screened positive for at least one DSM-IV mental disorder,[3] and 94% of students report experiencing stress.[4]

Evidence suggests that the health behaviors of tertiary education students, including physical activity, sedentary behavior, sleep, alcohol and drug use, tobacco smoking, and dietary intake are also often adversely impacted during this unique life stage.[5,6] For instance, data from the National College Health Assessment show high rates of health risk behaviors, e.g., 56% of students are not meeting physical activity guidelines and 44% are sleeping less than recommended.[5] Moreover, the literature shows that health risk behaviors often co-occur in tertiary education students[7–10] with data from the National College Health Assessment indicating that 85% of students experience two or more health risk behaviors.[6]

The higher rates of mental ill-health and poor health behaviors exhibited by university students may be linked to the unique transitions they experience during this time in their lives. For example, university students often experience changes to living arrangements, geographical separation from families, new financial responsibilities, the need to balance study with work, family, social and other commitments, and new academic expectations. Any of these lifestyle changes may adversely impact the students' stress/anxiety levels, financial status and their time availability and motivation to pursue and maintain healthy lifestyle behaviors such as regular physical activity, adequate sleep duration and a healthy diet.

Previous research demonstrates that relationships exist between health behaviors and mental health in adults, or more specifically that engaging in higher risk lifestyle behaviors are associated with increased risk of mental ill-health.[7–17] A 2020 systematic meta-review examined the impact of health behaviors, including physical activity, sleep, tobacco

CONTACT Melinda Hutchesson melinda.hutchesson@newcastle.edu.au School of Health Sciences, ICT Building, University of Newcastle, Newcastle, Australia.
Supplemental data for this article can be accessed online at https://doi.org/10.1080/07448481.2023.2201865.

smoking and diet on the risk and treatment outcomes of multiple indicators of mental ill-health (e.g. depression, anxiety, schizophrenia and bipolar disorder).[7] The meta-review concluded that there is substantial evidence of the protective effect of physical activity in the prevention of mental ill-health, significant evidence that poor sleep increases the risk of mental ill-health, and increasingly strong evidence implicating tobacco smoking as a causal factor in the onset of mental ill-health. Although the findings for diet were less clear, overall, the review concluded that the evidence synthesis added further support for health behavior interventions being part of routine service delivery for the treatment and prevention of mental ill-health.[7]

To-date, systematic reviews have explored associations between individual health risk behaviors and mental health among the general population and young adults.[7–17] To the authors' knowledge, no previous systematic reviews have evaluated the association between multiple health behaviors and mental health among tertiary education students. Nor have previous systematic reviews focused on the longitudinal changes in health behaviors that occur during enrollment, and their associations with mental health, with many including predominantly cross-sectional studies. Therefore, the aim of this systematic review is to describe associations between health behaviors (i.e., dietary intake, physical activity, sedentary behavior, alcohol intake, sleep, smoking and illicit drug use) and mental health outcomes among tertiary education students, using evidence from prospective cohort studies. Evidence from the systematic review can inform the development of interventions tailored to tertiary education students. This is important given the unique life transitions that they face, the prevalence of health risk behaviors and the impact on their mental health.

Materials and methods

Protocol and registration

The protocol for the systematic review was registered with Open Science Framework (https://osf.io/wysju). The outcomes of the systematic review exploring associations between health behaviors and academic and/or mental health outcomes in tertiary education students have been divided across two papers. The findings related to academic performance have been previously published;[18] this paper focuses on the mental health outcomes. The conduct and reporting of the systematic review is in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[19]

Eligibility criteria

Studies included in the systematic review had to meet eligibility criteria for the type of participants, exposures, outcomes, and study design, that were established a priori (Table 1).

Information sources and search strategy

Six electronic databases (MEDLINE, EMBASE, PsycINFO, Web of Science, CINAHL and CENTRAL) were searched from the date of inception to 4 September 2021, with searches limited to studies published in English and involving human subjects. A senior medical librarian developed the search strategy in consultation with the review team (Supplementary Table 1). The reference lists of all included studies were also searched for relevant articles, and relevant articles from a previous systematic review were included.[20]

Study selection

Study selection was managed in Covidence systematic review software (Veritas Health

Innovation, Melbourne, Australia). All records from the search, with duplicates removed, were uploaded to Covidence. Two independent reviewers screened the title, abstracts and keywords of all identified records (M.H. and M.W., L.A., or T.B.) against the eligibility criteria. Records that appeared to meet the eligibility criteria or where it was uncertain, proceeded to full text review. The full articles were retrieved and reviewed by two independent reviewers (M.H. and M.W.) against the eligibility criteria, with a third reviewer used in

Table 1. Eligibility criteria for the systematic review.

Participants	Tertiary education students (i.e., those enrolled in academic education as well as advanced vocational or professional education as per the UNESCO International Standard Classification of Education 2011)[a]
Exposure	One or more health behaviors must have been self-reported or objectively measured during the student's tertiary education enrollment. The health behaviors were included based on the following definitions: *Dietary intake:* energy, macro/micronutrients, or food group intake, as well as diet quality, or dietary or eating patterns. *Physical activity*: total energy expenditure, frequency or duration of physical activity in total or at different intensities or modes (e.g. aerobic, resistance). *Sedentary behavior*: frequency and duration of sitting time or screen time. *Alcohol intake:* frequency or quantity of alcohol intake, as well as alcohol dependence. *Sleep: sleep* duration, quality, timing or alertness. *Smoking* included tobacco smoking or e-cigarettes. *Illicit drug use:* frequency or quantity of use of illegal drugs, misuse or non-medical use of pharmaceutical drugs, or inappropriate use of other substances (such as inhalants), as well as drug dependence. Cannabis was included in this category.
Outcomes	One or more mental health outcome must have been measured, and the association between a health behavior and mental health outcome reported. Mental health outcomes included psychological well-being, or the absence or occurrence of mental illness/mental health disorders. Mental illness/mental health disorders including depression, anxiety, schizophrenia, bipolar mood disorder, personality disorders and eating disorders. Psychological well-being including hedonic (e.g. happiness, positive emotions) and eudemonic (e.g. self-acceptance, autonomy) domains.
Study design	Only prospective cohort studies were considered for inclusion in the review. Retrospective or cross-sectional analyses were excluded.

[a]United Nations Educational Scientific and Cultural Organization (UNESCO). International Standard Classification of Education (ISCED) 2011. Montreal, Canada; 2012.

the case of any disagreements (A.P.). Reasons for exclusion were recorded consistent with the eligibility criteria.

Data extraction

Data were extracted by one reviewer (K.S or S.F.), and checked by a second reviewer (S.F or M.H.). The data collection form was developed for the purposes of the review, and pilot-tested prior to implementation. Data extracted included study characteristics (e.g. country, year), participants (e.g. number, age, and gender), exposure (type and measurement method of health behavior), outcomes (type and measurement method for mental health outcomes) and study results (i.e. the association between health behaviors and mental health outcomes).

Risk of bias in individual studies

Risk of bias was assessed using the 11-item Joanna Briggs Institute Critical Appraisal tool (Checklist for Cohort Studies).[21] The tool was completed at the study level by two independent reviewers (KS and MW, TB or SF.), with a third reviewer consulted on any disagreements (M.H.). Questions were assessed as yes, no, unclear or not applicable. The overall risk of bias for each study was classed as high if three or more criteria were 'no' or 'unclear', or otherwise low risk.

Data synthesis

Data were analyzed using the vote counting method of Sallis et al.,[22] where the following categorizations apply: if 0 to 33% of studies reported a significant association, the results were classified as "no association"; if 34 to 59% of studies reported a significant association, the results were classified as "inconsistent"; and if 60% or more of studies reported a significant association, the result was classified as "positive" or "negative" based on the direction of the association. If fewer than four studies reported on that outcome the results were classified as "uncertain". Associations were classified as "positive" if the presence of the health risk behavior (e.g. smoking, illicit drug use, physical inactivity) was associated with an increased risk of a poor mental health outcome. For example, if one study reported a positive association between physical inactivity and higher risk of incident depression and another study reported a negative association between physical activity and lower risk of incident depression these results were both coded as positive. The vote counting method was applied for each health behavior individually, and psychological well-being, and mental ill-health related outcomes were reported separately.

