The Dietary Habits, Physical Activity and Mental Wellbeing of University Students' During the Covid-19 Lockdown in England.

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Impact of COVID-19

The Covid-19 pandemic has influenced the direction of this thesis entirely. Initially, I had thoroughly planned- and obtained ethical approval, to conduct two studies: a test-retest reliability study of the DEXA scanner at Essex University, and a correlates of body composition in students experimental study. Each study would have built upon two limited topics in the current research base, with the goal to publish both studies. I spent the first 3 months building a research proposal that would ultimately not be used come January, when the decisions were made to prevent face-to-face testing.

To mitigate this, I formulated and sought ethical approval for two new studies that would abide the social distancing rules: a review study, and a questionnaire-based experimental study. The studies herein encompass the key ideas of the hypothetical correlates of body composition study, that is, the health behaviours of university students.

Obtaining volunteers was a challenge during the pandemic, as I couldn't physically talk to would-be participants about the study, and instead had to utilise mass emails for advertisement. As such, the sample size in the experimental study was significantly smaller than similar studies in the literature and encompasses a key limitation of the work. Consequently, the present thesis contains a framework of ideas that can be applied to future studies to address this gap in the literature with a more suitably populated confirmatory study.

Acknowledgements

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Thesis Abstract

University students experience a unique combination of factors that can influence health-related behaviours and mental wellbeing, including greater autonomy, reduced budgets, and academic pressure. Therefore, students typically have sub-optimal diets and are of higher risk to adverse mental wellbeing. A scoping review identified considerable inter-study methodological heterogeneity in the assessment of dietary intake and mental wellbeing, and limited applications of a global mental wellbeing score in studies of students. However, most studies reported a positive association between better mental wellbeing and healthier dietary intake. Dietary intake, eating behaviours, physical activity and mental wellbeing are yet to be investigated simultaneously in a student population. Subsequently, an experimental study was designed to assess these behaviours and mental wellbeing using a global mental wellbeing score in students studying at a UK university and contextualise the findings to the Covid-19 pandemic (n = 59). Students reported poor diet quality, good mental wellbeing, and sufficient physical activity levels. Poor mental wellbeing was related to poor eating behaviours. This relationship was not moderated by the perceived changes to behaviours and mental wellbeing since the Covid-19 lockdown. Dietary intake and physical activity were not associated with mental wellbeing to a statistically significant level using the measures employed. This study was the first to assess these variables simultaneously in university students. This study should inform a larger, confirmatory future study to provide more powerful evidence of student health behaviours and mental wellbeing. Future works should outline if the relationship between poor eating behaviours and mental wellbeing is exclusive to students, or generalisable to all young adults. This thesis indicates a limited research base examining student health-related behaviours and mental wellbeing, and eating behaviours, but not dietary intake, are of more concern to the mental wellbeing of students.

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Abbreviations

ABS	Affect Balance Scale
AEB Score	Addiction-Like Eating Behaviour Scale Score
AEBS	Addiction-Like Eating Behaviour Scale
DHQ3	Dietary Health Questionnaire III
DI	Dietary Intake
FD-24	24-hour recall food diary
FD-7	7-day recall food diary
FFQ	Food Frequency Questionnaire
g	Grams
g.kg.bm-1	Grams per kilogram of body mass
GI	Glycaemic Index
HEI-2015	Healthy Eating Index-2015
IPAQ	International Physical Activity Questionnaire
Kcal.kg.bm-1	Kilocalories per kilogram of body mass
MED	Mediterranean Diet
MEQ	Mindful Eating Questionnaire
MET-min	Metabolic Equivalent minutes
MET-min.d-1	Metabolic Equivalent minutes per day
MET-min.wk-1	Metabolic Equivalent minutes per week
METs	Metabolic Equivalents
MW	Mental Wellbeing
NA	Negative Affect
PA	Physical Activity
PANAS	Positive and Negative Affect Scale

PG	Postgraduate
PHBCh	Perceived health-related behaviour change
PMWCh	Perceived mental wellbeing change
PRISMA-ScR	Preferred Reporting Items for Systematic Reviews and Meta Analyses – Protocol Extension for Scoping Reviews
QoL-15	15-item Quality of Life Scale
REAP-S	Rapid Eating and Activity Assessment (short form)
SD	Standard deviation
SF-12	12-item Short Form Health Survey
SWEMWBS	Warwick-Edinburgh Mental Wellbeing Scale (short form)
SWLS-5	5-item Satisfaction with Life Scale
UG	Undergraduate
WEMWBS	Warwick-Edinburgh Mental Wellbeing Scale
WHO	World Health Organisation
WHO-5 WBI	5-item World Health Organisation Wellbeing Index

1.0 Thesis Overview

1.1 Thesis Justification

The prevalence of chronic diseases has increased amongst younger generations, and 37% of young adults in England are either overweight or obese as of 2021(1,2). Contrasting positions are present in the current literature, where generally a higher level of education is associated with a decreased prevalence of overweightness and obesity, except for within one large-scale study from the US(3). Within this study, a greater instance of overweightness and obesity was reported in young adults that possessed a degree compared to their age-matched peers that did not attend university(4). The period of young adulthood is an important time for healthy lifestyle habits to be formed(5,6). Therefore, poor lifestyles developed at university can have lifetime implications due to their contribution to obesity and non-communicable diseases. The ‘university years’ occur during a crucial moment in the life-stages of young adults to create habits that will have positive or negative repercussions to their health in the short and long-term.

University students experience a unique combination of factors that can influence their health-related behaviours and mental wellbeing. A key health-related behaviour is dietary intake, which refers to the daily eating patterns of an individual, including specific food and calories consumed. Diet quality refers to the specific daily food and calories consumed of an individual and outlines how healthy or unhealthy the diet is as a result. Mental wellbeing comprises fulfilment, functioning and purpose of life (eudaimonic wellbeing) and happiness and life satisfaction (hedonic wellbeing)(7). It is therefore a multi-dimensional measure of positive mental health(8).The transition to life at university is associated with sudden greater autonomy, reduced budget, exposure to new social groups, and academic pressure(9,10). High fast food and confectionary intake, as well as low consumption of fruit and vegetables

and endemic binge drinking has been reported in the population(11,12). Reports of a reduction in diet quality in students during their time at university is common in longitudinal research(13,14). Moreover, students with poor dietary intakes are more likely to partake in other lifestyle risk factors such as smoking and low physical activity(9). Students also face a greater prevalence of mental illness compared to their peers not attending university, with contributing factors including: high workload, strict deadlines, and the desire to obtain a 'good' degree, culminating as significant academic stressors in the pursuit of a professional career(10,15). Whilst entering higher education can be symbolised as the start of an exciting 'journey', many students struggle with the transition into university, and subsequently develop components of poor mental wellbeing(10,15). Students are also at relatively higher risk of psychiatric disorders, with depression being listed as the most prevalent mental health problem affecting students worldwide(16).

The assessment of dietary intake can provide an evaluation of diet quality. Published research has revealed dietary intake affects mood and mental wellbeing, but the prevalence and magnitude of this relationship in a student population is unknown(17). An individual's dietary intake can directly affect mental wellbeing through microbiome- and immune-modifying, antioxidant and anti-inflammatory mechanisms(18). Moreover, dietary intake also influences endogenous hormones, neuropeptides, and neurotransmitters; each integral to stress and inflammation regulation and cognitive maintenance(19). This research area has focused on associations between dietary intake and clinical notions of mental health, from which researchers have inferred associative affects with subjective mental wellbeing, although mental wellbeing has not been directly assessed and investigated. As current research concludes students are a population at high-risk to having poor diet quality and understanding the link with aspects associated with mental wellbeing, it is poignant to understand how dietary intake and mental wellbeing are related in university students.

Systematic reviews have been published that assess the relationships between mental wellbeing and eating behaviours, and mental wellbeing and physical activity in student populations(20,21). However, no systematic or scoping reviews have been published as yet that aimed to synthesise the current literature which have assessed dietary intake and mental wellbeing in student populations.

Eating behaviour can be defined as a broad term encompassing the attitudes and psychosocial factors related to food choice, feeding practices, and eating-related problems such as eating disorders(22). Poor mental wellbeing can impact eating behaviour, for example, engaging in overeating and binge eating as a coping mechanism for feeling depressed, which can eventually equate to an unhealthy dietary intake of comforting foods high in calories, saturated fats and refined carbohydrates(23). Physical activity can be defined as any bodily movement produced by skeletal muscles that requires energy expenditure(24). Poorer mental health is associated with less physical activity in the general population, which suggests students with poor mental wellbeing might adopt more sedentary lifestyles(25). Moreover, it is widely accepted that the relationship between mental health and both eating behaviours and physical activity is bi-directional(26). That is, one's psychological state can affect what, and how much one eats, or exercises, and eating / exercise can affect one's mood and mental wellbeing(26). This bi-directional relationship outlines a complicated synergy between mental wellbeing and these health behaviours, and therefore understanding this relationship in university students is crucial to understanding the health of students in the UK post-matriculation and post-graduation.

Published research is yet to simultaneously investigate student dietary intake and eating behaviours, physical activity, and mental wellbeing altogether in students. The most current research of dietary intake, physical activity and mental wellbeing in UK university students is derived from a 2017 study of 468 students at Middlesex University London(27). 60% of

respondents were insufficiently physically active, 47% had an unbalanced diet, and 30% had low mental wellbeing(27). A 2018 study reported unhealthy dietary patterns were associated with lifestyle risk factors including smoking and low physical activity in UK students(9). The absence of new literature in this area is likely partly due to the topical demand for emerging studies focused on the Covid-19 pandemic. A study conducted in 2020 reported mental wellbeing and physical activity decreased during the first 5 weeks of 'lockdown' in students at an East Midlands University(28). Meanwhile, time spent sedentary and perceived stress increased in the cohort during the lockdown(28). As yet, dietary intake has not been investigated in university students in the UK during the lockdown. However, a 2021 study revealed macro- and micronutrient and caloric intakes decreased and alcohol intake increased during the pandemic in Canadian students(29). Further, physical activity level decreased, and time spent sedentary increased during the pandemic, in-line with findings of UK university students(28,29). Robinson et al. investigated the perceived changes of health-related behaviours during the Covid-19 lockdown in a general sample of UK adults(30). The majority of participants reported perceived negative changes in eating and physical activity behaviour (e.g., 56% reported more frequent snacking), and a decline in mental wellbeing because of the lockdown was predictive of more overeating and lower physical activity(30).

Evaluating student health-related behaviours is important to keep up to date on the habits and lifestyles that will inform the long-term physical and mental health of future adult generations. However, it is equally important to contextualise these behaviours within the unprecedented social context of the time in which data were collected, during the latter-period of the Covid-19 lockdown in the UK.

1.2 Thesis Aims

This thesis aims to understand the current state of health-related behaviours and mental wellbeing of university students in the UK. In order for this to be achieved, two studies were conducted:

Study 1: Systematic scoping literature review of the association between dietary intake and mental wellbeing in university students.

Specific study aims:

1. Investigate the literature on dietary intake and what associations exist with mental wellbeing in student populations.
2. Explore the methods used to assess dietary intake and mental wellbeing amongst student populations in the eligible literature.

Study 2: Assessment of dietary intake and eating behaviour, physical activity, and mental wellbeing of university students during the Covid-19 lockdown in the UK.

Specific study aims:

1. Explore and describe the dietary intake and eating behaviours, physical activity, and mental wellbeing of students currently attending a university in the UK.
2. Assess the relationships between dietary intake and eating behaviours, physical activity, and mental wellbeing in the cohort.
3. Investigate and account for the perceived Covid-19 lockdown effect on dietary intake and eating behaviours, physical activity, and mental wellbeing to add situational context to the findings.

1.3 Thesis Outline

The thesis overview (Chapter 1) and the introduction to the systematic scoping review (Chapter 2) provide justification for research in this topic area. The main body in Chapter 2 identifies and describes the current research on dietary intake and the associations that exist with mental wellbeing in university students. The systematic scoping review forms the rationale for the experimental study (Chapter 3). In Chapter 3, the experimental study is presented and designed to: (i) explore and describe the health-related behaviours of current students at a university in the UK; (ii) Assess relationships between the health-related behaviours; and (iii) investigate the perceived effect of Covid-19 lockdown on the health-related behaviours to add context to findings. The thesis is concluded in Chapter 4 where the thesis findings are summarised and recommendations for future research is presented.

2.0 Systematic Scoping Review

The Association between Dietary Intake and Mental Wellbeing in University Students: A Scoping Review

2.1 Introduction

University students represent a population of young adults with unique factors influencing dietary intake: the transition to life at university is associated with greater autonomy over the type, portion and frequency of food consumption, reduced food budgets, and exposure to new social groups and food cultures(9). Dietary intake refers to the daily eating patterns of an individual, including specific food and calories consumed. Diet quality refers to the specific daily food and calories consumed of an individual and outlines how healthy or unhealthy the diet is as a result. Diet quality can be deduced from the assessment of dietary intake. Poor diet quality is one of the six top health risk behaviours of university students, with the nutritional risks to the population alarmingly high(31,32). The diet quality of university students has received significant attention, with reports of high fast food and confectionary intakes, as well as low consumption of fruit and vegetables and endemic binge drinking in the population(11,12). Moreover, the first year of university is consistently identified as a period associated with weight gain in UK students and high rates of body dissatisfaction have been reported, particularly amongst female students(33–35). Dysfunctional relationships with food and poor diet behaviours impact on diet adequacy and can potentially create conflict for young adults as they develop relationships with new peer groups(36,37).

During the transition from youth to adulthood, young adults often suffer from mental health issues and a lapse in mental wellbeing. Whilst entering higher education can mark the start of an exciting new life stage or ‘journey’, many young adults struggle with the transition from school or college into university(10). It has been suggested that social media and the system

of student finance with fear of large debt accumulation contribute to the main pressures upon a student at university(10). Other contributing factors include the desire to obtain a ‘good degree’ and to set oneself apart from other graduates to find employment in the highly competitive environment today posed by the recent expansion of the university sector(10,38). Mental wellbeing comprises fulfilment, functioning and purpose of life (eudaimonic wellbeing) and happiness and life satisfaction (hedonic wellbeing)(7). It is therefore a multi-dimensional measure positive mental health, outlining more than an absence of mental distress, in which those better mental wellbeing are able to cope well with everyday stressors, and flourish mentally(8). Studies have primarily focused on the prevalence of poor mental health in the population, based upon clinical notions of wellbeing as opposed to subjective mental wellbeing. For instance, a survey of 2,279 graduate students from the US reported a high prevalence of both anxiety and depression in the population. Upon comparing to an age-matched general population sample, the authors suggested a mental health crisis was on the rise in the graduate student population(39). Interestingly, undergraduate students in the US have reported higher rates of poor mental health than graduate students, which suggests the crisis could also bare true to university students irrelevant of their stage of education(40).

Dietary intake has been shown to affect mood and mental wellbeing, but the magnitude of this relationship in a university student population is unknown. One’s dietary intake can alter microbiome- and immune-modifying, antioxidant and anti-inflammatory mechanisms and consequently influence mental wellbeing(17). Further, dietary intake influences endogenous hormones, neurotransmitters and neuropeptides; all of which are instrumental to stress management and cognitive maintenance(18). However, it is important to consider that relationships between mental wellbeing and dietary intake are likely to be bi-directional.

While dietary intake may influence mental wellbeing, mental wellbeing may also influence dietary intake. For example, a lack of motivation to purchase healthier foods, preferential selection of highly-palatable foods that increase mood such as sweets or refined carbohydrates, and altered physical activity levels, are all factors that may cause a person's diet to change with a decrease in mental wellbeing(41).

At present, published research in this area has focussed on associations between dietary intake and clinical derivatives of mental health, allowing researchers to infer associative affects with subjective mental wellbeing, despite the latter not being directly assessed. With published research presenting university students as a population at greater risk of poor diet quality, and diet quality widely accepted as an influential factor to one's mental wellbeing, it is crucial to understand the degree to which mental wellbeing and dietary intake are related in university students.

