Sex-Specific Physical Activity Levels and Energy Intake in US Young Adults with Depression: National Health and Nutrition Examination Survey 2017 – 2020 Pre-Pandemic Data

PAAH
PHYSICAL ACTIVITY AND HEALTH

RESEARCH

]u[ubiquity press

YOUNGJUN LEE
JANET HAUCK
DARICE BROOKS

*Author affiliations can be found in the back matter of this article

ABSTRACT

Background: Rising depression rates among young adults pose significant public health concerns. Engaging in physical activity (PA) can exert antidepressant effects. And there is a prevalent association between depression and unhealthy dietary habits.

Aims: We explored the intricate relationships between physical activity (PA), energy intake, depression, and potential sex disparities.

Methods: Using National Health and Nutrition Examination Survey data from March 2017 to the pre-pandemic period in 2020. Our sample encompassed 750 young adults aged 18–24, including 381 men.

Results: Significant interaction effects between sex and depression emerged, notably in vigorous recreation activity ($F(1, 749) = 24.089$, $p < 0.001$). Both men and women with depression spent significantly less time in such activities than non-depressed individuals ($p < 0.001$). Significant interaction effects between sex and depression emerged, notably in protein intake ($F(1, 749) = 8.830$, $p < 0.001$). Both men and women with depression exhibited significantly lower protein intake than non-depressed individuals ($p < 0.01$).

Conclusions: Our investigation of US young adults highlighted marked disparities in depression prevalence, low vigorous recreational activity, and low protein intake, contingent upon the individual's sex. These findings underscore the significance of designing targeted physical activity and nutrition interventions based on specific sex considerations.

CORRESPONDING AUTHOR:
Youngjun Lee
Michigan State University, US
leeyou72@msu.edu

KEYWORDS:
physical activity; energy intake; young adult; mental health

TO CITE THIS ARTICLE:
Lee, Y., Hauck, J., & Brooks, D. (2023). Sex-Specific Physical Activity Levels and Energy Intake in US Young Adults with Depression: National Health and Nutrition Examination Survey 2017 – 2020 Pre-Pandemic Data. *Physical Activity and Health*, 7(1), pp. 332–344. DOI: https://doi.org/10.5334/paah.305

1. INTRODUCTION

The stage of emerging adulthood is marked by several transformative changes in both personal development and the surrounding environment. These changes include increased responsibilities, adapting to novel roles, and navigating life-altering circumstances (Hochberg & Konner, 2020). Emerging adults may encounter greater challenges in dealing with fatigue and concentration issues compared to older adults who are not confronted with similar work and parenting demands. Furthermore, research has indicated that emerging adults may be particularly vulnerable to mental health issues due to the unique challenges they face during this transformative stage (Stallman et al., 2010). The demands of increased responsibilities, adapting to new roles, and navigating life-altering circumstances may contribute to unhealthy lifestyles and a range of emotional lifestyles among emerging adults (Chen et al., 2017; Sofija, 2020), indicating a potential link between unhealthy lifestyle habits and emotional functioning (Keyes, 2005). Therefore, adopting healthy lifestyle practices may play a crucial role in promoting mental well-being and overall health among young adults.

Depression is a common and enduring disorder that can have adverse effects on an individual's mental, emotional, and physical health. Research has demonstrated that depressive episodes can cause a decline in overall well-being, particularly when recurrent depressive episodes occur, leading to elevated risk of mortality. As per the World Health Organization (WHO), depression presently stands as the primary cause of disability on a global scale and holds the fourth position among the major contributors to the overall disease burden (*Depression*, 2019). Particularly noteworthy is the rapid increase in depression rates among the youth population compared to older age groups (Weinberger et al., 2018). Mojtabai et al. found that almost one in every 11 adolescents and young adults experience a major depressive episode each year, and this prevalence has risen between 2005 and 2014 (Mojtabai et al., 2016).

Introducing the concept of physical activity, which encompasses any skeletal muscle movement requiring energy expenditure (Caspersen et al., 1985), sets the stage for understanding its potential impact on mental health. A recent meta-analysis, examining 49 prospective cohort studies, revealed that individuals engaging in high levels of PA experienced a 17% reduced risk of depression (OR = 0.83, CI = 0.79, 0.88) compared to those with lower levels of PA (Schuch et al., 2018). Mckercher et al. found that young women who engaged in longer durations of recreational and ambulatory PA were less likely to have a suicide plan (McKercher et al., 2013). Additionally, in the context of young adulthood, cross-sectional data indicates a correlation between recreational PA and depression (McKercher et al., 2009). Recent research has provided promising evidence, indicating that exercise and PA can yield positive effects on depression symptoms comparable to those of antidepressant medications (Babyak et al., 2000; Blumenthal et al., 2007).