Results

Description of included studies

A total of 9438 unique articles were identified. From this, 33 studies were included (Figure 1). A summary of study characteristics is provided in Table 2, and detailed characteristics are presented in Supplementary Table 2. The majority of the studies were published since 2016 (n = 24; 73%), and fifty-four percent of the cohorts were from tertiary education institutions in North America (n = 18). All studies were in a university/college setting. While all studies were prospective cohort studies, the number of follow-up points and study duration were variable. The median number of follow-up points was two but ranged from one to 17. The duration of follow-up was most commonly (n = 21 studies, 63%) less than one year (or academic year), with many (n = 11, 33%) one semester or less.

Description of study designs and participant characteristics

There was a total of 63,374 participants across the included cohorts, ranging from 28 to 15,396 participants per cohort. All participants were university or college students, with no studies set in other tertiary education institutions. Eighty-eight percent of cohorts (n = 29) included both males and females, with an average of 65% female participants. The mean age of participants was 19.9 years. Sixty-one percent of the cohorts (n = 20) reported ethnicity; within these cohorts' participants were predominantly white. Most cohorts (n = 28, 85%) reported the type of student enrollment, and of these all studies recruited undergraduate students.

Description of exposure measures

The number of health behaviors measured ranged from one to six per study, with 21 studies (64%) measuring one health behavior, 6 studies (18%) two health behaviors, and the remaining six studies (18%) measuring three to six health behaviors. The most measured health behaviors were alcohol intake and sleep (n = 14 studies each, 42%), followed by physical activity (n = 13 studies, 39%), and the least commonly measured behavior was illicit drug use (n = 1 study, 3%). Despite 12 studies measuring more than one type of health behavior, only two studies of these considered the combined exposure to the health behaviors (i.e. concomitant smoking and alcohol intake,[23] and sedentary behavior and physical activity).[24] In 25 (76%) of the studies health behavior/s were measured at multiple time points (i.e. measuring change in the health behavior).

Alcohol intake

Fourteen studies measured alcohol intake as an exposure measure.[23,25–37] All 14 studies measured alcohol intake via self-report surveys, and 12 (86%) measured alcohol intake at multiple time points.[26–37] Ten studies (71%) assessed one component of alcohol intake, and four studies (29%) included more than one (e.g. frequency and quantity). The most common components of alcohol intake assessed were frequency of alcohol consumption and quantity of alcohol consumed (Figure 2).

Sleep

Fourteen studies measured sleep as an exposure measure, and all of these studies measured sleep via self-report.[23,25,

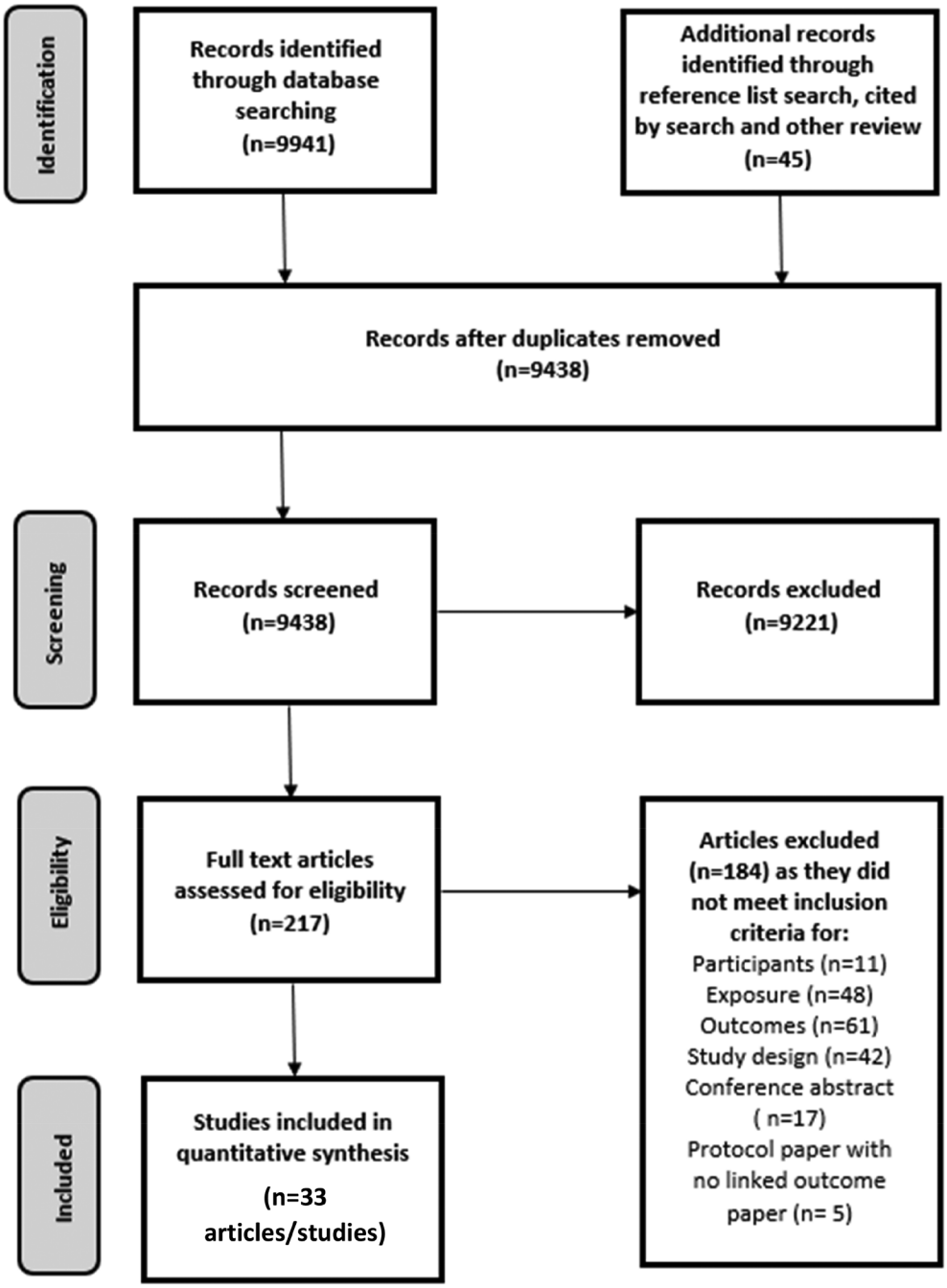

Figure 1. Flow diagram of included studies.

[27,34,35,37–45] Of these studies, sleep was measured only at baseline in five studies (36%), and at multiple time points in nine studies (64%). Eight studies (57%) measured one component of sleep, and six studies (43%) more than one. The most common components of sleep assessed were overall sleep quality, followed by sleep duration and daytime sleepiness/dysfunction (Figure 3).

Physical activity

Thirteen studies measured physical activity as an exposure measure, all using self-report surveys.[23–25,27–29,36,46–50] Eight studies (62%) assessed one component of physical activity, while five studies (38%) assessed more than one. The most common components of physical activity that were assessed were frequency and duration (Figure 4). Physical activity was measured only at baseline in two studies (15%), and at multiple time points in eleven studies (85%).

Smoking

Eight studies measured smoking as an exposure, all via self-report survey.[23,27–29,36,51–53] Seven studies (88%) measured one component of smoking exposure, and one study (12%) more than one. Current smoking status was the most common component assessed (Figure 5). One study measured smoking only at baseline (12%) and seven studies assessed smoking at multiple time points (88%).