The association between dietary intake and mental wellbeing in university students is a research area in its infancy. Initially in this study, a research question was derived to assess the association between dietary intake and mental wellbeing in the form of a PRISMA-guided systematic review. The current research, or lack thereof, is not suitable to evaluate the association of dietary intake and mental wellbeing in university students in a systematic review format. The scarcity of literature, and the absence of a scoping review in the area informed the decision to adopt a systematic scoping review approach for this study. Moreover, this scoping review- as first of its kind, lies at the purely descriptive end of the scoping review continuum. Therefore, the research aims and subsequent discussion of the current research base within this scoping review are descriptive in nature, to provide an introductory overview of a limited topic area.

2.2 **Research Aims**

This systematic scoping review aims to investigate the literature on dietary intake and what associations exist with mental wellbeing among university students. Secondarily, this review aims to explore the methods used to assess dietary intake and mental wellbeing amongst university student populations within eligible studies included in the review. The review will conclude the current available evidence and methodological considerations, which will then inform future research into the mental wellbeing of young adults at university and the role of dietary intake.

2.3 **Methods**

Protocol

This study follows the scoping review protocol, which is the most suitable knowledge synthesis technique for systematically identifying the main sources and types of available evidence and outlining key concepts underpinning a research area(42). The scoping review protocol used in this study was drafted using the Preferred Reporting Items for Systematic Reviews and Meta-analysis Protocols Extension for Scoping Reviews (PRISMA-ScR), available in the PRISMA scoping reviews position statement published in 2018(43). See Appendix A. for the completed PRISMA-ScR checklist.

Eligibility Criteria

This scoping review was conducted in spring 2020, and included data from studies published that investigated dietary intake and one or more key components of mental wellbeing in a university student population. Studies were included if they met the following criteria: 1) published in a peer-reviewed journal in English; 2) included undergraduate and/or postgraduate university students; 3) investigated the association between dietary intake and at least one eligible component of mental wellbeing. University students were defined as students regardless of their mode of enrolment (e.g., full-time or part-time, on-campus or online). Studies with populations other than undergraduate or postgraduate students were excluded (e.g., high school or vocational students, non-student adults etc.).

Articles were included if they used a measurement of dietary intake and reported food group and/or frequency of food consumption. Articles that used an eligible tool of dietary intake measurement were included if they measured an appropriate aspect of mental wellbeing i.e. a psychological construct assessed in the context of mental wellbeing. Articles that

assessed stress, psychological distress, depression, anxiety, or any other clinical derivatives of mental health were excluded. Valid analytical methods of association between dietary intake and mental wellbeing in quantitative studies included correlations, regression estimates, differences between groups and odds ratios. No unpublished (grey) literature, or published dissertations / theses were included in the review. The reference lists of all included articles and other relevant reviews were screened post-hoc to search for additional papers.

Information Sources

A literature search was conducted in February 2021 in the following databases: SCOPUS, Google Scholar, PubMed and Crossref. The search was supplemented with an examination of the references of included articles in the review to ensure a comprehensive data collection.

Search

Search terms were derived using appropriate synonyms and iterations for ‘dietary intake’, ‘mental wellbeing’ and ‘university students’. Terms were chosen to broaden the search, including utilising terms more commonly used in the United States, due to the small size of the research base. The search utilised Boolean operators of ‘AND’ and ‘OR’ as follows: ‘dietary intake’ OR ‘nutritional intake’ OR ‘dietary composition’ OR ‘dietary consumption’ AND ‘mental wellbeing’ OR ‘mental well-being’ OR ‘psychological wellbeing’ OR ‘psychological well-being’ AND ‘university students’ OR ‘college students’ OR ‘undergraduate students’ OR ‘undergrad students’ OR ‘collegiate students’ OR ‘students at

university'. This combination of search terms was utilised in each of the four databases accessed.

Selection of sources of evidence

Duplicates were removed, followed by irrelevant titles. The abstracts of the remaining articles were reviewed, and potential articles were considered based on the inclusion and exclusion criteria outlined above. The studies which assessed dietary intake and a component of mental wellbeing were read and analysed in full text. The database search and article screening process resulted in 8 articles being included in this review, as presented in **Figure 1**.

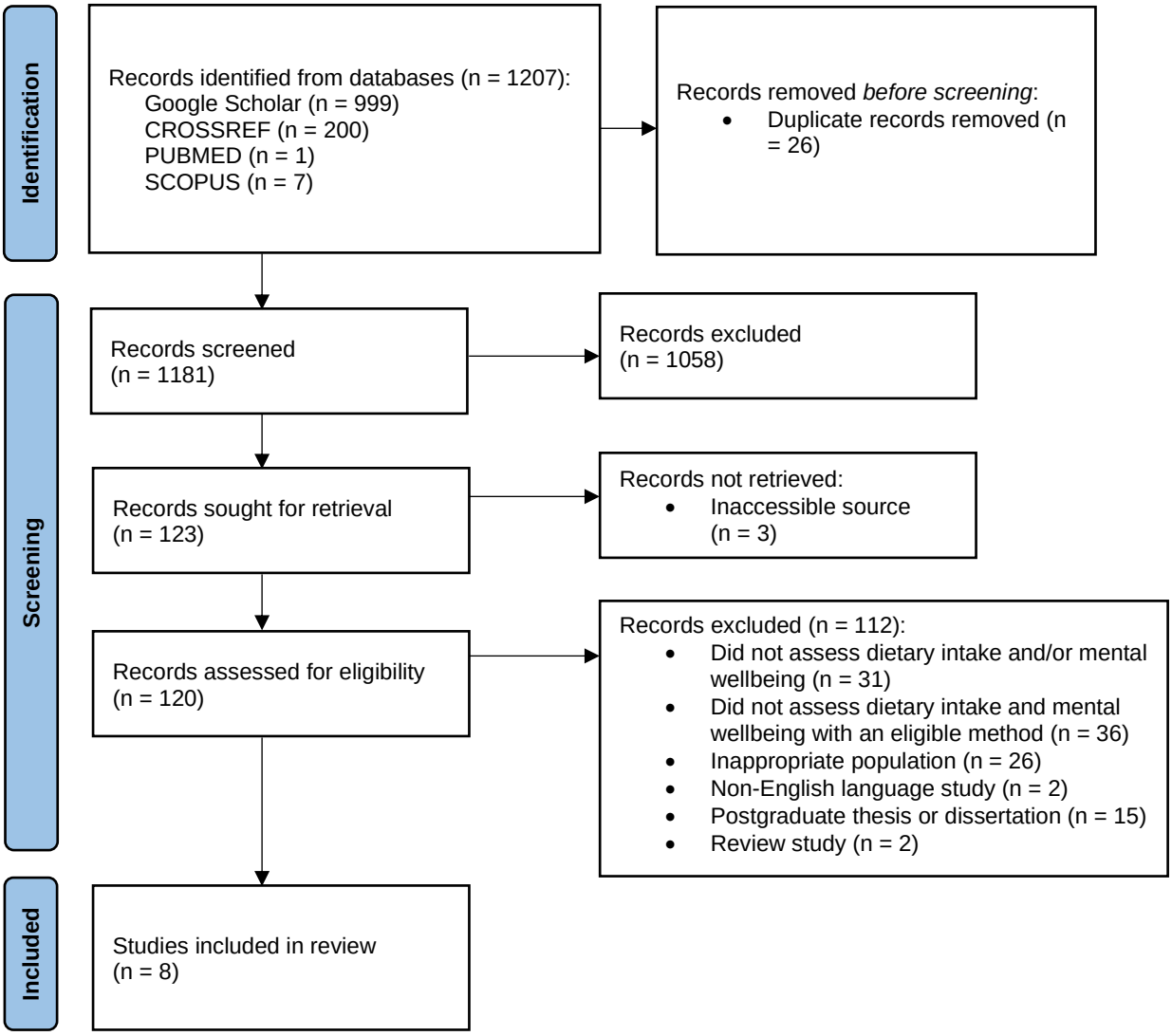

Figure 1. PRISMA Flow Chart Summary of the Article Selection Process.

Data Items

For each article included in the review after screening, the following data items are extracted:

- *Article characteristics:* Including year of publication, country of origin, period of data collection, research aims and study design.
- *Population characteristics:* Including number of participants and participant stage of study (undergraduate and/or postgraduate).
- *Methodological characteristics:* Including controls used, dietary intake measure used, psychological component assessed, and corresponding measure used.
- *Key findings:* Including main findings and conclusions reported.

Synthesis of Results

Included articles are grouped by the psychological component that was assessed, and the population, study design, measures used, and broader findings were summarised for each group. Evidence is presented in narrative and tabulated format (**Tables 1-4**) based upon the works of Arksey and O'Malley; specifically, the approach they developed for reporting evidence in scoping reviews(42).

2.4 **Results**

Selection of sources of evidence

A total of 1207 articles were initially identified (999 from Google Scholar; 200 from Crossref; 1 from PubMed and 7 from SCOPUS). After screening for duplicates and irrelevant titles 758 articles were excluded, and 326 abstracts were sought for retrieval. After screening abstracts, 203 articles were excluded: 21 abstracts were inaccessible (not available online, and no response from contacted authors); 132 reported inappropriate outcome variables; 70 investigated an inappropriate population; 66 were an inappropriate source (not published in a peer-reviewed journal); 32 were review studies and 5 were not available in English. Thus, after the initial screening 123 full-text articles were sought for retrieval, three of which were inaccessible sources (not available online, and no response from contacted authors), resulting in 120 full-text articles retrieved for secondary screening. During the second screening 112 papers were excluded: 31 did not assess either or both dietary intake and mental wellbeing, 31 did not assess dietary intake or mental wellbeing with an appropriate tool, 26 investigated an inappropriate population, 15 were postgraduate theses or dissertations, 2 were reviews and 2 were non-English language studies. Subsequently, 8 full papers were deemed eligible for the current review. The source selection process is shown in **Figure 1**.

Characteristics of sources of evidence

All studies included in this review used self-report data from university student populations in developed countries. One included study used an exploratory design(44), and one longitudinal(45), two micro-longitudinal(46,47), one cross sectional(48), and one used a mixed methods approach(27). Only the quantitative measures reported by Aceijas et al. in their mixed methods study will be presented and discussed(27). Five of the included studies

were correlational in nature(46–50). Locations included Italy(45), the United States(48–50), New Zealand(46,47), Spain(44) and the United Kingdom(27). Four studies investigated both undergraduate and postgraduate student populations(44–46,50) and four assessed undergraduate students only(27,47–49). Two studies included controls for race and gender(48,50), the latter also controlled for age. One study controlled for weekend effects(46), and one controlled for current day and previous day effects(47), while the other studies did not include any controls(27,44,45,49). Five studies utilised food frequency questionnaires(27,46–49), Two used 24-hour recall food diaries(45,50) and one used a 7-day recall food diary to assess dietary intake(44).

Included articles were grouped into one or more of three research themes that were derived from similarities in the mental wellbeing components assessed for analysis and discussion purposes (**Tables 1-4**). Some articles assessed more than one component of mental wellbeing and were consequently grouped into multiple research themes. Two articles investigated quality of life(45,50), two investigated daily life satisfaction(48,49), and one assessed eudaemonic wellbeing(46), and were subsequently grouped into the ‘quality of life’ research theme (**Table 2**). Four studies investigated either or both positive and negative affect(45,47,49,50), and were placed into the ‘affect’ group (**Table 3**). Two studies assessed mental wellbeing as a global score(27,44), and were grouped as ‘wellbeing’ (**Table 4**).

Results of individual sources of evidence

Analysis of each source identified the data considered for population, research aims, dietary intake and mental wellbeing component and measure used and main findings; a summary for each research theme is presented in **Tables 2-4.**

Table 1. Descriptive characteristics of the articles included in the systematic scoping review. (n=8)

Study	Country	Period of Data Collection	N	% of sample Female	Population graduate level	Study Design	Controls
Amatori et al (51)	Italy	April 2020	176	48%	UG and PG	Longitudinal observational	None
Williams et al (48)	USA	Autumn 2017	215	92%	UG	Cross-sectional correlational	Sex and ethnicity
Conner et al (52)	New Zealand	2013	405	67%	UG and PG	Micro-longitudinal, correlational	Weekend effects
Jackson et al (53)	USA	Spring 2017	73	81%	UG	Correlational	None
Cheng et al (50)	USA	Spring 2009 and Spring 2010	599	72%	UG and PG	Correlational	Age, Sex and ethnicity

White et al (47)	New Zealand	During termtime between 2008 and 2009	281	55%	UG	Microlongitudinal, correlational	Current day and previous day effects
Ugartemendia et al (44)	Spain	During termtime between 2016 and 2019	117	56%	UG and PG	Exploratory, small-scale	None
Aceijas et al (54)	UK	April 2015	468	70%	UG	Mixed methods (cross-sectional, focus group, interviews)	None

Table 2. Summary of main findings from the 'Quality of life' research theme group.

Study	N (% Female)	Population graduate level	Research Aims	Dietary Intake Measure	MW component assessed (measure)	Main findings
Amatori et al. (45)	176 (48%)	UG and PG	Investigate the effects of mood states and exercise on nutritional choices during the period of COVID-19 forced home-isolation.	FD-24 *21 days	Quality of life (SF-12)	↑ Quality of life was associated with ↓ intake of cereals, legumes, & low-fat meat. (t = -2.88, *p* = 0.004).
Cheng et al. (50)	599 (72%)	UG and PG	Examine personality traits, three health behaviours (substance use, physical activity, and healthy diet), and three dimensions of subjective wellbeing	FD-24 *7 days	Quality of life (QoL-15)	↑ Quality of life was associated with ↑ intake of fruit (*r* = .13, *p* < .01) and vegetables (r = .15, *p* < .01) independently.

			(positive affect, health status, quality of life).			
Williams et al. (48)	215 (92%)	UG	Examine associations between satisfaction with daily life, self-weight perception, body mass index, and intake of 18 commonly consumed foods and beverages over the previous 30 days.	FFQ (Subscale of BUCS: Live Well Survey) *30 days	Daily life satisfaction (7-item subscale of BUCS: Live well Survey)	↑ Life satisfaction was associated with ↓ energy drink (B = .20, SE = .07, β = .19, *p* = .006) & alcohol intake (B = .21, SE = .07, β = .20, *p* = .003).
Jackson et al. (49)	73 (81%)	UG	Explore subjective vitality as a potential mediator between components of subjective wellbeing and three dietary variables- plant-based/natural dietary intake, animal-	FFQ (Dietary Screener Questionnaire) *30 days	Daily life satisfaction (SWLS-5)	No association between daily life satisfaction and dietary intake.

			based/processed dietary intake and daily sugar intake.			
Conner et al. (46)	405 (67%)	UG and PG	Investigation of the association between fruit and vegetable consumption and eudaemonic well-being and eudaemonic behaviours.	FFQ (4-item subscale of New Zealand National Nutrition Survey 1997) *13 days	Daily eudemonic wellbeing (Adapted Flourishing Scale)	↑ Eudaemonic wellbeing was associated with ↑ intake of fruit (r = .185, p < .001) and vegetables (r = .200, p <.001) *independently*.

Key: MW, Mental wellbeing; UG, Undergraduate; PG, Postgraduate; FD-24, 24-hour recall food diary; SF-12, 12-item Short Form Health Survey; QoL-15, 15-item Quality of Life Scale; FFQ, Food Frequency Questionnaire; SWLS-5, 5-item Satisfaction with Life Scale.

Table 3. Summary of main findings from the 'Affect' research theme group.

Study	N (% Female)	Population graduate level	Research Aims	Dietary Intake Measure	MW component assessed (measure)	Main findings
Amatori et al. (45)	176 (48%)	UG and PG	Investigate the effects of mood states and exercise on nutritional choices during the period of COVID-19 forced home-isolation.	FD-24 *21 days	Positive and negative affect (PANAS)	Higher positive affect (PANAS Positive) was associated with ↑ intake of cereals, legumes, and low-fat meats (t = 3.01; *p* = 0.003). Higher Negative affect (PANAS Negative) was associated with ↑ intake of high fat meat, milk derivatives and fish (t = 2.57; *p* = 0.010).

Cheng et al. (50)	599 (72%)	UG and PG	Examine personality traits, three health behaviours (substance use, physical activity, and healthy diet), and three dimensions of subjective wellbeing (positive affect, health status, quality of life).	FD-24 *7 days	Positive affect (ABS)	Higher positive affect was associated with ↑ intake of fruit (r = .14, p <.01) and vegetables (r = .09, p < .05) independently.
Jackson et al. (49)	73 (81%)	UG	Explore subjective vitality as a potential mediator between components of subjective wellbeing and three dietary variables- plant-based/natural dietary intake, animal-based/processed dietary	FFQ (Dietary Screener Questionnaire) *30 days	Positive and Negative affect (PANAS)	Higher negative affect was associated with adhering to an animal-based food dietary pattern (r = .388, p = .001)

			intake and daily sugar intake.			
White et al. (47)	281 (55%)	UG	Investigate bidirectional associations between positive and negative affect and specific food consumption.	FFQ (4-item subscale of New Zealand National Nutrition Survey 1997) *21 days	Positive and negative affect (bespoke 18-item questionnaire)	Greater positive affect was associated with ↑ intake of fruit (G_{10} = 0.112, p = .002) and vegetables (G_{10} = 0.147, p <.001) independently.

Key: MW, Mental wellbeing; UG, Undergraduate; PG, Postgraduate; FD-24, 24-hour recall food diary; PANAS, Positive and Negative Affect Schedule; ABS, Affect Balance Scale; FFQ, Food Frequency Questionnaire.

Table 4. Summary of main findings from the 'Mental wellbeing' research theme group.

Study	N (% Female)	Population graduate level	Research Aims	Dietary Intake Measure	MW component assessed (measure)	Main findings
Ugartemendia et al. (44)	117 (56%)	UG and PG	Identify which nutrients can modulate mood and social cognition.	FD-7	MW (WHO-5 WBI)	Subjective wellbeing predicted by carbohydrate intake ($p < 0.05$, $R^2 = 0.054$, $f^2 = 0.012$; power: *0.726*). Greater subjective wellbeing was associated with ↑ intake of insoluble fibre ($p < .01$, $R^2 = 0.64$, $f^2 = 0.068$; power *0.80).*
Aceijas et al. (27)	468 (70%)	UG	Investigate health-related lifestyles in main areas directly	FFQ (REAP-S)	MW (SWEMWBS)	An unbalanced diet almost doubled the risk of low mental wellbeing. (OR =

	related to non-communicable diseases among UK undergraduate university students.	1.7; 95% CI = 1.1–2.7; *p* = .03) Low mental wellbeing scores were associated with a greater likelihood of having a problematic diet in males (OR = 3.2, 95% CI = 1.4-7.4; *p* = .01).

Key: MW, Mental wellbeing; UG, Undergraduate; PG, Postgraduate; FD-7, 7-day recall food diary; WHO-5 WBI, World Health Organisation 5-item Wellbeing Index; FFQ, Food Frequency Questionnaire; REAP-S, Rapid Eating and Activity Assessment short-form; SWEMWBS, Warwick-Edinburgh Mental Wellbeing Scale Short Version.

Synthesis of results

Food frequency questionnaire (FFQ) was the most common dietary intake measure and was used in 5 of the included studies(27,46–49). A 24-hour recall food diary was used in two studies, and a 7-day recall food diary was used in one study(44,45,50). Four studies assessed food groups (46,48–50), two assessed macro- and micronutrients (45,55), one assessed diet quality (54) and one assessed dietary patterns (27).

The heterogeneous nature of the evidence is further outlined by the frequency of combinations of dietary intake methodology and mental wellbeing component assessed for each included study, as presented in **Table 5.** There were two instances where FFQ was utilised and affect was measured, two with FFQ and life satisfaction, one with FFQ and global mental wellbeing and one with eudaemonic wellbeing. There were two instances of FD-24 utilised and affect was measured, and two with FD-24 and quality of life. There was one instance of DI measured with FD-7 and global mental wellbeing was assessed.

Table 5. Frequency of combinations of dietary intake measure and psychological variables assessed in included studies.

	Affect	Life satisfaction	Quality of life	Global Mental Wellbeing	Eudaimonic Wellbeing
FFQ	2	2		1	1
FD-24	2		2		
FD-7				1	

Key: FFQ, Food Frequency Questionnaire; FD-24, 24-hour recall food diary; FD-7, 7-day recall food diary.

All but one of the included articles (Amatori et al), reported a positive association between healthier dietary intakes and habits and a key component of mental wellbeing (**Tables 2-4**). Amatori et al reported better quality of life was associated with less consumption of cereals, legumes, and low-fat meats (45).

2.5 **Description**

This systematic scoping review aimed to investigate the literature on dietary intake and associations with mental wellbeing amongst university students. Further, this review aimed to explore the methods used in the assessment of dietary intake and mental wellbeing within included studies.

Quality of life

Five studies examined psychological components of mental wellbeing that were related to subjective quality of life. Quality of life and life satisfaction historically have been shown as indicators of mental wellbeing, and lifestyle behaviours have been shown to affect wellbeing perception, and quality of life(50,56). Two studies directly assessed quality of life with dedicated questionnaires(45,50). Two studies focussed on life satisfaction, assessed with different surveys, but both methods encompassed a domain of overall quality of life(48,49). One study assessed eudaemonic wellbeing, defined as the degree to which individuals perceive their lives as meaningful and purposeful(46). Sample sizes ranged from 73 to 599(49,50). The studies tended to have a large sample size, with 4 out of 5 reporting over 176 participants(45,46,48,50). Three of the studies included an undergraduate (UG) and postgraduate (PG) population(45,46,50) and two studies investigated only UG students(48,49), where on all but one occasion there were more female participants than male. Three studies assessed a specific student population enrolled in: nursing studies(48); pharmacy, biology or sport sciences(45); or psychological sciences programmes(49). The

other studies either assessed a generalised sample of students or did not otherwise note degree enrolment(46,50). Ages varied: for example, in one study of UG students the age range spanned from 18-50 years(48). One other study reported an age range of 18-35 years, while the other three studies all limited their population to between 18-25 years characteristic of ‘general’ university-attending individuals(45,46,49,50).

All studies used quantitative methods, and all but two controlled for at least one effect (e.g. race and gender)(45,49). Two studies employed a correlational design(49,50), one a cross-sectional correlational(48), one a micro-longitudinal correlational(46), and one a longitudinal, observational design(45). Three studies correlational by design utilised a FFQ to assess dietary intake (DI) (46,48,49). In the studies of Williams et al. and Jackson et al., an 18 and 26-item FFQ respectively was used to derive past month intakes of all major food groups predetermined from the outset of the studies, where both studies considered food groups high in fat and/or sugar as unhealthy (48,49). Conversely, Conner et al. utilised a 4-item FFQ to derive the previous 13 days intake of fruit, vegetables and chips (refined carbohydrates) only, also predetermined from study conception, considering fruit and vegetables as healthy, and chips unhealthy (46). The longitudinal observational study of Amatori et al. utilised a 24-hour recall food diary employed each day for 21 days to assess macro- and micronutrient quantities, identified from within the study(45). Amatori and colleagues then entered nutrients into factors including cereals & legumes, dry fruits & vegetable oils, high-fat meats & milk and derivatives, fresh fruit and vegetables, lean meats, fish, and wholegrain cereals, with all considered healthy except high-fat meats & milk and derivatives. Contrasting similarities can be drawn in the study of Cheng et al., which employed a 24-hour recall food diary over 7 days to record fruit and vegetable intake only, where total frequency of consumption was summed for the 7 days, as predetermined from

the outset of the study design, and greater quantities of fruit and vegetable consumption were considered healthy(50). Two studies that used a FFQ also assessed daily life satisfaction(48,49). Williams et al. used a 7-item subscale of a larger health-related survey entitled The BUCS: Live Well Survey(48). The questionnaire assessed a variety of domains which included overall quality of life, and produced a global satisfaction with daily life score once summed(48). Jackson and colleagues utilised the Satisfaction with Daily Life Scale, a 5-item measure of individuals' satisfaction with life, where responses were summed and produced a global satisfaction with life score(49). Williams et al. investigated associations with regression analyses and structural equation modelling paths analyses(48). Jackson at al investigated associations with bivariate correlation analysis(49).

Conner et al. used a FFQ and assessed eudaemonic wellbeing, measured using a daily adaptation of the Flourishing Scale(46). This was an 8-item measure to assess feelings of engagement, purpose and meaning in life, and responses were averaged across items each day for a measure of daily eudaemonic wellbeing(46). Cross-sectional relationships were tested using correlation coefficients and within-person relationships were tested with multilevel hierarchal linear models(46).

Both studies that utilised a 24-hour recall food diary assessed quality of life directly with a dedicated questionnaire(45,50). Amatori et al. used the 12-item Short Form Health Survey to measure health related quality of life. The survey encompassed eight domains split into physical-depending and mental-depending quality of life, where summed responses would produce a global quality of life score(45). Similarly, Cheng and colleagues used the 15-item Quality of Life Scale to assess a range of wellbeing domains that summed to a global quality of life score(50). Cheng et al. investigated associations using chi-square, bivariate correlations and hierarchal multivariate regression models with subjective wellbeing as the

dependent variable, and Amatori et al. used a multivariate generalised linear model with dietary factor groups as dependent variables(45,50).

Studies evaluated associations and relationships primarily between health behaviour related variables that included dietary habits and quality of life directly or a subsidiary of the mental wellbeing component. In the study of Amatori et al., reduced quality of life was associated with a higher consumption of cereals, legumes, and lean (low-fat) meats without considering other factors as controls. The authors found no other correlations between quality of life and the following components of diet: dry fruits and vegetable oils; high fat meat and milk derivatives; fresh fruit and vegetables; fish; and whole grain cereals(45). Alternatively, Cheng et al. reported greater quality of life was associated with greater fruit and vegetable consumption. The authors did not measure any other components of diet, but did control for age, sex and ethnicity(50). Supporting findings were found by Conner et al., who reported greater fruit and vegetable consumption was associated with better daily eudaemonic wellbeing. The study also found that the consumption of chips (refined carbohydrates and fried chip foods) was associated with eudaemonic wellbeing with a negative correlation. This suggests that greater consumption of fruit and vegetables was associated with greater daily eudaemonic wellbeing, and in contrast greater consumption of chips was associated with less eudaemonic wellbeing. The authors controlled for weekday versus weekend effects on dietary intake(46). For life satisfaction, greater consumption of potato chips was weakly associated with greater daily life satisfaction, as reported by Williams et al.(48). The authors also reported higher levels of daily life satisfaction were modestly associated with lower consumptions of energy drinks and alcohol, but did not report any other associations between components of diet and life satisfaction, when controlling for sex and ethnicity(48).

This is congruent to the findings of Jackson and colleagues, who also reported no associations between DI and life satisfaction(49).

Better quality of life was associated with healthy aspects of dietary intake in all studies that assessed quality of life but that of Amatori et al.

Affect

Four of the included studies examined either positive and/or negative affect. Positive affect considers the presence of pleasant emotions and negative affect considers the absence of pleasant emotions. Subsequently, affect has been shown to be an indicator of subjective mental wellbeing(56). Three studies assessed positive and negative affect and one study only assessed positive affect(45,47,49,50). The sample sizes in the affect studies ranged from 73 to 599(49,50). The studies tended to have a large sample size, with 3 out of 4 reporting over 176 participants(45,47,50). Two of the studies included an UG and PG population(45,50), and two investigated only UG students(47,49), where on all but one occasion there were more female than male participants. Two studies investigated specific student populations enrolled in: pharmacy, biology, or sport sciences(45), or psychological sciences programmes(49). One study reported most participants were psychology students (74%) but did not note the enrolment of other participants(47). The final study assessed a generalised sample of students(50). Participant ages were similar, one study reported an age range of 18-35 years, while the other three studies limited their population to between 18-25 years(45,47,49,50).

All studies used quantitative methods. Two of which included controls for at least one effect (e.g. gender, current day, and previous day effects), while the other two studies did not include any controls. Two studies employed a correlational design, one a micro-longitudinal correlational, and one a longitudinal, observational design. Two studies correlational by design utilised a FFQ to assess DI(47,49). In the micro-longitudinal study of White et al., a 5-item FFQ was used to derive previous day intakes of fruit, vegetables, sweet foods and cakes, and chips (refined carbohydrates and fries) over 21 days, and were predetermined from the investigation outset, with fruit and vegetable consumption considered healthy and

sweet foods, cakes and chips considered unhealthy(47). This contrasts to the study of Jackson et al., which used a 26-item FFQ to derive past month intakes of all food groups(49). The final two studies of Amatori et al. and Cheng et al. both employed 24-hour food diaries to assess DI(45,50). Intricacies between Amatori et al. and Cheng et al.'s respective DI measures have been discussed in greater detail in the previous section. Both studies that used a FFQ assessed both positive affect and negative affect(47,49). White et al. employed a bespoke 18-item questionnaire to capture a range of low- to high-intensity negative and positive states at the time of response, each day for 21 days(47). The authors averaged the positive affect and negative affect scores each day for an immediate snapshot of daily affect. Jackson et al. assessed positive affect and negative affect using the Positive and Negative Affect Schedule (PANAS), a 20-item questionnaire that asked participants to respond based upon their feelings over the previous 30 days, consistent with the timescale of the FFQ used(49). Items corresponding to positive and negative affect scales were separated and summed to provide total positive affect and negative affect scores. Jackson et al. investigated associations with bivariate correlation analysis(49), while White et al. investigated with hierarchal linear modelling analyses(47).

Similar to the study of Jackson et al., Amatori and colleagues utilised the PANAS assessment to measure positive affect and negative affect in their study and used a multivariate linear model with dietary factor groups as dependent variables to assess associations with DI, derived from 24-hour recall food diary(45). Cheng et al. assessed DI with the same measure, but only assessed positive affect(50). Cheng et al. used the Affect Balance Scale, a 10-item scale in which participants rate their positive and negative feelings. Negative affect items were reverse scored, and then scores for all 10 items were summed to derive a total affect score(50). Cheng et al. investigated associations using chi-square,

bivariate correlations, and hierarchal multivariate regression models with subjective wellbeing as the dependent variable(50).

Studies evaluated associations and relationships between dietary habits derived from DI, and positive affect and negative affect, or with positive affect individually. In the study of Amatori et al., it was reported greater positive affect was associated with more cereals and legumes, and lean (low-fat) meat consumption(45). The study also reported greater negative affect was associated with a lower intake of high fat meats and milk derivatives, as well as fish. No other associations were found in the study, and did not control for any external factors(45). In contrast, Jackson et al. reported students that possessed an animal based and processed food dietary pattern were associated with greater negative affect(49). Further, regression analysis found animal based and processed dietary patterns as a significant predictor of negative affect. No other associations were reported in the study, and did not control for any other influencing factors(49). Cheng et al. reported greater positive affect scores were associated with greater fruit and vegetable intake(50). The authors did not assess any other components of diet(50). This is congruent to the findings of White et al., who also found positive affect to be positively associated with both fruit and vegetable intake(47). Moreover, White and colleagues reported that when controlling for current-day fruit or vegetable consumption, on days when individuals consumed more fruit and/or vegetables, they reported experiencing greater positive affect the following day(47).