Table 2. Summary of study characteristics in 33 studies exploring associations between health behaviors and mental health in tertiary education students.

		n	%
Publication year	<2000	0	0
	2000–2005	2	6
	2006–2010	1	3
	2011–2015	6	18
	2016–2020	24	73
Country	USA	12	36
	Canada	6	18
	China	5	15
	UK	4	12
	Bangladesh	2	6
	Brazil	1	3
	Finland	1	3
	India	1	3
	China & Germany (multi-country study)	1	3
Number of participants at baseline	Total	63,374	
	Median	1057	
	Range	28–15,396	
Sex/Gender	Average proportion of females	65.2	
	Average proportion of males	34.8	
Age (years)	Mean (SD)	19.9 (1.2)	
	Young adults (16–31 years)	14	42
	Adults (18 years and over)	2	6
	Age range not reported/unclear	17	52
Ethnicity	Predominantly white	14	42
	Predominantly nonwhite	6	18
	Not reported	13	39
Type of student enrollment	Undergraduate students	28	85
	Undergraduate and postgraduate students	0	0
	Unclear/Not reported	5	15
Type of student enrollment	Students enrolled in health or medical degrees/courses	6	18
	Student's degree/course not specified	27	82
Health behavior/s assessed	Alcohol intake	14	42
	Sleep	14	42
	Physical activity	13	39
	Smoking	8	24
	Sedentary behavior	6	18
	Dietary intake	4	12
	Illicit drug use	1	3
	Assessed 1 health behavior	21	64
	Assessed 2 health behaviors	6	18
	Assessed >2 health behaviors	6	18
Number of times health behavior/s were measured	1	8	24
	>1	25	76
Type of mental health outcome/s assessed	Mental illness/mental health disorders	20	61
	Psychological well being	18	55
	Mental health composite measure	2	6
Length of follow up	≤ one academic semester	11	33
	> one academic semester to one year/academic year	10	30
	> one to 4 years/academic years	11	33
	Not reported/Unclear	1	3
Number of follow up time points	Median	2	
	Range	1–17	
Mean retention rate[a]	Mean (SD)	74 (23)	

[a]Based on 29 studies as n = 4 studies did not clearly report retention rate.

Sedentary behavior

Six studies measured sedentary behavior as an exposure measure, all using self-report surveys.[23,24,27,29,47,48] All studies assessed one component of sedentary behavior, with four studies (67%) assessing total daily time spent being sedentary, one study (17%) daily hours spent in recreational screen time, and one (17%) total daily screen time. All assessed sedentary behavior at multiple time points.

Dietary intake

Four studies measured dietary intake as an exposure measure, all via self-report survey.[27,29,36,54] The four studies each measured one component of dietary intake, with each assessing a different component (frequency of meal consumption; breakfast consumption; vegetarian diet status; and the degree of healthy eating practices). In three studies (75%) dietary intake was assessed at multiple time points, and in one study (25%) it was assessed at a single time point.

Illicit drug use

One study measured illicit drug use, via self-report survey.[25] In this study substance misuse was measured at a single time point.[25]

Description of outcome measures

Twenty studies (61%) examined mental ill-health related outcomes, with five different outcomes assessed: depression

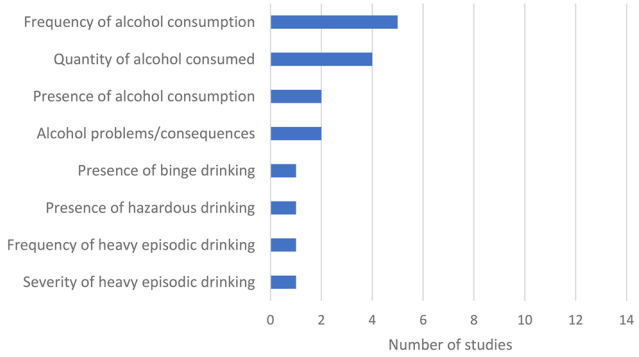

Figure 2. Measures of alcohol intake in 14 included studies.

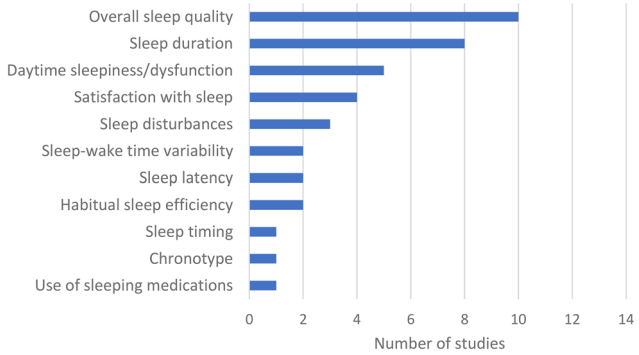

Figure 3. Measures of sleep in 14 included studies.

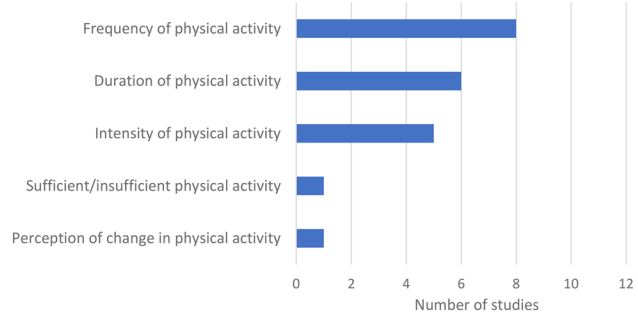

Figure 4. Measures of physical activity in 13 included studies.

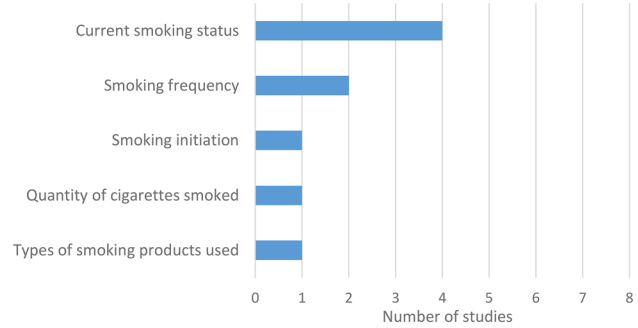

Figure 5. Measures of smoking in 8 included studies.

(n = 18 studies), anxiety (n = 5), stress (n = 5), suicide ideation and attempts (n = 3), and internalizing symptoms (n = 1). Eighteen studies (55%) examined psychological wellbeing related outcomes, with 13 different outcomes assessed: feelings of happiness, sadness, stress and anxiety (n = 2 studies), psychological impairment/stress (n = 2), mental wellbeing (n = 2), stressors (n = 1), sense of coherence (n = 1), self-concept (n = 1), subjective wellbeing (n = 1), affect (n = 1), psychological flexibility/inflexibility (n = 1), emotional dysregulation (n = 1), repetitive negative thoughts (n = 1), positive mental health (n = 1), and self-esteem (n = 1). Two studies examined a composite mental health measure, which was intrapersonal adjustment.

Risk of bias

Just over half of the included studies (n = 18, 55%) were assessed as low risk of bias,[23,25,32–35,37,39–45,47,48,50,54] and fifteen studies (45%) were assessed as high risk of bias (Table 3).[24,26–31,36,38,45,46,51–53] All studies had a low risk of bias in terms of the groups within studies being similar and recruited from the same population, and with the follow-up time being reported and sufficient. Most studies also had a low risk of bias for the exposures being measured similarly to assign people to both exposed and unexposed groups (n = 32, 97%), for the use of valid and reliable measures of exposures (n = 19, 58%), for the use of strategies to deal with confounding factors (n = 30, 91%), for the use of valid and reliable measures of outcomes (n = 29, 88%), whether follow-up was complete or loss to follow-up described (n = 18, 55%), and for appropriate statistical analyses (n = 32, 97%). High risk of bias was determined in most studies where the participants were free of the outcome at the start of the study (n = 25, 76%).

Description of associations between health behaviors and mental health outcomes

Table 4 summarizes the associations between health behaviors and mental health outcomes using the vote counting system. Hereafter, use of the term 'significant' is used to indicate an association that was statistically significant.

Alcohol intake:14 studies.[23,25–37]

The overall association between alcohol intake and psychological wellbeing was graded as "no association" with four out of five studies reporting no significant association.[25,28,29,35] One study in undergraduate students (n = 627 at baseline) with a three-year follow-up reported an association between greater alcohol intake and higher subjective wellbeing, and an association between greater adverse alcohol consequences and lower subjective wellbeing.[31]

Ten studies explored the association between alcohol intake with mental ill-health.[23,25–27,30,32–34,36,37] Six studies reported a significant association,[26,27,30,33,34] of these, five a positive association, and one a negative association. Therefore, the association was graded as "inconsistent". Two studies (n = 1140, n = 325 at baseline) reported significant positive associations between alcohol use and depression,[27,30] and one study in undergraduate students reported an association between additional alcohol consequences and

Table 3. Critical appraisal of 33 studies exploring associations between health behaviors and mental health in tertiary education students.

Study	Health behavior/s assessed	Critical appraisal item											Overall risk
		1	2	3	4	5	6	7	8	9	10	11	
Dinis and Bragança[55]	Smoking	Y	Y	U	Y	Y	N	Y	Y	N	U	Y	High
Kwak et al.[9]	Physical activity; alcohol intake; sleep; illicit drug use	Y	Y	U	Y	Y	Y	Y	Y	NA	NA	Y	Low
Tavernier and Willoughby[41]	Alcohol intake; sleep	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Low
Hossain et al.[27]	Physical activity; sedentary behavior; alcohol intake; sleep; smoking	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Low
Wong et al.[42]	Sleep	Y	Y	N	N	NA	N	N	Y	Y	Y	Y	High
Mohammed et al.[30]	Alcohol intake	Y	Y	Y	U	U	N	Y	Y	U	Y	Y	High
Molnar et al.[31]	Dietary intake; physical activity; sedentary behavior; alcohol intake; sleep; smoking	Y	Y	U	Y	Y	N	Y	Y	N	N	Y	High
Rosenthal et al.[33]	Dietary intake; physical activity; sedentary behavior; alcohol intake; smoking	Y	Y	U	Y	Y	U	U	Y	Y	NA	Y	High
Zhang et al.[50]	Physical activity	Y	Y	U	Y	Y	U	U	Y	Y	Y	Y	High
Zhang et al.[50]	Physical activity	Y	Y	U	Y	Y	U	U	Y	Y	Y	Y	High
Mushquash et al.[32]	Physical activity; alcohol intake; smoking	Y	Y	U	U	NA	N	Y	Y	N	N	N	High
Zou et al.[43]	Sleep	Y	Y	U	Y	Y	Y	Y	Y	Y	Y	Y	Low
Gardani et al.[56]	Smoking	Y	Y	U	Y	Y	N	Y	Y	N	Y	Y	High
Semplonius and Willoughby[34]	Alcohol intake	Y	U	U	U	NA	N	Y	Y	Y	Y	Y	High
Tavernier and Willoughby[35]	Alcohol intake	Y	Y	Y	U	NA	N	Y	Y	N	Y	Y	High
Velten et al.[36]	Alcohol intake	Y	Y	Y	U	NA	N	Y	Y	Y	Y	Y	Low
Shi et al.[44]	Sleep	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	Low
Marquez et al.[57]	Dietary intake	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Low
Evans et al.[37]	Alcohol intake	Y	Y	U	Y	Y	Y	Y	Y	Y	Y	Y	Low
Buysse[58]	Smoking	Y	Y	Y	U	NA	N	Y	Y	N	N	Y	High
Bandiera et al.[51]	Physical activity; sedentary behavior	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	Low
Marsden et al.[52]	Physical activity; sedentary behavior	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	Low
Garett et al.[38]	Alcohol intake; sleep	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	Low
Savage et al.[48]	Sleep	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Low
Wilson et al.[49]	Sleep	Y	Y	Y	Y	U	N	Y	Y	N	Y	Y	High
Langberg et al.[39]	Sleep	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Low
Langberg et al.[39]	Sleep	Y	Y	U	Y	U	Y	Y	Y	Y	Y	Y	Low
Kuuppelomaki and Utriainen[28]	Physical activity; sedentary behavior	Y	Y	Y	Y	Y	U	Y	Y	N	U	Y	High
Peltz et al.[40]	Dietary intake; physical activity; alcohol intake; smoking	Y	Y	N	U	NA	N	Y	Y	U	U	Y	High
Saules et al.[53]	Physical activity	Y	Y	Y	Y	Y	N	Y	Y	Y	NA	Y	Low
Kroencke et al.[46]	Sleep	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Low
Ren et al.[54]	Physical activity	Y	Y	Y	Y	Y	N	Y	Y	Y	NA	Y	Low
Savage et al.[47]	Sleep	Y	Y	Y	Y	Y	N	Y	Y	Y	U	Y	Low

Item descriptions; 1) Were the two groups similar and recruited from the same population?, 2) Were the exposures measured similarly to assign people to both exposed and unexposed groups?, 3) Was the exposure measured in a valid and reliable way?, 4) Were confounding factors identified?, 5) Were strategies to deal with confounding factors stated?, 6) Were the groups/participants free of the outcome at the start of the study (or at the moment of exposure)?, 7) Were the outcomes measured in a valid and reliable way?, 8) Was the follow up time reported and sufficient to be long enough for outcomes to occur?, 9) Was follow up complete, and if not, were reasons to loss to follow up described and explored?, 10) Were strategies to address incomplete follow up utilized?, 11) Was appropriate statistical analysis used?.

increased risk of onset depression.[33] One study (n = 1140 at baseline) reported a positive association between alcohol intake and anxiety at 15-months,[27] and one study in 2607 undergraduate students found that alcohol problems were associated with increased internalizing symptoms.[26] One study which recruited first year undergraduate male and female students reported a positive association between concomitant alcohol use and smoking, and risk of depression in the female participants.[23] One study found that alcohol use was associated with lower depressive symptoms.[34]

Sleep: 14 studies.[23,25,27,34,35,37–45]

The overall association between sleep and psychological wellbeing was graded as "positive" (i.e. poor sleep was consistently associated with poorer psychological wellbeing) with five of six studies reporting a significant association.[34,38–40,45] Of these five studies, poorer sleep quality was associated with higher stress in one 10-week study in undergraduate students,[38] increased psychological inflexibility in an 8-week study (n = 792 at baseline),[40] and greater emotional dysregulation in another study in undergraduate students.[34] One study which measured sleep in undergraduate students daily for 18 days over a three week period reported an association between shorter sleep duration and later bedtime, and increased repetitive negative thoughts.[45] One study in 62 undergraduate students diagnosed with Attention Deficit Hyperactivity Disorder found that daytime sleepiness was associated with greater overall psychological impairment.[39]

The overall association between sleep with mental ill-health was graded as "positive" (i.e. poor sleep was consistently associated with greater mental ill-health.) with eight of nine studies reporting a significant association.[25,27,34,37,40,42–44] Of these eight studies, four studies in undergraduate students with follow-ups ranging from two to twelve months reported that poorer sleep quality was associated with increased depression,[34,37,40,43] and one 12 month study (n = 686 at

Table 4. Summary of 33 retrospective cohort studies exploring the associations between health risk behaviors and mental health outcomes among tertiary education students.