Each study that assessed affect reported a positive association between better mental wellbeing (either/or increased positive and decreased negative affect) and an inference of a healthy dietary intake, including: increased cereals, legumes and low-fat meats, and fruit and vegetable consumption, as well as reduced high fat meat, milk derivatives and fish consumption.

Mental Wellbeing

Two studies assessed mental wellbeing with a global score. The methods used by both studies provided a generalised, global indication of overall mental wellbeing. Sample sizes for these studies varied between Ugartemendia et al. (n = 177) and Aceijas (n = 468)(27,44). One study included an UG and PG student population(44) and the other study included UG students only(27), where on both occasions there were more female than male participants. One study assessed students of the Faculty of Science(44), and the other included a heterogenous population of students across a variety of faculties and schools(27). Ages were similar: for example, in one study of UG students the age ranged from 18-30 years(27). The other study of UG and PG students limited the population age to between 18-25 years(44).

One study used quantitative methods(44), and one used quantitative and qualitative methods(27). Neither study controlled for influencing factors. One study employed an exploratory, small-scale design(44), and the other used a cross-sectional mixed methods design(27). The study of Aceijas et al. employed the Rapid Eating and Activity Assessment for Patients-Short Form (REAP-S) FFQ to assess DI(27). The survey was used to assess dietary habits that included meal skipping, and the frequency of food group consumption over an average week, which were then categorised into unproblematic (healthy) and problematic (unhealthy) eating patterns for analysis (27). Ugartemendia et al. utilised a 7-

day recall food diary to assess DI, in which participants documented all ingested foods and beverages over a week, and software was used to analyse DI(44). Ugartemendia and colleagues considered complex carbohydrates, fibre, and monounsaturated fat as healthy in their study. Dietary measures for both studies were predetermined from investigation outset. Aceijas et al. assessed mental wellbeing using the Warwick-Edinburgh Mental Wellbeing Scale Short Version (SWEMWBS), a 7-item questionnaire that evaluates individual's mental wellbeing with a balance of feeling and functioning items(27). Responses were scored and summed to provide a global score of mental wellbeing. In contrast, Ugartemendia et al. used the World Health Organisation – Five item Well-being Index to assess mental wellbeing(44). The 5-item scale consists of questions which assess positive aspects of subjective wellbeing. Responses were scored and summed to provide a global score of mental wellbeing. Aceijas et al. employed multivariate analysis including bivariate correlations and logistic regression models to assess associations between DI and mental wellbeing(27). Ugartemendia et al. used multiple linear regression analyses to assess relationships between nutrition factors outcomes of psychological questionnaires. Test scores from questionnaires were used as criterion, and components of diet were used as predictors(44).

Both studies evaluated associations between dietary habits and specific components of DI and a global score of mental wellbeing. In the study of Aceijas et al., mental wellbeing was associated with problematic nutrition patterns in males (based upon dietary balance, fruit and vegetable intake and meal skipping)(27). The authors reported males with low scores in mental wellbeing were three times more likely to have a problematic diet than a healthy diet. No associations between dietary habits and mental wellbeing in females were reported(27). Ugartemendia et al. found mental wellbeing was predicted by the carbohydrate group(44). Further multiple regression analysis found insoluble fibre intake to be the specific

nutrient in the group that was associated with mental wellbeing with a positive correlation. This suggests greater insoluble fibre intake was associated with greater mental wellbeing scores in the study(44).

Both studies that assessed mental wellbeing directly found a positive relationship between subjective mental wellbeing and at least one marker of a healthy dietary intake, specifically greater fibre intake, and inferences of a balanced diet.

2.6 **Limitations and Future Studies**

Limitations of this scoping review are related to the included databases for article retrieval. The search considered some popular scientific literature directories but not all. Moreover, the search was restricted to published scientific literature, so associations outlined in grey literature could have been missed. Only full-text publications published in English were included in the review, which may lead to selection bias. As with most questionnaire-based research, DI and mental wellbeing was assessed with self-reported data, where misreporting is possible(57,58).

There were limitations regarding the investigations of the association of DI and mental wellbeing in university students within included studies. Firstly, the component of mental wellbeing assessed varied significantly between studies (affect, life satisfaction, quality of life, global mental wellbeing and eudaimonic wellbeing). Although each does represent a key contributor to mental wellbeing, and some components can be grouped for discussion, they are each vastly different in nature and application. Each component represents a small part of the complicated construct that is mental wellbeing, but only once assessed together as one entity can they paint an accurate picture of wellbeing from a psychological perspective, such as in the form of a global mental wellbeing score. Individually the components assessed can be used as an indicator of mental wellbeing but the power of the

conclusions in that regard are hindered as a result. Secondly, articles did not share inter-study likenesses in their study design or measurement methods, where studies that did assess the same mental wellbeing component typically used different measurements to obtain their data. This heterogeneity was also present for measurements of dietary intake. Taken together, the limitations highlight the requirement for greater consistency in future studies in this area. Future studies would usefully include consideration for greater consistency in the measurement of DI. For example, the most accurate self-report method is the FFQ, which provides greater detail and validity than the FD-24 and FD-7 methods(59). Consistent use of the FFQ in future studies will add to the power of the findings and increase comparability between previous and future works. Furthermore, future works would benefit from using a global mental wellbeing score to assess mental wellbeing, that encompasses the different components of mental wellbeing in one measurement.

2.7 **Conclusions**

This review aimed to assess associations present in the current literature between dietary intake and mental wellbeing in a student population. At present, there are limited studies in this area. However, despite methodological heterogeneity between studies, most reports noted a positive association between mental wellbeing or a component therein, and healthier dietary habits. Specifically, a positive association with dietary intake was present in the following components of mental wellbeing: quality of life, eudaemonic wellbeing, and positive and negative affect. Only two studies directly measured mental wellbeing using a global score: one reported a positive association between problematic dietary patterns and poor mental wellbeing, and the other reported a positive association between insoluble fibre intake and mental wellbeing. This scoping review aimed to explore how dietary intake and mental wellbeing was assessed in university students. Large variation in study characteristics were present within the small sample of eligible studies.

3.0 Experimental Study

Dietary Habits, Physical Activity and Mental Wellbeing During Covid-19 Lockdown: A Study of University Students in the United Kingdom

3.1 Justification

Considerable methodological heterogeneity exists in the published studies that have assessed the associations between dietary intake and mental wellbeing in university students, as concluded in Chapter 2. Studies included utilised a variety of dietary intake and mental wellbeing measurements. Moreover, only two studies utilised a global mental wellbeing score to assess mental wellbeing(27,44). Further, published research is yet to investigate dietary intake, eating behaviours, physical activity, and mental wellbeing simultaneously in a student population. Therefore, the following experimental study will add to the present literature, by assessing the dietary intake and mental wellbeing of university students using the WEMWBS, a global measure of mental wellbeing. Similarly, the experimental study will assess student dietary intake and subsequent diet quality by using a FFQ. One study included in the scoping review suggested exercise partially mediated the relationship between components of mental wellbeing and healthy diet habits(45). Subsequently, physical activity will be assessed and examined as a marker of health-related behaviour in the experimental study.

3.2 **Introduction**

The increase in prevalence of diabetes, hypertension, heart disease and other non-communicable diseases has become a public health concern around the globe(60). It is estimated that 68% of men and 60% of women in England are overweight or obese as of 2021(2). A recent international report found chronic diseases such as diabetes mellitus, dyslipidaemia, and heart disease are not only limited to adults but are now affecting younger generations(1). Developing a healthy lifestyle is important for all ages, but research suggests the earlier a habit is formed, the more likely an individual is to sustain it(61). Despite being the least likely age group to be obese, 37% of young adults (16-24) in England are either overweight or obese, and the prevalence is above 70% among all age groups from age 45 upwards(2). A greater instance of overweightness and obesity was reported in young adults that had completed a college degree compared to their age matched peers who did not go to university(4). The university years typically occur during a crucial age for the creation of habits that are likely to persist through to adulthood(61). Attending university poses significant challenges to forming a healthy lifestyle for students, in the form of greater autonomy, negotiating living on a budget, and integrating with new social groups(9,62). Students at university are more prone to engage in riskier lifestyle behaviours that negatively affect physical and mental wellbeing than non-students(63). Current research indicates some students have poor diets and practise unfavourable lifestyle behaviours(9). Moreover, less healthful dietary patterns are positively associated with other poor health behaviours such as low physical activity and smoking(9).

Mental wellbeing

University students also face a greater burden of mental illness than their peers not attending university(15). This has been partly attributed to their exposure to unhealthy lifestyles and risk of psychiatric disorders, with depression being listed as one of the most common mental health problems affecting the student population worldwide(15,16). Students must prepare for a professional career, during which time they experience a significant psychological and psychosocial transition which contributes to feelings of stress, anxiety, depression, and poor mental wellbeing(15,16,64). High rates of anxiety and depression were recently found in both male and female students at a British university(65). To date, much of the research on student psychological health focuses on 'clinical' mental health issues such as depression, anxiety, and emotional distress. Less has focussed on more subjective, and generalised notions of mental wellbeing, albeit clinical mental health issues and mental wellbeing have been linked previously. For example, individuals with better mental wellbeing were recently shown as at lower risk of clinical psychological issues(66,67). Mental wellbeing can be defined as a global measure of an individual's positive experiences of life and judgements(68). Subjective mental wellbeing is considered an emotional construct that encompasses an individual's cognitions regarding positive and negative affect, and an overall satisfaction with life and happiness(56,68).

Maintaining a healthy state of mental wellbeing is of particular importance for university students. The high workload, strict deadlines, and the desire to obtain a 'good degree' are academic-related stressors that can impact student mental wellbeing(10). A small to medium positive correlation between subjective mental wellbeing and academic success in university students was reported in a recent meta-analysis(66). This is relevant as the accumulating effects of academic success or failure when combined to other stress factors associated

with university can have long-term effects on an individual's health and wellbeing(66). Additionally, the negative impacts on learning, participation, and the 'university experience' caused by psychological distress illustrates the importance for universities to understand the contributing stressors to better support the psychological wellbeing of the population(69,70).

Dietary intake and eating behaviours

Some researchers have speculated that greater autonomy over the type, portion and frequency of food consumption, reduced food budgets, and exposure to new social groups and food cultures are associated with the dietary behaviours of university students(9). A 2017 study indicated 65% of students had significantly changed their diet, including an alteration of fruit, vegetables, meat and dairy consumption, since attending university(71). Further, students who had moved away from home to attend university were more likely to report a change in eating behaviours compared to those who had remained in their hometown(71). The study reported around 60% of students consumed the same quantity or less healthy foods (fruits and vegetables) since matriculation, and more than half of the population (55.2%) reported that they no longer eat as many regular meals since being enrolled at university. (71) Reports of a reduced diet quality that consisted of a decrease in caloric intake and healthy food consumption in students during their first semester at university are common in the literature. (13,14) Lifestyle risk factors such as smoking and low physical activity are associated with poor dietary habits in UK students, according to cross-sectional research(9). The same research identified that poorer diet patterns were less nutrient dense, meaning a higher prevalence of foods that provided less macro- and micronutrient sustenance relative to the amount of calories consumed, compared with healthy diet patterns(9). Moreover, students that reported weaker cooking competence tended towards poorer dietary patterns(9). This highlights recent alarming trends among

university students in the UK regarding their dietary habits, and signals a need for greater promotion of pro-health lifestyles via university policy(9,13,14). This includes incorporating efforts to promote student engagement in cooking and education on the availability of low-cost healthier food items(9).

Dietary intake in students is typically assessed using validated food frequency questionnaires (FFQs) in the current literature(9,72,73). FFQs have good administrative convenience and produce a strong estimation of usual dietary intake, and show power in large epidemiological studies(74). The healthy eating index-2015 (HEI-2015) is a diet quality measurement that assesses how dietary intake aligns with guidelines from the 2015-2020 Dietary Guidelines for Americans(75,76). This measure of diet quality was chosen for use within this study because it combines a broad range of aspects of dietary intake and provides an objective score of specific diet quality based upon high construct validity, and has previously used previously in studies of university students(75,77,78). The balance of dietary energy intake to energy expenditure dictates body mass maintenance, loss and gain(79). A 2006 study reported body mass and adiposity was reduced when adhering to calorie-restricted diets compared to control groups in an overweight population(80). Unhealthy dietary patterns and alcohol consumption were positively correlated with energy intake in the study of Sprake et al.(9). Therefore, dependence on poor diets, and increased energy intake, could increase the risk of mass and adiposity gain in students(9). Reducing saturated fat intake can decrease total energy intake, and subsequently reduce adiposity, as fat is the most energy-dense nutrient(81). Saturated fat intake was associated with an increase in adiposity and identified as a marker of poor diet quality in a recent longitudinal study of students(72). Moreover, increased saturated fat intake raises low-density lipoprotein cholesterol, which is associated with increased risk of cardiovascular disease,

and reducing saturated fat intake is recommended to decrease disease risk(82,83). Subsequently, saturated fat intake has been adopted as a measure of diet quality in this study. Similarly, an excessive intake of added sugar has been associated with increased risk of non-communicable diseases, such as type 2 diabetes mellitus, and obesity(84,85). Further, high added sugar intake is related to unhealthy lifestyles and habits including overall poor diet quality and was subsequently chosen as a measure of diet quality in this study(86). High alcohol use in students is documented in many studies(9,11,12,72). Students that consume more alcohol are more likely to smoke, engage in lower levels of physical activity and consume takeaways more frequently as outlined in the current research(9). Alcohol intake has a problematic relationship with poor lifestyle behaviours in students(9,12). Due to alcohol intake's link with poor lifestyle behaviours in student populations at present, this was selected for use as another marker of unhealthy behaviours in the present study.

Overeating behaviours have been associated with anxiety and depression in university students(23,87). Depressive symptoms strongly predict overeating in students, suggesting binge- and overeating may be initiated as a coping mechanism for poor mental wellbeing(23). The Addiction-Like Eating Behaviour Scale (AEBS) is a questionnaire used to quantify addiction-like eating behaviours(88). The scale has been shown as a valid and reliable tool to assess addiction-like eating behaviours in varying cohorts(88). In a recent validation study, the scale was shown to successfully predict a significant proportion of the variance in BMI above that predicted by other popular measures of eating behaviours including the Yale Food Addiction Scale and the Binge Eating Scale(88). The AEBS was therefore chosen to quantify overeating behaviours in the present study. The appetitive-drive subscale of the questionnaire focuses on items relating to binge- and overeating. The

subscale was recently used to quantify overeating in a study of adults in the UK(30). As of yet, no studies have applied the scale to a student population.

Links between students' dietary habits and mental wellbeing

Chapter 2 identified two studies that assessed the relationship between dietary intake and mental wellbeing in students with a global mental wellbeing score. Male students with low mental wellbeing scores were three times more likely to have a problematic diet (low energy intake, reduced fruit and vegetable consumption, and increased meal skipping) as reported by Aceijas et al.(27). Conversely, low dietary fibre intake was associated with poorer mental wellbeing in students in the other study(44). Higher depression levels and less satisfaction with life were related to lower consumption of cereals & legumes and lean meat in students(45). Despite methodological heterogeneity, healthier dietary habits were related to better mental wellbeing, similar to findings in the wider adult population(89).

Physical activity correlates of mental wellbeing and dietary habits

Amatori et al. reported physical exercise mediated healthier dietary habits in students(45). Students that exercised more had a higher consumption of fresh fruit and vegetables and fish, and lower intake of fatty meat and milk-derivatives(45). Further, exercise partially mediated the relationship between components of mental wellbeing (depression, positive and negative affect and satisfaction with life) and healthy diet habits(45). This suggests physical exercise contributed to the relationship between mental wellbeing and dietary intake, where students that were more physically active showed a more beneficial relationship between mood and diet(45).