Health risk behaviors	Summary of studies with psychological well-being related outcomes		Summary of students with mental ill-health related outcomes	
	n/N	Association	n/N	Association
Alcohol use	1/5 (20%)	No association	6/10 (60%)	Inconsistent*
Poor sleep[a]	5/6 (83%)	Positive	8/9 (100%)	Positive
Physical inactivity	6/8 (75%)	Positive	3/7 (43%)	Inconsistent
Smoking	0/3 (0%)	Uncertain	3/6 (50%)	Inconsistent
Poor dietary intake	0/2 (50%)	Uncertain	2/3 (67%)	Uncertain
Sedentary behavior	2/ 4 (50%)	Inconsistent	2/3 (67%)	Uncertain
Illicit drug use	0	Uncertain	0/1 (0%)	Uncertain

n/N (%) = number of studies reporting a significant association/Number of studies which explored the association, and the % that demonstrated a significant association. Association with mental health outcome: No association if 0 to 33% of studies report a significant association; Inconsistent if 34 to 59% of studies report a significant association, Positive or Negative if 60% or more of studies report a significant association, based on the direction of the association. Uncertain if less than four studies reported on the exposure/outcome.* Inconsistent as 5 studies positive association and 1 study negative association

baseline) found an association between poorer sleep quality and increased anxiety.[43] One study (n = 3029) in first year undergraduate students that assessed sleep at baseline only, reported an association between poorer sleep quality and increased risk of depressive symptoms, and anxiety, at follow-up.[25] Increased dissatisfaction with sleep was also associated with depression and anxiety,[27] as was short sleep and long sleep time frequency in one study conducted over 15 months.[27] Poorer sleep quality was associated with increased suicidal ideation in one, two month study,[40] and sleep disturbances were also associated with increased risk of suicidal ideation and attempts in another study (n = 11740), which measured sleep disturbances at baseline only.[44] One 15 month study (n = 1195 at baseline) found associations between daytime dysfunction and depression, daytime dysfunction and anxiety, and sleep disturbance and anxiety.[42]

Physical activity: 13 studies.[23–25,27–29,36,46–50]

The overall association between physical activity with psychological wellbeing was graded as "positive" (i.e. physical inactivity was consistently associated with poorer psychological wellbeing) with six of eight studies reporting a significant association.[24,28,29,36,46] Increased physical activity frequency was associated with decreased anxiety and increased feelings of happiness in two studies in undergraduate psychology students conducted over 13 and 15 weeks,[46] increased sense of coherence in one study conducted over three academic semesters,[28] and positive mental health in one study (n = 15396 at baseline) with a one year follow-up.[36] One study in 28 undergraduate students found that greater time spent doing physical activity was associated with higher self-concept.[29] The remaining study (n = 573 at baseline) reported that insufficient physical activity (combined with high or low sedentary behavior) was associated with higher psychological distress in the cohort of undergraduate students.[24]

Seven studies explored the association between physical activity and mental ill-health, [23,25,27,36,48–50] with three studies reporting a significant "positive" association.[25,27] Therefore, the evidence was graded as "inconsistent'. One study in 1140 undergraduate students reported that high physical inactivity was associated with depression and anxiety,[27] and one study (n = 3029) which assessed physical activity at baseline only found that less frequent physical activity was associated with increased risk of depressive symptoms at the six month follow-up.[25] One study in 1163 undergraduate students conducted over one year reported that high leisure-time physical activity was associated with lower levels of depressive symptoms.[50]

Smoking: 8 studies.[23,27–29,36,51–53]

Three studies investigated the association between smoking status, and poor psychological well-being, with no significant associations reported.[28,29,36] The evidence was classified as "uncertain" due to the low number of studies exploring this association.

Six studies investigated the association between smoking status and mental ill-health.[23,27,36,51–53] Three of the six studies reported a significant "positive" association,[23,36,52] therefore, the evidence was categorized as "inconsistent". Of the three positive associations, one study (n = 15396 at baseline) reported an association between current smoking and increased mental health problems at the one year follow-up,[36] and one study in undergraduate students (n = 5236) found that increased frequency of use of cigarettes, e-cigarettes and hookah was associated with increased depressive symptoms.[52] The other study in undergraduate male and female students reported a positive association between concomitant smoking and alcohol use, and risk of depression in the female participants.[23]

Sedentary behavior: 6 studies.[23,24,27,29,47,48]

Four studies explored the association between sedentary behavior and poor psychological well-being,[24,29,47,48] with two reporting a significant "positive" association,[24] therefore, the evidence was categorized as "inconsistent". One study reported that increased time spent in sedentary behavior was associated with decreased mental wellbeing at the one-year follow-up.[47] Another study in undergraduate students reported that high or low sedentary behavior (combined with insufficient physical activity) was associated with higher psychological distress.[24]

Three studies investigated the association between sedentary behavior and mental ill-health,[23,27,48] with two

reporting a significant "positive" association.[27,48] One study conducted over 15 months in undergraduate students (n = 1140 at baseline), reported an association between high and excessive screen time and depression and anxiety.[27] The other study, conducted over six months, found that increased time spent in sedentary behavior was associated with an increase in perceived stress.[48] The evidence was classified as "uncertain" given that only two studies were identified.

Dietary intake: 4 studies.[27,29,36,54]

Two studies explored the association between dietary intake with poor psychological wellbeing,[29,36] and no significant associations were reported. Given there were only two studies exploring this association, the evidence was classified as "uncertain".

Three studies explored the association between dietary intake and mental ill-health,[27,36,54] with two reporting a positive significant association.[27,54] The evidence was categorized as "uncertain". One study reported an association between low and high daily meal consumption frequency and depression and anxiety,[27] and the other study found that higher breakfast consumption frequency was associated with decreased depressive symptoms.[54]

Drug use: 1 study.[25]

One study explored the association between illicit drug use with mental ill-health.[25] No significant association was reported and therefore the evidence is "uncertain".

Discussion

The aim of this systematic review was to describe prospective associations between health behaviors and mental health among tertiary education students. We found consistent evidence for an association between poor sleep, and physical inactivity with increased risk of poor psychological wellbeing, and between poor sleep and increased mental ill-health related outcomes. Inconsistent evidence was found for the association between alcohol use and sedentary behavior with psychological wellbeing, and also between alcohol use, physical inactivity and smoking with mental ill-health. Due to a low number of included studies, the evidence for the association between illicit drug use and dietary intake with psychological wellbeing, and dietary intake, sedentary behavior, and illicit drug use with mental ill-health remains uncertain.

The included studies explored a wide variety of outcomes pertaining to mental ill-health and psychological wellbeing. For mental ill-heath indicators, five different groupings of outcomes were assessed and for psychological wellbeing 13 different outcomes. Across these groupings of outcomes a variety of measurement tools were also used. For example, for the five studies considering anxiety, three different tools were utilized. Similarly, for the assessment of the health behavior exposure, a variety of different components of the individual health behaviors were assessed within each construct. For example, across the 14 studies measuring sleep, there were 11 different sleep variables assessed. Therefore, although the systematic review located consistent evidence (positive and no association) for the association between some health behaviors and a range of mental health outcomes, it is important to consider the diversity in health behavior variables, as well as the mental health outcomes across the included studies. There is currently insufficient evidence to confirm associations between specific components of individual health behaviors (e.g. frequency of alcohol consumption vs. quantity of alcohol consumption) with specific psychological wellbeing outcomes, or indicators of mental ill-health. Therefore, while this systematic review provides guidance as to what health behaviors are important for treatment and prevention of mental ill-health among tertiary education students, it cannot provide evidence of what specific changes to health behaviors to target within interventions. Furthermore, the diversity in exposure and outcome measurements across the included studies may explain some of the findings in the current review that are inconsistent with previous research. The heterogeneity within the measurement of both the exposure and outcomes also precluded meta-analyses to be conducted in this review.

The current systematic review found consistent evidence that poor sleep was associated with poorer psychological wellbeing and greater mental ill-health. The results from the current review are comparable with previous systematic reviews demonstrating an association between sleep and mental health outcomes in adults, including reviews focusing on university students. [7,14,55,56] For example, Firth et al.[7] demonstrated from 25 observational studies a weighted pooled effect size of 0.39 for the association between sleep quality and stress among undergraduate university students. Similar to this review, the authors highlighted the heterogeneity in measurement of both sleep quality and stress within the studies included in the meta-analysis. Therefore, future research is required to consider the multiple components of sleep (i.e., quality, duration, timing, satisfaction) that comprise overall sleep health,[58] to clarify the association between sleep and mental health among university students.

The current systematic review found consistent evidence that low levels of physical activity was associated with poorer psychological wellbeing, but inconsistent evidence for the association between physical activity and mental ill-health. Our findings are consistent with the growing evidence of the positive impact of increased physical activity on wellbeing among adults.[57] However, they are contradictory to a recent meta-review of evidence examining health behaviors impact on the risk and treatment of mental ill-health, which concluded there is 'substantial evidence' that physical inactivity is a risk factor for mental ill-health.[7] The current systematic review also demonstrated no association between alcohol use and psychological wellbeing, and inconsistent evidence for the association between alcohol use and mental ill-health. Previous research exploring the association between alcohol use and mental health outcomes has also produced variable findings.[10,15,59] For example, a 2018 meta-analysis examining the association between substance use and mental health disorders among adolescents and young adults demonstrated a positive association between alcohol use with depression (OR: 1.50, 95% CI: 1.24-1.83)

and anxiety (OR: 1.54, 95% CI: 1.19–2.00),[15] whereas other reviews reported a lack of consistency in findings.[10,59] This inconsistency in findings for alcohol and physical activity may be due to the variability of measurement of exposure/outcome previously discussed, short duration of follow-up across the included studies, or the quality of the studies included in this review.

The current systematic review cannot draw conclusions regarding the association between smoking and mental-ill-health, or the association between sedentary behaviors with psychological well-being, due to inconsistent evidence. Our results for smoking are inconsistent with a recent meta-review of evidence examining health behaviors impact on the risk and treatment of mental ill-health, which concluded there is 'increasingly strong' evidence that smoking is a risk factor for mental ill-health.[7] Whereas, our finding for the association between sedentary behavior and psychological wellbeing is consistent with previous research. For example, Teychenne et al systematically reviewed observational studies (n = 26) exploring associations between time in sedentary behavior and stress and concluded the poor-quality evidence provided inconsistent or null evidence of an association.[12] Due to the low number of studies exploring some health behaviors, the current review also cannot draw conclusions regarding the association between illicit drug use and dietary intake with psychological wellbeing, and dietary intake, sedentary behavior, and illicit drug use with mental ill-health, further highlighting the need for further research in this area. Research of these health behaviors among tertiary education students is especially important, given the known changes to these behaviors that may occur during the transition to university or college.

A major gap in the existing evidence for the association between health behaviors and mental health of tertiary education students is the lack of studies that consider the co-occurrence of health risk behaviors, given strong evidence of co-occurrence in this population.[6,60–63] However, despite several included cohort studies assessing more than one health behavior, only two explored the cumulative impact of more than one health behavior. Notably, these two studies both focused on two health behaviors only. Further, included studies also failed to consider co-occurring mental ill-health outcomes. Another limitation of the included cohort studies was the short follow-up periods (i.e. 63% of studies were one year or less), which limited the ability of the studies to understand changes in health behaviors and mental health throughout enrollment in tertiary education, or their changing associations over time. This is particularly important given the nature of both the exposure and outcomes of interest, which often take time to change, and therefore may have limited the ability to detect associations. Future prospective cohort studies in this setting should therefore address these gaps, by considering how multiple health behaviors change and interact throughout the entire duration of a student's enrollment. Finally, despite the reviews focus on tertiary education, the included studies recruited only college/university students, with a specific focus on undergraduate students and therefore highlights the need for research including those enrolled in vocational courses, and higher university degrees.

Future studies should also address the methodological limitations of the studies included in this review, with almost half of the included studies (n = 15, 45%) assessed as having a high risk of bias. Overall, more transparent and clear reporting of cohort methodology may improve overall risk of bias. Most important is transparent reporting of identification of confounding factors, and strategies used to account for confounding factors, and incomplete follow-up. A consistent limitation of the included studies was in the reporting of health risk behaviors measurement, and therefore uncertainty over the validity and reliability. Notably, most studies (n = 21) did not exclude participants based on the occurrence of the mental health outcome of interest at cohort commencement. While this is understandable, given the nature of the outcome measure, it is an important consideration in the interpretation of the findings, and associations reported between health behaviors and mental health outcomes.

Strengths and limitations of the systematic review

This systematic review has several methodological strengths. It was undertaken in accordance with the PRISMA guidelines, six databases were searched for relevant studies, and studies were included that were established a priori. The review also used a vote counting method to synthesize the data that has been used previously,[64,65] and is therefore reproducible. However, this method only considers the statistical significance of the findings in terms of the number of studies finding a positive, negative or no association. The results therefore do not consider the magnitude of the association. Further, due to the evidence synthesis approach, along with the nature of the studies included in the systematic review, it was not possible to explore other factors that may influence the association between health behaviors and mental health, such as country the study was undertaken in or key student characteristics (e.g., 1st year students, program of study). In addition, for the purposes of this review health behaviors were considered as the exposure, and mental health as the outcome. The potential bi-directional association between some health behaviors and mental health was not explored, and is therefore an area for future research. Finally, the review was also limited to studies published in English, which may have resulted in relevant studies being excluded.

Conclusion

This systematic review describing prospective associations between health behaviors and mental health among tertiary education students found consistent evidence for an association between poor sleep, and physical inactivity with increased risk of poor psychological wellbeing, and between poor sleep and increased mental ill-health related outcomes. Inconsistent or uncertain evidence was found for all other health behaviors of interest.

Implications for practice

The review provides further support for the implementation of interventions to address poor sleep and physical inactivity for the treatment and prevention of mental ill-health in the tertiary education setting. The findings can be used to advocate for investment in such strategies.

Implications for future research

The systematic review highlighted there is currently no evidence evaluating the impact of multiple health risk behaviors on mental health of tertiary education students, as well as a lack of evidence for some individual health behaviors (dietary intake, sedentary behavior, illicit drug use and smoking). Furthermore, most studies focused on only one semester or academic year, and therefore did not explore the likely transitions in health behaviors and mental health that occur throughout enrollment. The available evidence does not consider what facets of each health behaviors are associated with mental health outcomes (e.g. what components of dietary intake). This knowledge is vital to our understanding of how to intervene most effectively to improve health behavior for treatment and prevention of mental ill-health for tertiary education students, and therefore should be the focus of future research.

Acknowledgments

Debbie Booth, Senior Librarian, University of Newcastle for applying the search strategy. Kaylee Slater for assistance with data extraction.

Conflict of interest disclosure

The authors have no conflicts of interest to report. The authors confirm that the research presented in this article met the ethical guidelines, including adherence to the legal requirements, of Australia. As it is a systematic review no ethics approval was required.

Funding

This work was supported by a School of Health Science pilot grant. Burrows supported by a NHMRC Investigator Grant (fellowship), Duncan supported by a NHMRC Career Development Fellowship, and Kay-Lambkin supported by a NHMRC Investigator Grant (fellowship).