University students report low levels of physical activity (PA) compared to the general adult population(90,91). Decreased PA levels are associated with unfavourable body composition changes that put individuals at a greater risk of cardio-metabolic diseases(92–94). Individual factors (e.g., self-discipline, motivation and time constraints) as well as university residency, examinations and academic pressure, are among the contributing factors to reduced habitual PA in students(90,91). Findings are mixed in this area, as in one longitudinal study student PA level was greater than government recommendations and did not change throughout the academic year(95,96). Aside from the benefits to physical health, frequent exercise is beneficial to mental health(25). PA was associated with reduced risk of problematic mental health, including experiencing anxiety and depression in the general population in recent systematic reviews(25,97).

The Covid-19 lockdown

The Covid-19 outbreak was declared a global pandemic by the World Health Organisation (WHO) in March 2020. Covid-19 is a respiratory virus that is transmitted by respiratory droplets and contact with infected secretions(98). Therefore, the UK government enforced strict restrictions to the public that limited the contact individuals have with each other (social distancing) to reduce the risk of transmission on March 23, 2020. As Covid-19 cases began to fall, the UK government slowly lifted restrictions until June 21, 2021, when all legal restrictions were eventually lifted. The WHO recognised such restrictive measures could have significant impacts on individuals' mental wellbeing and PA habits, with recreational sport centres, gyms and pools being closed down(98,99). Most university buildings were closed, leaving students unable to attend classes, socialise, exercise, or leave their accommodation except for in emergencies. The pandemic has had a significant effect on the diet habits, PA habits, and the mental wellbeing of students globally(28,29,100,101).

Student nutrient and caloric intakes were reduced and alcohol intake increased during the pandemic(29). The decreased consumption of nutrient-dense foods explains the increase in prevalence of nutrient inadequacy during the Covid-19 pandemic in students(29). Only 10% of students met the PA guidelines while 30% met the sedentary activity guidelines in the same study(29). Moreover, physically active students experienced a greater decline in PA and wellbeing levels than non-active students(100). In UK students, mental wellbeing and PA decreased during the first 5 weeks of lockdown(28). Greater change in sedentary behaviour and perceived stress were positively associated in the study(28). In contrast, an increase in time and frequency of PA despite an increase in sitting time has been observed in the population during the Covid-19 lockdown(101). This shows some students modified their lifestyles for the better despite having to spend more time in isolation. Robinson et al. investigated perceived changes (before vs. during lockdown) to weight-related behaviours and barriers to healthy eating/PA in a large sample of UK adults(30). The authors developed survey items relating to health-related behaviours and used a Likert scale to measure the degree of perceived change in behaviours since the Covid-19 lockdown. Measuring perceived change provides valuable context into the affect the lockdown has bestowed upon significant health-related behaviours, without measuring behaviour change directly pre-post Covid-19 lockdown. However, most research in this area was conducted during the beginning and middle of the lockdown period, where students were likely still transitioning to life within the restrictions(28,29,100,101).

Current research

Research is yet to simultaneously investigate student dietary intake and eating behaviours, PA, and mental wellbeing altogether. The most similar and up-to-date study is that of Aceijas et al., which investigated dietary intake, PA and mental wellbeing (but not eating behaviours)

in 468 students from Middlesex University London in 2017(27). 60% of respondents were insufficiently physically active, 47% had an unbalanced diet, and 30% had low mental wellbeing(27). In relation to the covid-19 pandemic, a 2020 study revealed mental wellbeing and PA decreased during the first 5 weeks of lockdown in students at an East Midlands University(28). Meanwhile, perceived stress and time spent sedentary increased in the cohort during the lockdown(28). Dietary intake has not been investigated in students in the UK during the lockdown thus far. However, a 2021 study reported macro- and micronutrient and caloric intakes decreased alongside an alcohol increase during the pandemic in Canadian students(29). Moreover, PA level decreased, and time spent sedentary increased during the pandemic, in-line with reports of UK university students(28,29) As yet, no research has investigated student perception of how the Covid-19 restrictions have affected the diet, PA, and mental wellbeing of the individuals. Robinson et al. investigated the perceived changes of health-related behaviours during the Covid-19 lockdown in a general sample of UK adults(30). The majority of participants reported perceived negative changes in eating and PA behaviour (e.g., 56% reported more frequent snacking), and a decline in mental wellbeing, as the lockdown was predictive of more overeating and lower PA(30).

Evaluating student health-related behaviours is important to keep up to date on the habits and lifestyles that will inform the long-term physical and mental health of future adult generations. However, it is equally important to contextualise these behaviours within the unprecedented social context of the time in which data were collected, during the latter-period of the Covid-19 lockdown in the UK.

3.3 **Research Aims**

The aims of this study were to (i) explore and describe the current dietary intake and eating behaviours, PA, and mental wellbeing of students currently attending a university in the UK; (ii) assess the relationships between these health-related behaviours in the cohort; (iii) add context to the findings by investigating and accounting for the perceived Covid-19 effect on health-related behaviours and mental wellbeing.

Due to the exploratory nature of a ‘snapshot’ of student health-related behaviours during the latter-period of the lockdown for the first time, no formal hypotheses are proposed for research aim (i). For research aim (ii) the hypotheses are: students that report better diet quality will exhibit better mental wellbeing; students that report better eating behaviours will exhibit better mental wellbeing; and students that report being more physically active will exhibit better mental wellbeing. Finally, for research aim (iii) the primary hypothesis is perceived lockdown health-related behaviour and mental wellbeing change will moderate the relationship between health-related behaviours and mental wellbeing.

3.4 **Methods**

3.4.1 Participants and recruitment

71 university students enrolled in undergraduate or postgraduate courses at the University of Essex, Colchester, UK volunteered to participate in the study. 10 participants were removed from the sample for not completing the survey, and 2 were removed for providing implausible data which resulted in a final sample size of 59, aged between 18-45 years, of which 34 were male and 25 were female. Participant characteristics are summarised in **Table 6**. Participants were recruited via emails distributed across university faculties and departments. Volunteers expressed participation interest and were sent full participant information and consent forms via email. This research study gained ethical approval and conformed to the declaration of Helsinki. All volunteers provided full written informed consent prior to receiving links to the study survey material.

3.4.2 Protocol and data collection

After ethical approval, a cross-sectional study was conducted in 2021. Data were collected during a period of approximately one month during the spring term of the 2020-2021 university year (12th Feb 2021 – 13th Apr 2021). All data were collected using an online survey that took ~1 hour to complete. Data collected included self-reported anthropometrics (height and body mass), age, year of study, dietary intake, eating behaviour, habitual PA, current mental wellbeing and perceived changes to health-related behaviours and mental wellbeing since before the Covid-19 lockdown in the UK imposed 23 March 2020.

3.4.3 Measures

Mental wellbeing

The Warwick-Edinburgh Mental Wellbeing Scale (WEMWBS) was used to determine a global mental wellbeing score. The WEMWBS is a 14-item survey which measures subjective wellbeing over a two-week period using a self-report 5-item Likert scale. The scale includes items which focus on interpersonal relationships, positive affect, and positive functioning, focusing on both eudaimonic and hedonic wellbeing. A global score for mental wellbeing is calculated by summing the values for each response, providing a value between 14 and 70, with a greater score symbolising better mental wellbeing. This score is referred to as mental wellbeing score in this paper. The WEMWBS has been validated for use with student populations, and has demonstrated a high Cronbach's alpha of 0.87(102,103). Mental wellbeing score is the acquired variable that will be used in the analysis.

Dietary intake and eating behaviour

Dietary intake from the previous 4 weeks was determined using the validated, web-based Diet History Questionnaire III (DHQ3) food frequency questionnaire without portion size (DHQ3, National Cancer Institute, Bethesda, MD, USA)(104). The DHQ3 was composed of 135 food and beverage frequency questions and 26 dietary supplement frequency questions. Participants were asked to complete the DHQ3 in one sitting and were instructed to contact an investigator via email if assistance was required. DHQ3 data were downloaded from the DHQ3 online software. Energy and saturated fat intake data was transformed from absolute to relative values from division by body mass for analysis.

Diet quality was determined using the Healthy Eating Index 2015 (HEI-2015), a measure that assesses how well dietary intake aligns with guidelines from the 2015-2020 Dietary Guidelines for Americans(75,76). HEI-2015 score ranges from 0-100 with 100 indicating better diet quality. The measure is based on 13 components measuring both dietary adequacy and food group moderation. Adequacy components are dietary intake elements that are encouraged, with higher scores indicating higher intake, and moderation components represent the elements that are recommended to be limited, with higher scores reflecting lower intake(76). Each component is scored and summed to generate a total HEI-2015 score. For the present study, the HEI-2015 score was produced by the DHQ3 output and summed using the dietary intake data inputted for the last 7 days. Relative daily energy ($kcal.kg.bm^{-1}$), relative daily saturated fat ($g.kg.bm^{-1}$), absolute daily free sugar (g), absolute alcohol intake (g), and HEI-2015 score are the acquired variables from DHQ3 that will be analysed as independent variables.

To assess overeating, participants completed the validated 8-item Appetitive-Drive subscale of the Addiction-Like Eating Behaviour Scale(88). The subscale has produced good test re-test reliability and convergent validity(88). Participants reported on the last week their tendency to elicit overeating behaviours (e.g., ‘I binged when eating’, 5 item response scale of ‘never’ to ‘always’). Responses were summed and provided a score between 8 and 40, with a greater score indicating more problematic eating behaviour. This score is referred to as Addiction-Like eating behaviour score (AEB score) throughout this paper. The full survey questions for the Appetitive-Drive subscale are presented in **Appendix A**. AEB score is the acquired variable that will be analysed as an independent variable.

Physical activity

Physical activity was determined using the International Physical Activity Questionnaire Long-form (IPAQ)(105). The IPAQ has been frequently used in the assessment of PA in the literature, and has been validated for use with student populations(90,91,106). The five sections of the IPAQ focussed on a different type of PA undertaken in a 7-day period prior to study participation.

The IPAQ included questions related to: occupational activity including paid jobs, volunteer work, farming, coursework, and any other unpaid work completed outside of home; PA related to transportation; domestic work, general home maintenance and caring for family such as housework and gardening; recreational PA in leisure time, devoted to sport and other leisure activities; and time spent seated (including sitting during transportation, at the movies, at a desk etc.)(105).

PA level was calculated using markers of intensity (metabolic equivalent of work; MET), to enable the assessment of different types of PA as instructed in the IPAQ guidelines(105). The volume of activity was calculated by categorising each type of activity by its energy requirements defined in METs to yield a score in MET-minutes (MET-min) by multiplying the MET score of an activity by the minutes performed.

Daily PA (MET-min.day^{-1}) was presented as the total daily MET-minutes attributed across all domains. Total daily MET-min were computed using the following formula: total MET-min.day^{-1} = MET-min.wk-1 (at work + yard work + inside work + in leisure time) + cycling MET-min.wk-1 for transport + MET-min.wk-1 for vigorous yard work / 7 days(32). As recommended in the IPAQ guidelines, total walking, moderate and vigorous data exceeding

three hours in duration were truncated to be equal to 180 minutes, to normalise the distribution(105).

The average values for MET coefficient of different types of PA in IPAQ are: walking (stroll), 3.3 x MET-min.wk^{-1}; moderate activity, 4.0 x MET-min.wk^{-1}; moderate activity related to domestic works, 3.0 x MET-min.wk^{-1}; intensive activity, 8.0 x MET-min.wk^{-1}; intensive activity related to domestic works, 5.5 x MET-min.wk^{-1}; and riding bicycle as a form of transportation, 6.0 x MET-min.wk^{-1}.

Daily PA was the acquired variable from IPAQ that will be analysed as an independent variable.

Implausible physical activity data was identified and excluded congruent to methods identified in the Guidelines for Data Processing and Analysis of the International Physical Activity Questionnaire(105). All cases in which the sum total walking, moderate and vigorous time variables were greater than 960 minutes (16 hours) were excluded as outliers due to the data being unreasonably high.

Perceived changes since Covid-19 lockdown

Items relating to lockdown behaviour and mental wellbeing change were adapted from a survey created by Robinson et al. in their 2021 study(30). Participants were asked ‘Compared to before the Covid-19 lockdown in the UK, I have…’ and using a 7-point response scale (1 = a lot less frequently, 4 = the same amount, 7 = a lot more frequently) responded to 9-items on health-related behaviours relating to diet and PA changes. Responses for health-related behaviour change items were scored, with the following items reverse-scored: ‘eaten a healthy and balanced diet’; dieted/fasted; exercised; been physically active; and ‘got a good night’s sleep’ and then summed to provide an overall pattern of change as a numerical score between 9 and 63. Higher scores indicated a greater

worsening of perceived health-related behaviour change since the Covid-19 lockdown. This score is referred to as perceived health behaviour change (PHBCh) throughout this paper. The full survey questions for PHBCh are presented in **Appendix B**.

Next, participants were asked ‘Compared to before the Covid-19 lockdown in the UK, I have…’ and using a 5-point response scaled (1 = never, 3 = sometimes, 5 = always) responded to 6-items on mental wellbeing-related changes. The items included on mental wellbeing changes were derived from the WEMWBS. The 6-items chosen were the most important with regards to aspects of mental wellbeing most likely to have been affected by the Covid-19 lockdown in the UK. Mental wellbeing change items were summed to produce an overall pattern of change as a numerical score between 6 and 36. Higher scores indicated greater a greater worsening of perceived mental wellbeing changes since the Covid-19 lockdown. This score is referred to as perceived mental wellbeing change (PMWCh) throughout this paper. The full survey questions for PMWCh are presented in **Appendix B.** PHBCh and PMWCh were the acquired variables that will be analysed as moderator variables.

3.4.4 Data Analysis

In order to quantify student health-related behaviours and mental wellbeing, the mean and standard deviation (SD) for dietary intake, eating behaviour, physical activity and mental wellbeing variables were calculated and compared with normative data and UK government guidelines for descriptive purposes. Shapiro-Wilk values were used to assess the distribution of normality of the data. Within the independent variables, analyses of standardised residuals were carried out to identify outliers, and multicollinearity was assessed using tests of collinearity assumption in all statistical tests of relationship.

In order to investigate associations between health-related behaviours and mental wellbeing, a Pearson's correlation analysis was conducted to assess correlations between mental wellbeing, components of dietary intake, eating behaviour, and physical activity. Pearson's product moment was investigated to infer the direction and magnitude of relationships. Multiple regression analysis using the enter method was used to assess the contribution of dietary intake, eating behaviour and physical activity variables as predictors of mental wellbeing score in the cohort. Adjusted R^2 was investigated to compare the explanatory power of the variables entered into the model. Unstandardised β-coefficient values were investigated to assess the direction and degree of change in the outcome variables for every one-unit of change in the predictor variable of the regression models. Mental wellbeing score was included in the regression analysis as the dependent variable. The independent variables included in the model were as follows: relative daily energy intake ($kcal.kg.bm^{-1}$); relative daily saturated fat intake ($g.kg.bm^{-1}$); absolute alcohol intake (g); HEI-2015 score; AEB score; and daily physical activity ($MET\text{-}min.day^{-1}$).

Moderation analyses were performed in order to examine the possible influence of the Covid-19 lockdown upon the observed relationships between predictor variables (relative daily energy intake, relative daily saturated fat intake, absolute daily free sugar intake, daily alcohol intake, HEI-2015 score, AEB score and daily PA) and reported mental wellbeing score (WEMWBS). For each predictor variable (independent variable) two moderation analyses were performed whereby PHBCh and PMWCh (participants' own perceptions of changes due to lockdown) were each entered as the moderator variable, and mental wellbeing (WEMWBS) was entered as the outcome variable (dependent variable). To clarify, the WEMWBS was used to measure subjective mental wellbeing itself, whilst PMWCh was used to quantify the participant's individual perception of mental wellbeing change since before the enforcement of the Covid-19 lockdown. Similarly, PHBCh was used to quantify the participant's individual perception of health-related behaviour change since before the enforcement of the Covid-19 lockdown.

The moderation analysis was conducted using the PROCESS macro for SPSS version 3.5(107).

All statistical analyses were performed using Statistical Package for Social Sciences (SPSS) version 27. The alpha level for statistical significance was set at .05.

3.5 **Results**

3.5.1 Sample

A total of 71 participants were recruited into the study. Removal of 10 participants who did not complete the survey, and 2 participants who provided implausible physical activity data resulted in a final sample size of n = 59, of which 34 were male, and 25 were female. Participant characteristics are reported in **Table 6.**

Table 6. Participant Characteristics.

Variable	(unit)	Mean ± SD, range
Age	(years)	22.1 ± 5.6 (18, 45)
Height	(cm)	173.7 ± 10.5 (155, 203)
Body mass	(kg)	74.3 ± 17.2 (44, 130)
Year of study	(year)	2.9 ± 0.7 (2, 4)

3.5.2 Health behaviours during lockdown

Table 7 shows the mean ± standard deviation for dietary intake, eating behaviour, physical activity, and mental wellbeing variables in comparison to normative data and UK government guidelines(108–110). 20% reported meeting the Daily Recommended Values (DRVs) for daily energy intake; 90% reported meeting the DRVs for saturated fat intake; and none reported meeting DRVs for daily free sugar intake. On average, the population reported consuming 3.94g (<0.5 units) of alcohol a day, which equates to ~3.5 units a week. This is within the weekly recommendations for alcohol consumption in the UK. The average HEI-2015 score reflected the average diets did not align with the dietary recommendations set in the 2015-2020 Dietary Guidelines for Americans. 71% reported meeting the UK guidelines for physical activity, and 86% of participants scored equal or better than the UK average WEMWBS mental wellbeing score.

Table 7. Mean ± SD of dietary intake, eating behaviour, physical activity, and mental wellbeing variables, with comparison to normative data and UK government guidelines.

		n = *59* Mean ± SD	Percentage of participants that met normative average / guidelines %
Dietary Intake	Relative daily energy intake (kcal.kg.bm^{-1})	23.66 ± 9.51	20%*
	Relative daily saturated fat intake (g.kg.bm^{-1})	0.28 ± 0.12	90%*
	Daily free sugar intake (g)	94.37 ± 39.73	None*
	Daily alcohol intake (g)	3.94 ± 6.10	/
	HEI-2015 Score (g)	65.75 ± 7.55	/
Eating Behaviour	AEB Score	20.5 ± 7.2	/
Physical Activity	Daily physical activity (MET-min.day^{-1})	578.8 ± 566.1	71%*
Mental wellbeing	WEMWBS score	43.7 ± 8.4	86%**

SD, standard deviation; kcal.kg.bm^{-1}, kilocalories per kg of body mass; g.kg.bm^{-1}, grams per kilogram of body mass; HEI-2015, Healthy Eating Index-2015; AEB score, Addictive-like eating behaviour score; MET-min.day^{-1}, metabolic equivalent minutes per day; WEMWBS score, Warwick-Edinburgh Mental Wellbeing Scale score.

** Based on the United Kingdom government guidelines for adults (19+) in the UK:*

Energy (Kcal/day) Male 2500Kcal, Female 2000Kcal; Saturated Fat (g/day) Male <31g, Female <24g; Free Sugars (g/day) Male <33g, Female <27g.

*** Based on WEMWBS normative data- percentage that scored the average or better: WEMWBS UK average score 51.6.*

3.5.3 Associations between health behaviours

Pearson's product moment revealed a significant, weak, negative correlation between mental wellbeing score and addictive-like eating behaviour (AEB) score ($r(59) = -0.297$, $p = 0.023$), indicating those with a lower mental wellbeing score demonstrate greater addiction-like eating behaviours.

Pearson's product moment also revealed a significant, strong, positive correlation between relative daily energy intake and saturated fat intake ($r(59) = 0.860$, $p < 0.001$), and total free sugar intake ($r(59) = 0.712$, $p < 0.001$), and a significant, weak, positive correlation with alcohol intake ($r(59) = 0.293$, $p = 0.024$), suggesting the greater the energy intake the greater consumption of saturated fat, total free sugar and alcohol. Analysis also revealed a significant, weak, positive correlation between relative saturated fat intake and total free sugar intake ($r(59) = 0.478$, $p < 0.001$), indicating the greater the saturated fat intake, the greater the total free sugar consumption.

No statistically significant relationships were observed between mental wellbeing and dietary intake or physical activity variables, nor between physical activity and dietary intake or AEB score. Pearson correlation coefficients for mental wellbeing, dietary intake, AEB score, and physical activity variables are shown in **Table 8**.

Table 8. Pearson correlation coefficients between mental wellbeing, eating behaviour, dietary intake, and physical activity variables.

Variable	1.	2.	3.	4.	5.	6.	7.	8.
1. MW Score	-	**-.297***	.228	-.001	.178	.240	.024	-.024
2. AEB Score		-	-.252	.092	-.205	-.017	.041	-.039
3. Total daily METs			-	-.093	-.195	-.065	-.107	.243
4. Relative daily energy intake				-	**.860****	**.712****	**.293***	.116
5. Relative daily saturated fat intake					-	**.478****	.199	-.125
6. Total daily free sugar intake						-	.255	.160
7. Total daily alcohol intake							-	.162
8. Total HEI-2015 score								-

Bold values represent significant results
*Key: MW Score, Mental wellbeing score; AEB Score, Addiction-like eating behaviour score; METs, Metabolic equivalent(s). *p<.05 **p<.001*

3.5.4 Predictors of mental wellbeing

An analysis of standard residuals was conducted on the dependent variable, mental wellbeing score. The data contained no outliers (Std. Residual Min = -1.81, Std. Residual Max = 2.02). The histogram of standardised residuals indicated that the data contained normally distributed errors, as did the normal P-P plot of standardised residuals, which showed good normality and linearity against the line of best fit. The scatterplot of standardised residuals revealed the data met the assumptions of homogeneity of variance and linearity.

Mental wellbeing was predicted by eating behaviour in the model, whereby each percent increase in AEB score explained -0.31% (β = -0.37, t(51) = -2.20, *p* = 0.03) of mental wellbeing score. Rel. daily energy intake (β = -.068, t(51) = -.19, p = .85), rel. saturated fat

intake (β = 3.13, t(51) = .15, p = .88), total daily free sugar intake (β = .06, t(51) = 1.37, p = .18), total daily alcohol intake (β = -.005, t(51) = -.02, p = .98), HEI-2015 score (β = -.09, t(51) = -.54, p = .59) and total daily METs (β = .001, t(51) = .42, p = .68), were not significant predictors. 15% of the variance of mental wellbeing was explained by the predictors (R^2 = 0.15). A summary of the model is presented in **Table 9.**

Table 9. Summary of the multiple regression model for mental wellbeing.

Measure	Coefficient Values and Collinearity Statistic					Model Values			
	Coefficient	Unstandardized Beta	Standardised Beta	p	Tolerance	r	R^2	Adjusted R^2	Durbin Watson
Mental wellbeing	Constant	51.6		<0.01		0.39	0.15	0.036	2.25
	Rel. daily energy intake	-0.07	-0.076	0.85	0.11				
	Rel. daily sat. fat intake	3.13	0.046	0.83	0.17				
	Daily free sugar intake	0.06	0.284	0.18	0.39				
	Daily alcohol intake	-0.01	-0.003	0.98	0.86				
	HEI-2015 score	-0.09	-0.08	0.59	0.75				
	AEB score	-0.37	-0.31	0.03*	0.84				
	Daily PA	0.001	0.06	0.68	0.88				

Rel., Relative; HEI-2015, Healthy Eating Index-2015; AEB score, Addictive-like Eating Behaviour score; PA, Physical Activity.
*Significant at the 0.05 level.

3.5.5 Perceived health-behaviour and mental wellbeing changes since the Covid-19 lockdown

All participant responses to questions of changes in health-related behaviour and mental wellbeing are reported in **Table 10.** The majority of the participants indicated a change since the Covid-19 lockdown for each component of health-related behaviour and mental wellbeing change except for ‘feeling able to make up one’s own mind about things’. The majority of responses with regards to health-related behaviour change were ‘less’, which would be considered a negative change aside from ‘snacked’, ‘skipped meals’, ‘spent time sitting down’ and ‘drank alcohol’. 88% of the sample indicated they have spent more time sitting down since the lockdown. Similarly, only 14% of the sample indicated exercising the same amount as before the lockdown. 51% of the population indicated exercising less, while 35% indicated exercising more. The most varied observation in health-related behaviour change was dieting / fasting, in which 50% of the sample indicated they have dieted or fasted the same amount as before the Covid-19 lockdown, and 50% indicated they have dieted or fasted either less or more. For mental wellbeing, the most frequently reported change was in the aspect of ‘being able to think clearly’, where 89% reported a change, of which 66% reported to being less able to think clearly since the Covid-19 lockdown. 62% of the sample responded as feeling less ‘optimistic about the future’ since the Covid-19 lockdown.

Table 10. Changes in health-related behaviours and mental wellbeing during lockdown.

		Response frequency (n = *(%)*)[a]		
		Less	*More*	*The same amount*
Health-related behaviours	Eaten a healthy and balanced diet	25 (43%)	18 (30%)	16 (27%)
	Snacked	7 (12%)	35 (59%)	17 (29%)
	Dieted / fasted	16 (27%)	14 (23%)	29 (50%)
	Skipped meals	13 (22%)	25 (42%)	21 (36%)
	Exercised	30 (51%)	20 (35%)	9 (14%)
	Been physically active	22 (38%)	24 (40%)	13 (22%)
	Spent time sitting down	4 (7%)	52 (88%)	3 (5%)
	Drank alcohol	24 (41%)	18 (30%)	17 (29%)
	Got a good night's sleep	25 (42%)	19 (32%)	15 (26%)
Mental wellbeing	Felt optimistic about the future	36 (62%)	14 (23%)	9 (14%)
	Felt useful	32 (54%)	17 (29%)	10 (17%)
	Felt relaxed	30 (51%)	18 (30%)	11 (19%)
	Felt able to deal with problems well	26 (44%)	12 (20%)	21 (36%)
	Felt able to think clearly	39 (66%)	14 (23%)	6 (11%)
	Felt able to make up my own mind about things	11 (19%)	13 (22%)	35 (59%)

[a] *Participants were asked 'compared to before the Covid-19 lockdown in the UK, I have…'*

3.5.6 Moderation of the relationship between AEB score and mental wellbeing

Moderation analyses were conducted to investigate if PHBCh and PMWCh moderated the relationship between each predictor variable (relative daily energy intake, relative daily saturated fat intake, absolute daily free sugar intake, daily alcohol intake, HEI-2015 score, AEB score and daily PA) and the outcome variable mental wellbeing score, but none were statistically significant for main effects nor interaction effects. For illustration purposes, please see **Figure 3.** and **Figure 4.** for moderation models.

A moderation analysis was conducted to investigate if PHBCh moderated the relationship between AEB score and mental wellbeing score. The interaction between AEB score and PHBCh was not statistically significant (β = -.003, 95% C.I. (-.04, .04), *p* = .90). The main effect of AEB score on mental wellbeing was also not statistically significant (β = -.13, 95% C.I. (-1.9, 1.6), *p* = .88). PHBCh did not moderate the relationship between eating behaviour and mental wellbeing to a statistically significant extent. The statistical model of the moderation analysis is presented in **Figure 3**.

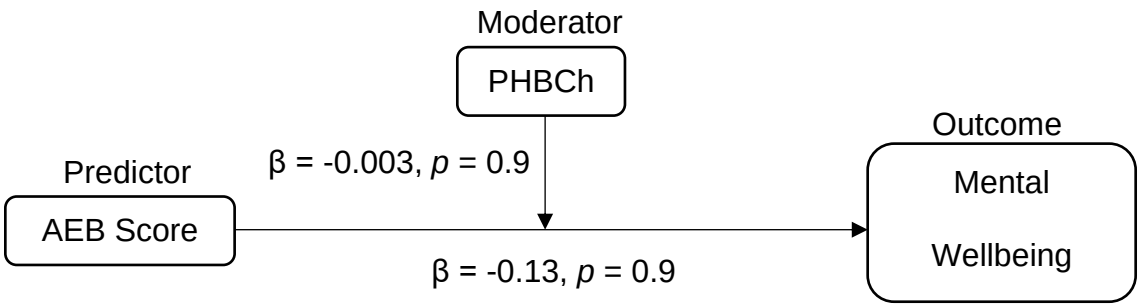

Figure 2. The statistical model of the moderation effect of perceived health-behaviour change on the relationship between AEB score and mental wellbeing score.

A moderation analysis was performed to investigate if PMWCh moderated the relationship between AEB score and mental wellbeing. The interaction between AEB score and PMWCh was not statistically significant (β = -.002, 95% C.I. (-.03, .03), *p* = .90). The main effect of AEB score on mental wellbeing was also not statistically significant (β = -.28, 95% C.I. (-1.05, .05), *p* = .48). PMWCh did not moderate the relationship between eating behaviour and mental wellbeing to a statistically significant extent. The statistical model of the moderation affect is presented in **Figure 4**.

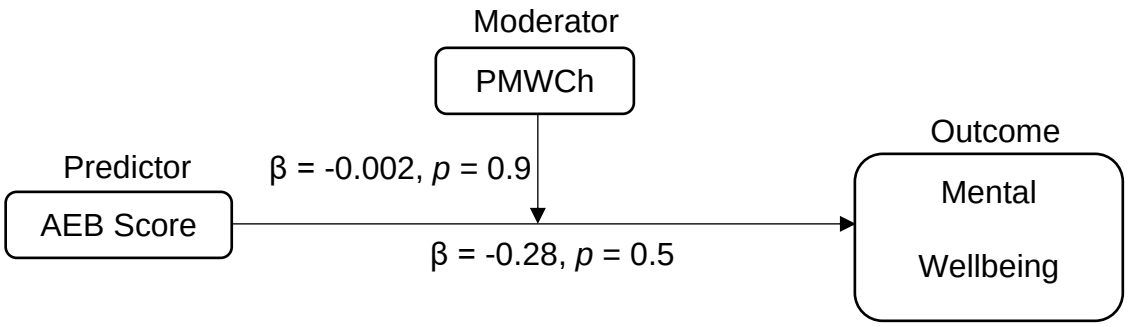

Figure 3. The statistical model of the moderation effect of perceived mental wellbeing change on the relationship between AEB score and mental wellbeing score.

3.6 **Discussion**

The purpose of this study was to (i) explore and describe the current dietary intake and eating behaviours, physical activity, and mental wellbeing of students currently attending a university in the UK; (ii) assess the relationships between these health-related behaviours and mental wellbeing in the cohort; and (iii) add context to the findings by investigating and accounting for the perceived effect of lockdown on health-related behaviours and mental wellbeing.

Mental wellbeing and eating behaviour

The significant relationship between mental wellbeing score and AEB score indicated students that reported better eating behaviours exhibited better mental wellbeing, thereby supporting hypothesis ii. Currently no other studies have assessed this relationship using a global measure of mental wellbeing. However, this finding is consistent with those reported in studies of food addiction symptoms (overeating and binge eating) and adverse symptoms of mental health understood to be closely related to mental wellbeing(23,66,67,111–114). For example, young women that reported depressive symptoms were twice as likely to start overeating and binge eating than their peers in a 2011 study(23). More recently, overeating and binge eating were associated with greater depression and mood disturbance in a study of students from the University of Brighton(115). These findings are alike to those in the present study, and suggest overeating behaviours may be initiated as a coping mechanism for adverse mental wellbeing(23). Studies in this area, including the present study, follow a cross-sectional design and so only explore the relationships of measured variables and are unable to infer causality.