ORCID

Melinda Hutchesson http://orcid.org/0000-0002-1851-0661
Jordan Smith http://orcid.org/0000-0003-4640-8645

References

1. GBD 2017 Disease and Injury Incidence and Prevalence Collaborators. Global, regional, and national incidence, prevalence, and years lived with disability for 354 diseases and injuries for 195 countries and territories, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. *Lancet*. 2018;392(10159):1789–1858. doi:10.1016/S0140-6736(18)32279-7.
2. Solmi M, Radua J, Olivola M, et al. Age at onset of mental disorders worldwide: large-scale meta-analysis of 192 epidemiological studies. *Mol Psychiatry*. 2022;27(1):281–295. doi:10.1038/s41380-021-01161-7.
3. Auerbach RP, Mortier P, Bruffaerts R, et al. WHO World Mental Health Surveys International College Student Project: Prevalence and distribution of mental disorders. *J Abnorm Psychol*. 2018;127(7):623–638. doi:10.1037/abn0000362.
4. Karyotaki E, Cuijpers P, Albor Y, et al. Sources of stress and their associations with mental disorders among college students: results of the World Health Organization World Mental Health Surveys International College Student Initiative. *Front Psychol*. 2020;11:1759. doi:10.3389/fpsyg.2020.01759.
5. American College Health Association. National College Health Assessment – Spring 2020 Reference Group Executive Summary. Silver Spring, MD; 2020.
6. Kang J, Ciecierski CC, Malin EL, et al. A latent class analysis of cancer risk behaviors among U.S. college students. *Prev Med*. 2014;64:121–125. doi:10.1016/j.ypmed.2014.03.023.
7. Firth J, Solmi M, Wootton RE, et al. A meta-review of "lifestyle psychiatry": the role of exercise, smoking, diet and sleep in the prevention and treatment of mental disorders. *World Psychiatry*. 2020;19(3):360–380. doi:10.1002/wps.20773.
8. Li J, Wang H, Li M, et al. Effect of alcohol use disorders and alcohol intake on the risk of subsequent depressive symptoms: a systematic review and meta-analysis of cohort studies. *Addiction*. 2020;115(7):1224–1243. doi:10.1111/add.14935.
9. Dharmayani PNA, Juergens M, Allman-Farinelli M, Mihrshahi S. Association between fruit and vegetable consumption and depression symptoms in young people and adults aged 15–45: a systematic review of cohort studies. *Int J Environ Res Public Health*. 2021;18(2):780.
10. Treur JL, Munafò MR, Logtenberg E, Wiers RW, Verweij KJH. Using Mendelian randomization analysis to better understand the relationship between mental health and substance use: a systematic review. *Psychol Med*. 2021;51(10):1593–1624. doi:10.1017/S003329172100180X.
11. Maynou L, Hernández-Pizarro HM, Rodríguez E. M. The association of physical (in)activity with mental health. Differences between elder and younger populations: a systematic literature review. *Int J Environ Res Public Health*. 2021;18(9):4771.
12. Teychenne M, Stephens LD, Costigan SA, Olstad DL, Stubbs B, Turner AI. The association between sedentary behaviour and indicators of stress: a systematic review. *BMC Public Health*. 2019;19(1):1357. doi:10.1186/s12889-019-7717-x.
13. Teychenne M, Costigan SA, Parker K. The association between sedentary behaviour and risk of anxiety: a systematic review. *BMC Public Health*. 2015;15:513. doi:10.1186/s12889-015-1843-x.
14. Hertenstein E, Feige B, Gmeiner T, et al. Insomnia as a predictor of mental disorders: a systematic review and meta-analysis. *Sleep Med Rev*. 2019;43:96–105. doi:10.1016/j.smrv.2018.10.006.
15. Esmaeelzadeh S, Moraros J, Thorpe L, Bird Y. Examining the association and directionality between mental health disorders and substance use among adolescents and young adults in the U.S. and Canada-a systematic review and meta-analysis. *J Clin Med*. 2018;7(12):543.
16. Collins S, Dash S, Allender S, Jacka F, Hoare E. Diet and mental health during emerging adulthood: a systematic review. *Emerg. Adulthood*. 2022;10(3):645–659.
17. Saha S, Okafor H, Biediger-Friedman L, Behnke A. Association between diet and symptoms of anxiety and depression in college students: a systematic review. *J Am Coll Health*. 2021:1–11. doi :10.1080/07448481.2021.1926267.
18. Whatnall M, Ashton L, Patterson A, et al. Are health behaviors associated with academic performance among tertiary education students? A systematic review of cohort studies. *J Am Coll Health*. 2022:1–13. doi:10.1080/07448481.2022.2063024.