Adjacent literature suggests that symptoms of disordered eating can lead to depression and anxiety, through failure to meet unrealistic body image standards(116). For example, quality of life was associated with body shape concern and emotional eating in students in the study of Da Silva et al.(117). To this point, poor mental health could be etiological to the development of disordered eating behaviours, as overeating could be used in attempt to reduce negative mood states(118,119). A proposed bi-directional theory suggests if disordered eating behaviours were used to reduce an adverse mood state, it could unwittingly worsen the mental state if the solution is ineffective(119). Thus creating a cycle of depression/anxiety causing disordered eating behaviours which in-turn causes further depression/anxiety(119). This relationship is therefore perhaps of greater prevalence and concern in university students because they are already predisposed to poor relationships with food and adverse mental wellbeing due to factors specific to the population(15,119).

As PHBCh and PMWCh did not moderate the relationship between mental wellbeing and eating behaviour in the current study, hypothesis iii was rejected. This finding suggests that a similar result would have been likely in normal (non-lockdown) contexts. This is concurrent with the already well-reported relationships between mental wellbeing and eating behaviour, which outlines this relationship is often independent of pandemics or other social constructs(111–113). Although recent literature also suggests the Covid-19 lockdown has impacted the mental wellbeing and eating behaviours of university students(28,120–122), it might be that these factors have been affected in a way that does not alter the relationship between them. Of alternative note, the survey items used to determine health-related behaviour change in the present study did not encompass items relating to overeating and binge eating and were instead focused on diet quality and PA. Therefore, it is possible the degree of health behaviour change measured in the present study was not of enough

relevance to eating behaviour in order to see a meaningful moderation effect on this relationship.

The current study described the mental wellbeing of students studying at a UK university. The mean mental wellbeing score was similar to other studies that also used WEMWBS in university student populations(27,28,123,124). Moreover, the mean mental wellbeing score was similar to that of a study conducted in students of a UK university during the Covid-19 lockdown(28). The proportion of students that reported below-average mental wellbeing in the current study (14%) was less than half the proportion that reported this in a previous UK study (30%)(27). This study collected data from a much larger sample than the present study which may explain the increased prevalence of low mental wellbeing(27). Of even greater importance to this comparison, Aceijas and colleagues do not disclose the scale used to categorise WEMWBS score, which weakens the reliability of comparing the prevalence of low mental wellbeing between studies. The findings of the present study indicate a low prevalence of adverse mental wellbeing in students studying at a UK university, albeit the sample size is small, and does not represent the national student population. No normative value exists for AEB score in any population. However, the mean AEB score identified in this study (20.5) is similar with that reported in previous research of a university student population from Ruddock et al. (23.5)(88).

Mental wellbeing and dietary intake

Markers of diet quality (i.e. saturated fat, free sugar intake and HEI-2015 score) were not associated with mental wellbeing to a statistically significant level in this study- thereby failing to support hypothesis ii.

This finding is notably different to the majority of published research findings, as greater mental wellbeing has been consistently associated with better diet quality in university students(27,44–50). However, saturated fat and free sugar intake were associated with daily caloric intake. Specifically, students that consumed more saturated fat and free sugar (markers of poor diet quality) consumed more calories daily, which is consistent with another study of students in the UK(9). It is perhaps unsurprising that students with greater daily calorie intakes consumed more saturated fat and free sugar in their diet in the present study, as university years can be particularly stressful, and most individuals report eating more during times of stress- often as a coping mechanism(115,125). Of note, physical activity level may have also affected energy intake, in that those that are typically more physically active may have increased caloric intakes to offset their energy balance in response to expending more calories each day.

This finding is concerning, as greater energy intake is associated with adiposity gain, which is related to obesity and non-communicable diseases in young adults(11,83,85). Students that consumed more saturated fat and free sugar may have consumed more calories due to feeling hungry more often, as saturated fat and free sugar is related to low satiety(126). Therefore, diets with a high saturated fat and free sugar content will not prompt the feeling

of ‘fullness’, where the individual is likely to feel hungry more frequently(126).

By investigating *relative* energy intake values (rather than absolute), the relationships reported between these variables are attributed to interactions between nutrients and calorie intake and were not skewed by the tendency of larger (mass) individuals to consume more calories compared to their smaller peers. This represents a strength to the present study over previous literature in this area, that do not assess relative dietary values(9,27,45,115).

Mental wellbeing was not associated with saturated fat or free sugar intake in the present study. Although these variables have not been explicitly assessed in the current literature, comparisons can be drawn with findings reported in a 2021 study of mental wellbeing and adherence to a Mediterranean diet (MED) in Italian students(123). The MED is typically characterised as calorie-restricted, high in plant-based foods, and low in saturated fats and free sugars(127). Therefore, those adhering to a MED consume less saturated fat and free sugar. Higher adherence to a MED was associated with better mental wellbeing in the population(123). In contrast to the findings in the present study, this suggests a lower consumption of saturated fat and free sugar are associated with positive mental wellbeing in students. It is unclear why the present study did not find an association between diet quality and mental wellbeing in the population, and further qualitative research with regards to student dietary intake and mental wellbeing is required to shed light on this. The beneficial effects of better diet quality achieved previously might be attributable to participant’s sense of self-efficacy, where those who perceive themselves in control of their own lives were more likely eat a better quality diet(128).

The finding that mental wellbeing was not associated with saturated fat or free sugar intake in the present study also seems to support those of a 2021 population-based cohort study of adults in the Netherlands despite methodological differences(129). Overall diet quality did not predict poor mental health outcomes in the full sample or those with pre-existing anxiety or depression(129). Further, diet quality did not play a mediating role in two established pathways to common mental health problems (stress and neuroticism)(129). Although, this study was suited to investigate the general Dutch population, and not that of UK university students. The findings of the present study suggest the protective effects of diet quality on the development of components of poor mental wellbeing, as commonly reported, are unlikely caused by dietary intake(129).

Alcohol intake was statistically significantly associated with relative energy intake, but not mental wellbeing in the present study. Students that consumed more alcohol also consumed more calories each day. This was expected, as research indicates younger adults do not compensate appropriately for alcohol energy by eating less, and a moderate intake of alcohol may lead to an increase in food consumption(130). In a sample of UK adults, more than one in six individuals increased their alcohol consumption during the Covid-19 lockdown period according to a 2020 study(131). 50.4% of those with increased alcohol consumption were young adults(131). The study revealed increased alcohol consumption was associated with lower mental wellbeing to a statistically significant level, in contrast to the findings of the present study(131). The alcohol intakes reported by participants in this study are indicative of healthy consumption(132). Students are typically associated with greater alcohol intake in the literature, so this finding is unexpected(9,11,72). It is possible

that the participants in the present study were consuming less alcohol, due to the decrease in social interaction brought upon by adhering to lockdown guidelines. With bars, pubs and clubs closed alongside advice to stay isolated from their peers, the sample may represent that of student's following guidelines set by the UK government with regards to social distancing, and safe alcohol consumption. Although, due to the nature of self-report questionnaire data, mis-reporting and under-reporting are a possible alternative explanation for this outcome.

Although most students reported consuming a healthy amount of saturated fat (90%), all indicated a free sugar intake higher than the DRV(110). A similar proportion (89%) adhered to fat intake guidelines in a recent study of German students(133). Most students did not consume enough calories to reach daily recommendations in the present study. Further, student diet quality was categorised as poor according to HEI-2015 score, similar to a 2021 study of Turkish students(77). However, this study utilised a 24-hour recall food diary to assess HEI-2015 score, so did not represent usual dietary intake. The use of a FFQ to derive a HEI-2015 score at present represented a more valid and therefore stronger measurement. These findings demonstrate that following some dietary recommendations is difficult for students. Hilger et al. revealed students experienced a lack of time due to workload, high prices of healthy meals and a lack of healthy options available in a 2017 study(71). Students reported low daily calorie intakes alongside high free sugar consumption in this study, which was unexpected, as high free sugar intakes have been associated with high calorie intakes in the recent literature(9). Some students indicated skipping meals and snacking more frequently (42% & 59% respectively) since the Covid-19 lockdown. Therefore, it is possible in the absence of consuming a balanced meal, some students often ate sugary snacks which did not provide enough calories to reach recommendations.

It is possible other factors could have confounded the relationships between diet and mental wellbeing in the present study. For instance, a link has recently been reported between mental health and socio-economic status, and socio-economic status and poor diet quality(134). It is therefore possible that student's social background could have influenced both their mental wellbeing and their diet quality in the present findings. Another potential confounding factor is participant subject of study. Participation was advertised to an array of different schools and departments, but the greatest uptake was likely that of students enrolled in sport-related courses, due to this study being undertaken within the School of Sport, Rehabilitation and Exercise Sciences at the University of Essex. Students enrolled in sport courses are likely to have greater knowledge, and perhaps more motivation with regards to healthier eating, and mental wellbeing due to their learning modules.

Mental wellbeing and physical activity

No association was observed between mental wellbeing and PA in the present study, indicating students that were more physically active did not report better mental wellbeing, allowing hypothesis ii to be rejected. This differs from the majority of the existing literature, as a positive relationship between components of mental wellbeing and PA is commonly reported in the general population(97,135). Although an unexpected observation amongst studies of total PA, the present findings are consistent with a recent meta-analysis on domain-specific PA(25). White et al. demonstrated PA was not consistently associated with mental health across different life domains(25), with data suggesting that PA conducted in leisure-time is the most beneficial to mental wellbeing, whilst work, school and transport-related PA domains have a weaker or often statistically non-significant relationship with components of mental wellbeing(25). Further, increased work and school related PA does not reduce the prevalence of mental ill-health, as individuals with higher work or school-

related PA, such as students enrolled in sport-related courses, are just as likely to experience mental ill-health(25), indicating contextual factors of PA seem integral to this relationship(25). However, domain-specific PA was not investigated in the present study.

The finding that 71% of the present sample reported meeting the UK recommendations for PA differs to that of Aceijas et al., who reported 60% of respondents were physically inactive in their 2017 study of UK students(27). Similarly, only 16% of participants reported meeting PA guidelines of 150 moderate-vigorous PA per week in Bertrand's study of Canadian students(29).

The context of the Covid-19 lockdown

There was considerable variability in perceived change in each of the 4 diet-related behaviours since before the Covid-19 lockdown. That 43% of the sample reported eating a healthy and balanced diet less frequently- and 30% indicated eating a healthy and balanced diet more frequently is similar to a 2021 study of adults in the UK (n = 2002)(30). However, a smaller proportion of the sample in Robinson et al.'s study reported consuming a healthy and balanced diet less (35%) compared to the present study (43%)(30). Moreover, the majority of students reported snacking more often, congruent to the adult population(30). In contrast, the majority of the present population reported skipping meals more often, where the majority in the adult population of Robinson et al. reported less frequent meal skipping(30). These findings suggest UK student diet quality may have been negatively impacted to a greater degree by the Covid-19 lockdown compared with the adult population. This is perhaps unsurprising, as students are known to face unique factors that influence

their dietary intake that the normal adult population are less impacted by(9). Therefore, challenges such as supermarket food shortages and anxiety regarding leaving one's home, may have impacted the already unstable relationships students have with food(29,115). Moreover, those who had changed their work to remote or 'working from home' reported perceived unhealthier changes in diet during the lockdown in a 2020 study of UK adults (n = 399)(136). Student diet quality may have been similarly affected, as students were forced to continue their studies via 'remote learning' with university buildings closed down(29). Participants perceived their diet to be 'more unhealthy' as a result of working from home compared to before lockdown(136). These findings suggest the Covid-19 lockdown may have attributed to the poor dietary quality observed in the population in the present study. Although, the magnitude of impact from the lockdown on diet quality cannot be inferred from the data collected in this study, and future studies should aim to investigate this topic.

Considerable variability was observed for being physically active, where around the same proportion of the sample reported more (40%), and less (38%) frequent PA, and more (35%) and less (51%) frequent exercise, similar to the findings of Robinson et al.(30). In both studies, a greater proportion of the samples reportedly perceived being physically active and sedentary more frequently since the Covid-19 lockdown. Indeed, analysis from the IPAQ showed the majority of the present cohort reported being sufficiently physically active despite the restrictions in place during the Covid-19 lockdown. Therefore, despite some students perceiving their PA level having decreased, the majority of the population were still sufficiently physically active according to recommendations. This may be indicative of gym and pool closures, and restrictions altering the PA habits participants adhered to prior to the lockdown. Moreover, some participants would have become sufficiently active as a result of positively changing their activity habits, evident from the 40% of the sample that reported being more active since the start of the lockdown.

Some researchers expected a decrease in PA and an increase in sedentary behaviour due to the lockdown(137). In fact, during lockdown, some modified their lifestyles to counteract an increase in sitting time, by being more physically active(101). Some individuals may have realised their time spent sitting had increased, and thus compensated by increasing their exercise and activity habits, similar to the findings of a previous investigation of Spanish students(101). Romero Blanco et al. found students increased the amount of time and frequency of PA, alongside an increase in sedentary behaviour during the lockdown(101). However, Health Sciences students were used in the sample of Romero Blanco's study, and it is possible their knowledge and training in promoting healthy habits influenced their change in PA(101). These findings differ from a study of Canadian students, where PA decreased while sedentary behaviour increased during the Covid-19 lockdown(29). A possible explanation may be that students were no longer commuting to university, as the university transition to remote learning had already occurred(29).

The finding that the majority of students reportedly perceived negative changes to aspects of their mental wellbeing compared to before the Covid-19 lockdown is congruent to the current published literature using student samples(28,121,122,138). The studies of Meo et al. and Khan et al. investigated the impact of the Covid-19 lockdown on the mental wellbeing of students in Saudi Arabia and Bangladesh respectively(121,122). Meo et al. reported a decrease in perceived mental wellbeing in the population, which correlated to a perceived decrease in academic performance(122). Similarly, Khan et al. observed high rates of depression, anxiety and stress in their student population during the Covid-19 lockdown in Bangladesh(122). However, present findings suggest only a small portion of the sample had mental wellbeing considered 'low'. Therefore, despite an overarching perception of reduced

mental wellbeing since the Covid-19 lockdown, the magnitude of change was not enough to consider the majority of participants as having adverse mental wellbeing. In contrast, mental wellbeing continued to decrease throughout the Covid-19 lockdown in the UK in a longitudinal study of students(28). After 5 weeks in lockdown, mental wellbeing had significantly decreased(28). The average decrease in mental wellbeing score until the lifting of restrictions in the UK was 4 points on the WEMWBS, which exceeds the 3-point change that may indicate a meaningful decline(28). Caution must be taken when attributing changes in mental wellbeing directly to the Covid-19 lockdown, as other factors might have contributed to mental wellbeing during this time. For instance, the prevalence of depression and anxiety increases in students throughout the academic year, which culminates around the exam and coursework deadline period in May(139). Each university approached assessments differently as a result of the Covid-19 pandemic, calling upon novel methods such as open-book examinations and ‘no-detriment policies’ that students are unlikely to have experienced before(138). It is possible the uncertainty surrounding assessment has provoked a lapse in mental wellbeing in the student population. Completing assessments in a novel fashion may cause students to worry that the new modes of assessment may not capture their ability, and therefore induce anxiety regarding their academic success(138). Other potential causes for negative mental wellbeing during the lockdown may be attributed to individuals’ considering isolation an unpleasant experience, having to maintain seclusion from family and friends, losing the feeling of ‘freedom’, and experiencing fear regarding the spread of the disease and the health of themselves and loved ones(121).

3.6.1 Strengths and limitations

A strength of this study is that it is the first of its kind to assess a snapshot of, and the relationships between, dietary intake, eating behaviours, PA, and mental wellbeing simultaneously in a student population. This research is important as the findings develop the current understanding of student health-related behaviours and mental wellbeing. This study provides additional findings surrounding relationships between health-related behaviours and mental wellbeing that have been assessed sparsely in students at UK universities.