19. Moher D, Shamseer L, Clarke M, et al. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. *Syst Rev*. 2015;4(1):1–9. doi:10.1186/2046-4053-4-1.
20. Burrows TL, Whatnall MC, Patterson AJ, Hutchesson MJ. Associations between dietary intake and academic achievement in college students: a systematic review. *Healthcare* 2017;5(4):e60. doi:10.3390/healthcare5040060.
21. Moola S, Munn Z, Tufanaru C, et al. Chapter 7: Systematic reviews of etiology and risk. In: Aromataris E, Munn Z, eds. *JBI Manual for Evidence Synthesis*. Joanna Briggs Institute; 2020.
22. Sallis JF, Prochaska JJ, Taylor WC. A review of correlates of physical activity of children and adolescents. *Med Sci Sports Exerc*. 2000;32(5):963–975. doi:10.1097/00005768-200005000-00014.
23. Fonseca LB, Pereira LP, Rodrigues PRM, et al. Incidence of depressive symptoms and its association with sociodemographic factors and lifestyle-related behaviors among Brazilian university students. *Psychol Health Med*. 2021;27(6):1–15.
24. Uddin R, Burton NW, Khan A. Combined effects of physical inactivity and sedentary behaviour on psychological distress among university-based young adults: a one-year prospective study. *Psychiatr Q*. 2020;91(1):191–202. doi:10.1007/s11126-019-09697-2.
25. Duffy A, Keown-Stoneman C, Goodday S, et al. Predictors of mental health and academic outcomes in first-year university students: Identifying prevention and early-intervention targets. *BJPsych Open*. 2020;6(3):e46. doi:10.1192/bjo.2020.24.
26. Homman LE, Edwards AC, Cho SB, Dick DM, Kendler KS. Gender and direction of effect of alcohol problems and internalizing symptoms in a longitudinal sample of college students. *Subst Use Misuse*. 2017;52(4):429–438. doi:10.1080/10826084.2016.1233983.
27. Hossain S, Anjum A, Uddin ME, Rahman MA, Hossain MF. Impacts of socio-cultural environment and lifestyle factors on the psychological health of university students in Bangladesh: a longitudinal study. *J Affect Disord*. 2019;256:393–403. doi:10.1016/j.jad.2019.06.001.
28. Kuuppelomaki M, Utriainen P. A 3 year follow-up study of health care students' sense of coherence and related smoking, drinking and physical exercise factors. *Int J Nurs Stud*. 2003;40(4):383–388. doi:10.1016/s0020-7489(02)00103-7.
29. Kwak J, Amrhein M, Barkhoff H, Heiby E. Daily self-monitoring of physical leisure activities and health practices, self-concept, and quality-of-life. *Sport J*. 2015;18:unpaginated. doi:10.17682/sportjournal/2015.015.
30. Mohammed S, Tharayil H, Gopakumar S, George C. Pattern and correlates of depression among medical students: an 18-month follow-up study. *Indian J Psychol Med*. 2020;42(2):116–121. doi:10.4103/IJPSYM.IJPSYM_28_19.
31. Molnar DS, Busseri MA, Perrier CP, Sadava SW. A longitudinal examination of alcohol use and subjective well-being in an undergraduate sample. *J Stud Alcohol Drugs*. 2009;70(5):704–713. doi:10.15288/jsad.2009.70.704.
32. Mushquash AR, Stewart SH, Sherry SB, Sherry DL, Mushquash CJ, MacKinnon AL. Depressive symptoms are a vulnerability factor for heavy episodic drinking: a short-term, four-wave longitudinal study of undergraduate women. *Addict Behav*. 2013;38(5):2180–2186. doi:10.1016/j.addbeh.2012.11.008.
33. Rosenthal SR, Clark MA, Marshall BDL, et al. Alcohol consequences, not quantity, predict major depression onset among first-year female college students. *Addict Behav*. 2018;85:70–76. doi:10.1016/j.addbeh.2018.05.021.
34. Semplonius T, Willoughby T. Psychosocial adjustment throughout university: a longitudinal investigation of the roles of sleep quality and emotion dysregulation. *J Youth Adolesc*. 2018;47(6):1267–1278. doi:10.1007/s10964-018-0826-5.
35. Tavernier R, Willoughby T. Are all evening-types doomed? Latent class analyses of perceived morningness-eveningness, sleep and psychosocial functioning among emerging adults. *Chronobiol Int*. 2014;31(2):232–242. doi:10.3109/07420528.2013.843541.
36. Velten J, Bieda A, Scholten S, Wannemuller A, Margraf J. Lifestyle choices and mental health: a longitudinal survey with German and Chinese students. *BMC Public Health*. 2018;18(1):632. doi:10.1186/s12889-018-5526-2.
37. Evans S, Alkan E, Bhangoo JK, Tenenbaum H, Ng-Knight T. Effects of the COVID-19 lockdown on mental health, wellbeing, sleep, and alcohol use in a UK student sample. *Psychiatry Res*. 2021;298:113819. doi:10.1016/j.psychres.2021.113819.
38. Garett R, Liu S, Young SD. A longitudinal analysis of stress among incoming college freshmen. *J Am Coll Health*. 2017;65(5):331–338. doi:10.1080/07448481.2017.1312413.
39. Langberg JM, Dvorsky MR, Becker SP, Molitor SJ. The impact of daytime sleepiness on the school performance of college students with attention deficit hyperactivity disorder (ADHD): a prospective longitudinal study. *J Sleep Res*. 2014;23(3):318–325. doi:10.1111/jsr.12121.
40. Peltz JS, Rogge RD, Bodenlos JS, Kingery JN, Pigeon WR. Changes in psychological inflexibility as a potential mediator of longitudinal links between college students' sleep problems and depressive symptoms. *J Contextual Behav Sci*. 2020;15:110–122. doi:10.1016/j.jcbs.2019.12.003.
41. Tavernier R, Willoughby T. Bidirectional associations between sleep (quality and duration) and psychosocial functioning across the university years. *Dev Psychol*. 2014;50(3):674–682. doi:10.1037/a0034258.
42. Wong ML, Lau EY, Wan JH, Cheung SF, Hui CH, Mok DS. The interplay between sleep and mood in predicting academic functioning, physical health and psychological health: a longitudinal study. *J Psychosom Res*. 2013;74(4):271–277. doi:10.1016/j.jpsychores.2012.08.014.
43. Zou P, Wang X, Sun L, et al. Poorer sleep quality correlated with mental health problems in college students: a longitudinal observational study among 686 males. *J Psychosom Res*. 2020;136:110177. doi:10.1016/j.jpsychores.2020.110177.
44. Shi X, Zhu Y, Wang S, et al. The prospective associations between different types of sleep disturbance and suicidal behavior in a large sample of Chinese college students. *J Affect Disord*. 2020;279:380–387.
45. Stewart E, Coles ME. Sleep timing and duration predict levels of repetitive negative thinking the following day. *J Cogn Ther*. 2021;14(2):289–304. doi:10.1007/s41811-020-00074-7.
46. Kroencke L, Harari GM, Katana M, Gosling SD. Personality trait predictors and mental well-being correlates of exercise frequency across the academic semester. *Soc Sci Med*. 2019;236:112400. doi:10.1016/j.socscimed.2019.112400.
47. Savage MJ, Hennis PJ, Magistro D, Donaldson J, Healy LC, James RM. Nine months into the COVID-19 pandemic: a longitudinal study showing mental health and movement behaviours are impaired in UK students. *Int J Environ Res Public Health*. 2021;18(6):2930.
48. Savage MJ, James R, Magistro D, et al. Mental health and movement behaviour during the COVID-19 pandemic in UK university students: prospective cohort study. *Ment Health Phys. Act*. 2020;19:100357. doi:10.1016/j.mhpa.2020.100357.
49. Wilson OWA, Holland KE, Elliott LD, Duffey M, Bopp M. The impact of the COVID-19 pandemic on US college students' physical activity and mental health. *J Phys Act Health*. 2021;18(3):272–278. doi:10.1123/jpah.2020-0325.
50. Zhang J, Gu X, Zhang X, Lee J, Chang M, Zhang T. Longitudinal effects of motivation and physical activity on depressive symptoms among college students. *Int J Environ Res Public Health*. 2021;18(10):5121.
51. Bandiera FC, Loukas A, Li X, Wilkinson AV, Perry CL. Depressive symptoms predict current e-cigarette use among college students in texas. *Nicotine Tob Res*. 2017;19(9):1102–1106. doi:10.1093/ntr/ntx014.
52. Marsden DG, Loukas A, Chen B, Perry CL, Wilkinson AV. Associations between frequency of cigarette and alternative tobacco product use and depressive symptoms: a longitudinal study of young adults. *Addict Behav*. 2019;99:106078. doi:10.1016/j.addbeh.2019.106078.

53. Saules KK, Pomerleau CS, Snedecor SM, et al. Relationship of onset of cigarette smoking during college to alcohol use, dieting concerns, and depressed mood: results from the Young Women's Health Survey. *Addict Behav*. 2004;29(5):893–899. doi:10.1016/j.addbeh.2004.02.015.
54. Ren Z, Cao J, Cheng P, et al. Association between breakfast consumption and depressive symptoms among Chinese college students: a cross-sectional and prospective cohort study. *IJERPH*. 2020;17(5):1571. doi:10.3390/ijerph17051571.
55. Dinis J, Bragança M. Quality of sleep and depression in college students: a systematic review. *Sleep Sci*. 2018;11(4):290–301. doi:10.5935/1984-0063.20180045.
56. Gardani M, Bradford DRR, Russell K, et al. A systematic review and meta-analysis of poor sleep, insomnia symptoms and stress in undergraduate students. *Sleep Med Rev*. 2022;61:101565. doi:10.1016/j.smrv.2021.101565.
57. Marquez DX, Aguiñaga S, Vásquez PM, et al. A systematic review of physical activity and quality of life and well-being. *Transl Behav Med*. 2020;10(5):1098–1109. doi:10.1093/tbm/ibz198.
58. Buysse DJ. Sleep health: can we define it? Does it matter? *Sleep (New York, NY)*. 2014;37(1):9–17. doi:10.5665/sleep.3298.
59. Visontay R, Sunderland M, Slade T, Wilson J, Mewton L. Are there non-linear relationships between alcohol consumption and long-term health?: A systematic review of observational studies employing approaches to improve causal inference. *BMC Med Res Methodol*. 2022;22(1):16. doi:10.1186/s12874-021-01486-5.
60. Kwan M, Arbour-Nicitopoulos KP, Duku E, Faulkner G. Patterns of multiple health risk-behaviours in university students and their association with mental health: application of latent class analysis. *Health Promot Chronic Dis Prev Can*. 2016;36(8):163–170. doi:10.24095/hpcdp.36.8.03.
61. Ye Y, Wang P, Qu G, Yuan S, Phongsavan P, He Q. Associations between multiple health risk behaviors and mental health among Chinese college students. *Psychol Health Med*. 2016;21(3):377–385. doi:10.1080/13548506.2015.1070955.
62. Jao N, Robinson L, Kelly P, Ciecierski C, Hitsman B. Unhealthy behavior clustering and mental health status in United States college students. *J Am Coll Health*. 2019;67(8):790–800. doi:10.1080/07448481.2018.1515744.
63. Hutchesson M, Duncan M, Oftedal S, et al. Latent class analysis of multiple health risk behaviors among Australian university students and associations with psychological distress. *Nutrients* 2021;13(2):425. doi:10.3390/nu13020425.
64. Batacan RB, Duncan MJ, Dalbo VJ, Tucker PS, Fenning AS. Effects of light intensity activity on CVD risk factors: a systematic review of intervention studies. *Biomed Res Int*. 2015;2015:596367. doi:10.1155/2015/596367.
65. Batacan RB, Duncan MJ, Dalbo VJ, Tucker PS, Fenning AS. Effects of high-intensity interval training on cardiometabolic health: a systematic review and meta-analysis of intervention studies. *Br J Sports Med*. 2017;51(6):494–503. doi:10.1136/bjsports-2015-095841.