The study originality improves the current research base by providing evidence derived from valid and standardised measurements including the FFQ, the IPAQ, and the WEMWBS, which haven't been previously utilised together. All measures used in the present study were created for use in large epidemiological studies, and the findings herein are therefore easy to replicate and reproduce.

The AEB survey was used for the first time in a student population in the UK and was integral to the main findings of the study. This demonstrates the measurement's usefulness in studies of students, and the findings created a base of results to be used in future research.

The dietary intake variables (energy and fat intake) were expressed as relative values, which attributed reported relationships to interactions between variables, and limited the influence of participant characteristics.

It is important to consider that this study has some limitations. A small, convenience sample was used in the study. Despite efforts to increase participant uptake throughout the recruitment period during Covid-19 lockdown, the study was unable to uptake a sample of a similar size to the current published literature in this area. Data were collected during the spring term, in the lead-up to the examination period. Therefore, students may have been hesitant to participate as a result of being inundated with their own studies and felt participating may have encroached on their time(140). Consideration of the 12 respondents that were removed from the analysis for not completing the full survey or providing implausible data could support this. Hence, the findings reported in this study and comparisons made with previous literature within must be interpreted with caution. Subsequently, statistical limitations were present. For example, there should be a minimum of 10 observations per variable inputted in regression analysis, as supported by researchers, with some suggesting over 20-30 observations(141). The sample in the present study falls short of meeting the lower-bound of this assumption, and therefore weaken the power of the results discussed in this investigation. It is likely that the sample size was not large enough to detect meaningful statistical relationships between some or all of the variables in the present study and may provide cause for unexpected findings.

Questionnaire items that examined self-reported changes in health-related behaviours and mental wellbeing compared to before lockdown measured perceived change rather than actual change. Although analyses revealed the items were in-line with validated measurements of contemporary behaviour measured during lockdown (e.g. those that reported an increase in PA compared to before lockdown showed greater IPAQ-derived PA compared to others in the sample), the survey's retrospective nature makes it prone to socially desirable answering and recall bias(30). However, other research has used similar

perceived change measures, and it could be argued as a pragmatic solution to obtain change data without face-to-face objective measurement in response to an unexpected event(30,120). Measures of PA, dietary intake, eating behaviour, and mental wellbeing were subjective in nature as they were based on self-report so will be prone to bias(57). For example, subjective PA is typically subject to overestimation when compared with accelerometery(142). However, validated, and standardised methods (DHQ3, IPAQ, WEMWBS, & AEB) were used to maximise the likelihood of collecting the most accurate self-report data from participants for dietary intake, PA, mental wellbeing and eating behaviour. Finally, the present study did not account for participants with a history of clinical eating or mental health disorders. Therefore, it is possible that some participants may have skewed the findings, particularly in the relationship between mental wellbeing and eating behaviour, due to pre-existing clinical conditions and subsequent behaviours.

3.6.2 Implications and future research

This research was the first of its kind with regards to an investigation of dietary intake, eating behaviour, PA, and mental wellbeing in students studying in the UK. Although this initial research provided insight into the health-related behaviours and mental wellbeing of students at a UK university during the Covid-19 lockdown, ultimately the methodology must be replicated with a larger sample size to understand the current lifestyles of students in the UK. A larger sample would be indicative of a more generalised student population and would reduce the likelihood of statistical limitations. The findings from this hypothetical study may prove valuable in further understanding student health behaviour, and the subsequent development of health-benefitting interventions aimed at the population. Therefore, the structure and findings from the present study would be suitable to design a larger, confirmatory study(143).

The present findings add to the understanding of student health-related behaviours during the Covid-19 lockdown in the UK. There was no interaction effect of perceived lockdown health related-behaviour and mental wellbeing change on the relationship between mental wellbeing and overeating. This implies the relationship existed irrespective of perceived changes due to the lockdown. Future works could investigate eating behaviour using additional scales, such as the Dietary Control Scale of the AEB. This would provide an additional layer of understanding of the relationship observed herein, by investigating appetitive drive alongside dietary control with greater purpose and rigour than the present study. Moreover, future works should look to assess perceived eating behaviour changes relating to overeating and binge eating due to the lockdown, to understand if these behaviours have been impacted. Subsequently, the interactional relationship with mental wellbeing and eating behaviour should be assessed using the framework provided in this study to shed light on if this relationship can be attributed to perceived changes in behaviour since the Covid-19 lockdown.

Future research should investigate the prevalence of adverse eating behaviours and mental wellbeing, and the intervariable relationship, in an age-matched cohort of students and non-students i.e., a control / comparison group. This study would compare the instances of overeating, binge eating and accompanying mental wellbeing in those that are and are not attending university. Subsequent findings may inform the current understanding of how much life at university negatively affects the eating behaviours and mental wellbeing of students. Specifically, understanding if a problematic relationship between eating behaviours and mental wellbeing is specific to university students or perhaps a problem affecting young people irrespective of their education. Confounding results from this hypothetical study would illustrate this problematic relationship as an issue that needs to be

addressed by universities in the UK, or the UK government on a national scale, or perhaps both. The findings could inform future intervention-creating studies that are aimed at improving the eating behaviours and mental wellbeing of young adults regardless of their studentship.

The present study reported no association existed between mental wellbeing and total daily PA. It would therefore be prudent of future studies to break PA down into separate domains as implied in previous research, to strengthen the understanding of the degree of influence different types of PA can have on mental wellbeing in students.

3.6.3 Conclusions

This study aimed to explore and describe the current dietary intake, eating behaviours, physical activity and mental wellbeing of students attending university in the UK. Based on a quantitative analysis of self-reported variables, the majority of students were sufficiently physically active and exhibited normal mental wellbeing, although their diet quality was poor. Eating behaviour is related to mental wellbeing in students, and this relationship was not statistically significantly moderated by perceived Covid-19 lockdown-related changes in health-related behaviours and mental wellbeing. Finally, mental wellbeing was not associated with diet quality or physical activity in students. However, there are a number of design limitations that restrict confidence in and generalisability of the findings.

4.0 Thesis Summary

University students experience a unique combination of factors than can influence their health-related behaviours and mental wellbeing(9,10). However, research was yet to investigate student dietary intake, eating behaviours, physical activity, and mental wellbeing simultaneously. At present, published research has evidenced poor diet quality, low physical activity levels and adverse mental wellbeing in the population(9,27). A recent study reported negative changes to physical activity, sedentary behaviour, and mental wellbeing in students in the UK since the Covid-19 lockdown in the UK(28). Prior to the research present in this thesis, no published works had examined changes in diet quality since the lockdown in UK students. The aim of this thesis was to understand the state of health-related behaviours and mental wellbeing of students at university in the UK, and to contextualise the behaviours within the UK lockdown, during which the data was collected.

Initially, a systematic scoping review (Chapter 2) was undertaken to investigate the associations reported across the past 11 years between dietary intake and mental wellbeing in university students, and explore the methodological approach implemented in eligible studies. Subsequently, a cross-sectional study was conducted to explore the current dietary intake and eating behaviours, physical activity and mental wellbeing of students currently attending a university in the UK (Chapter 3).

The main findings of this thesis were as follows;

1. A positive association between components of mental wellbeing and a healthy dietary intake is present in current studies of university students.
2. Considerable methodological heterogeneity is present between current studies.
3. There are limited studies that utilise a measure of global mental wellbeing.
4. Students reported poor diet quality, but the majority were sufficiently physically active and reported good mental wellbeing.
5. Eating behaviour was related to mental wellbeing in students, and this relationship was present irrespective of perceived changes since the Covid-19 lockdown.
6. Diet quality and physical activity level were not related to mental wellbeing in the sample.

4.1 **Practical Implications**

The finding that students have a poor diet quality outlines a need for UK universities to provide more dietary support to students. University policy should include greater efforts to increase the variety of healthy food options available on campus and lower the costs of the healthy foods where possible. Improving the access to healthy foods is a tangible change that universities implement to increase student diet quality. Moreover, education on the importance of a healthy diet should be available to all students where possible, and not limited to students of health-related degrees. To the same point, university policy could organise cooking skills classes, to develop student cooking ability, and perhaps decrease snacking, fast-food, and ready-meal consumption in the population.

Students with poorer eating behaviours had worse mental wellbeing. This finding suggests the need for more effective support of disordered eating and mental wellbeing issues that students face during their time in university. Support that focuses on specific social, psychological, and environmental predisposing factors that influence disordered eating in the population, will benefit student eating behaviours, and subsequently improve mental wellbeing. For example, university policy should include constant psychological support with a focus on improving mindful eating, and utilising other, less harming methods to cope with adverse mental wellbeing than overeating and binge eating. Further, UK universities could utilise preventative behavioural treatment plans that include mindful eating interventions in students concerned about their eating behaviour and mental wellbeing.

4.2 **Thesis limitations**

Limitations were present as a result of the ongoing COVID-19 lockdown in the UK. Chapter 2 synthesised current literature and found the base to be very limited. The absence of emerging literature in this area is likely partly due to the demand for studies focused on the Covid-19 pandemic. Therefore, some researchers may have altered their studies to fill this topical demand with more focus on the Covid-19 pandemic, subsequently reducing the relevance to the review in Chapter 2. It is also likely the lockdown affected participant uptake for Chapter 3, where online-based methods were used as face-to-face recruitment strategies were impossible, due to lockdown restrictions.

Chapter 2 identified only two studies that used a global mental wellbeing score to assess mental wellbeing(27,44). The other studies assessed components of mental wellbeing, specifically: positive, and negative affect, life satisfaction, quality of life, and eudaemonic wellbeing. Although each component represents an important contributor to mental wellbeing, they are different in nature and application. Mental wellbeing is a complex construct that is influenced by these components. Therefore, only once assessed together as one entity can the components inform an accurate overall inference of mental wellbeing, such as in the form of a global mental wellbeing score(102). This epitomises the primary limitation of the studies included in the review, as the power of the findings with regards to overall mental wellbeing is less than it would be had the research utilised a measure of global mental wellbeing.

A limitation of the findings in Chapter 2 is the methodological heterogeneity in eligible studies. This occurred as the research area is in its infancy, and only a limited number of studies have been published. As such, despite similar themes and opinions amongst the literature, conclusions of the review are weekend due to a lack of consistency between measures used to collect data. However, efforts were made to present reliable findings, including following stringent eligibility criteria, and describing, rather than discussing analytical findings of the literature.

A population of students from one university in the UK was investigated. Findings presented herein therefore represent that of students at one university, and subsequently do not represent findings that can be generalised to the wider UK student population. Chapter 3 did not include a control population i.e., an age-matched group of non-students, which would have provided valuable insight into if reported findings were related specifically to students, or young-adults in general.

The most significant limitation of Chapter 3 is that of the small sample size. Ideally, this study would have adopted a sample of greater than 70, to reduce statistical limitations. Similar studies identified in Chapter 2 were conducted with samples of between 73 – 599, outlining a greater sample size would have improved the power of the present study. Despite efforts to increase participant uptake during the Covid-19 lockdown, including mass emailing and advertisement, the study was unable to uptake a sample similar to that of the comparable current published literature. However, validated, and standardised measures were used to maximise the likelihood of obtaining reliable data.

Chapter 3 did not account for participant with a clinical history of eating disorders or mental health disorders. It is therefore possible that some participants may have skewed the findings as a relationship between eating behaviours and mental wellbeing could have been present due to pre-existing clinical conditions that were unaccounted for.

4.3 **Future research directions**

The findings of the systematic scoping review outline the requirement for greater consistency in future studies in this area. Further research would usefully include consideration for greater consistency in the measurement of dietary intake, with the most accurate option to utilise a FFQ, which provides greater detail and validity than the FD-24 method. In future studies, the assessment of mental wellbeing would benefit from being derived, analysed, and discussed, from a measure of global mental wellbeing that encompasses different mental wellbeing components within one measurement.

Albeit the thesis has some limitations, the experimental study in particular could effectively serve as a template to design a larger, confirmatory study. The implementation of a larger sample size more generalisable to the student population in the UK would reduce the statistical and comparative limitations at present. This theoretical study could improve the power of the present findings and allow for more reliable comparisons between previous and future works surrounding student health-related behaviours in the UK.

The tools used to derive the findings within this thesis, specifically, the DHQ3 FFQ, IPAQ and WEMWBS were used because they are valid and reliable measurement methods as evidenced by recent studies. Future works should show good scientific rigour by utilising these tools, as they provide reliable and highly comparable results.

Future research should investigate the prevalence of adverse eating behaviours and mental wellbeing, and the intervariable relationship, in an age-matched cohort of students and non-students. Subsequent findings may inform the current understanding of how much life at university negatively affects the eating behaviours and mental wellbeing of students. Confounding results from this hypothetical study would illustrate this problematic relationship as an issue that needs to be addressed by UK universities, or the British government on a national scale, or perhaps both. The findings could inform future intervention-creating studies that are aimed at improving the eating behaviours and mental wellbeing of young adults regardless of their studentship.

4.4 **Conclusion**

The work contained in this thesis has contributed within two distinct areas.

Considerable methodological heterogeneity exists at present in studies that assess the association between dietary intake and mental wellbeing in students. Albeit different data collection methods were used, the majority of studies agree a better-quality diet equates to better mental wellbeing in students. Future works should be more consistent with their methodology compared to previous studies, to be able to draw more powerful conclusions generalisable to the student population.

Second, students studying in the UK during the Covid-19 lockdown have inadequate diet quality but are sufficiently physically active and have good mental wellbeing. In contrast to the findings of Chapter 2, not diet quality, but eating behaviour has the more profound relationship to mental wellbeing in students studying in the UK. However, this can only be concluded for measures used in this study, as it is possible different dietary intake, physical activity or mental wellbeing measures may have shown statistically significant relationships. Moreover, eating behaviour and mental wellbeing were related irrespective of the Covid-19 lockdown. Mental wellbeing was not associated with diet quality or physical activity in students. Although, a number of design limitations restrict confidence in and generalisability of the findings. This study should inform a future larger, confirmatory study that will add to the limited research base.

5.0 References

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6.0 Appendices

Appendix A.

Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a scoping review.	Page 16.
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	N/A.
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	Pages 16-18.
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	Page 18.
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	Page 19.
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	Pages 19-20.
Information sources*	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	Page 20.
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	Page 20.
Selection of sources of evidence†	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	Page 21.
Data charting process‡	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	Page 22.
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	Page 22.

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
Critical appraisal of individual sources of evidence	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	N/A.
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	Page 22.
RESULTS			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	Page 23.
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	Pages 23-24.
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	N/A.
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	Page 24.
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	Page 33.
DISCUSSION			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	Pages 35-43.
Limitations	20	Discuss the limitations of the scoping review process.	Pages 43-44.
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	Page 45
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	N/A.

Appendix B.

The 8-item Appetitive-Drive subscale of the Addiction-Like Eating Behaviour Scale question block.

	Never	Rarely	Sometimes	Most of the time	Always
I continue to eat despite feeling full					
I serve myself overly large portions					
I find it difficult to limit what/how much I eat					
Once I start eating certain foods, I can’t stop until there is nothing left					
When it comes to food, I tend to overindulge					
I binge eat					
I eat until I feel sick					
I tend to overeat					

Appendix C.

Perceived behaviour changes since Covid-19 lockdown question block

Compared to before the COVID-19 lockdown in the UK, I have:

	A lot less	Less	A little less	The same amount	A little more	More	A lot more
Eaten a healthy and balanced diet							
Snacked							
Dieted / fasted							
Skipped meals							
Exercised							
Been physically active (e.g. gardening, housekeeping, walking)							
Spent time sitting down							
Drank alcohol							
Got a good night's sleep							

Compared to before the COVID-19 lockdown in the UK, I have:

	Never	Rarely	Sometimes	Most of the time	Always
Felt optimistic about the future					
Felt useful					
Felt relaxed					
Felt able to deal with problems well					
Felt able to think clearly					
Felt close to other people					

Perceived mental wellbeing changes since Covid-19 lockdown question block