Recent research has indicated that modifiable factors, such as energy intake, play a role in the development of mental health disorders. The relationship between energy intake and depression is complex; however, a prevailing consensus suggests a positive association between depression and unhealthy dietary habits (Jacka et al., 2015; Weng et al., 2012). Numerous studies have provided evidence supporting the notion that the energy intake quality significantly influences the susceptibility to various diseases, including mental disorders such as depression and anxiety (Khalid et al., 2016; Lassale et al., 2019; Sanchez-Villegas et al., 2009; Sanchez-Villegas et al., 2012) in a negative way. Observational and efficacy data within the domain of Nutritional Psychiatry indicate that adopting healthy dietary patterns can influence both the likelihood of experiencing depression and the management of depressive symptoms (Adan et al., 2019; Jacka et al., 2017; Lassale et al., 2019; Marx et al., 2017). Furthermore, a multitude of studies present compelling evidence linking poor dietary patterns and increased vulnerability to depression (Lai et al., 2014). In other words, these studies suggest that poor energy intake quality is linked to an increased vulnerability to mental health disorders. As we evolve our knowledge of dietary patterns and increased vulnerability to depression, we must consider adolescence and young adults. These developmental stages play a pivotal role in establishing health behaviors, including dietary habits, which are likely to endure into adulthood (Kessler et al., 2005).

There is concern that the coronavirus disease 2019 (COVID-19) pandemic has negatively impacted depressive and anxiety symptoms (Amsalem et al., 2021; Holmes et al., 2020; Pfefferbaum & North, 2020), especially among young adults aged 18-25 years (Fancourt et al., 2020; Lai et al., 2020; McGinty et al., 2020; Qiu et al., 2020). Given the detrimental effects of

DOI: 10.5334/paah.305

depression on mental well-being (Moussavi et al., 2007), it is imperative to explore potentially modifiable factors that may influence depression, while also providing the most up-to-date information before these unique pandemic periods (March 11, 2020 – May 11, 2023 (Health & Services, 2023; Ryan, 2021)) began, thereby establishing a baseline point for comparing pandemic-related phenomena. However, conducting large cohort studies to evaluate PA levels and energy intake by sex and depression in young adults may not be entirely appropriate due to variations in their lifestyles and sex-related factors. To address these concerns, the present study aimed to analyze disparities in PA levels and energy intake based on sex and depression status among young adults in the United States, utilizing data from the National Health and Nutrition Examination Survey (2017–2020 Pre-Pandemic Data).

2. METHODS

2.1. SAMPLE AND DESIGN

The National Health and Nutrition Examination Survey (NHANES) is a nationwide survey designed to assess the health and nutritional well-being of the U.S. population living in community settings yearly. Approximately 5,000 individuals in diverse locations across the U.S participate in the data collection process which consists of questionnaires, physical and psychological exams, and laboratory exams. Further details about the NHANES data collection and survey instruments can be found in other sources (*National Health and Nutrition Examination Survey*). The present research study utilized cross-sectional data extracted from NHANES during the period of 2017 to 2020, conducted by the Centers for Disease Control and Prevention (CDC) before the onset of the COVID-19 pandemic. It is important to note that NHANES data is updated every three years, thus data collection for the NHANES 2019–2020 cycle is still ongoing, leading to a non-nationally representative dataset. Consequently, data collected from 2019 to March 2020 were combined with the NHANES 2017–2018 cycle to establish a nationally representative sample covering the NHANES data from 2017 to March 2020, pre-pandemic. Ethical approval for this study was obtained from the National Center for Health Statistics (NCHS) Review Board under the protocol numbers #2011–17 and 2018–01, and all survey participants provided informed consent during collection of data included in this analysis. Following the anonymization process, the NHANES data becomes accessible to the public, allowing researchers to convert the data into a format suitable for study. We commit to adhering to the specified guidelines for data usage in the study, ensuring that the data is solely employed for statistical analysis and that all experiments are conducted in accordance with relevant standards and regulations.

Between 2017 and 2020, a total of 15,560 individuals took part in the health interview survey, nutrition survey, and health examination. Among these participants, 14,414 were excluded due to age, being either under 18 years old or over 24 years old, resulting in a remaining sample size of 1,146 individuals aged between 18 and 24 years. Many societies recognize the age of 18 as the legal age of adulthood, granting individuals certain rights and responsibilities such as voting and legal autonomy (Bertram, 2020). The age of 24 is often associated with the completion of undergraduate education for many individuals. These societal milestones make the chosen age range particularly relevant for examining the experiences and behaviors associated with the transition to adulthood. In addition, previous research in various fields, including psychology, sociology, and public health, often employs the age range of 18 to 24 when studying young adults (Cuellar et al., 2020; Mitchell et al., 2017; Newman & Zainal, 2020). This allows for comparability across studies and contributes to a cohesive understanding of this specific life stage. Further exclusions were made for participants with missing data on anthropometric measurements, health examination, and physical activity (refer to Figure 1). Ultimately, the study included 750 young adults in the final cohort. Table 1 displays the analyzed characteristics of the participants based on their sex.

2.2. DEPRESSION

NHANES employed the Patient Health Questionnaire (PHQ-9) as a screening tool for depression to determine its presence or absence. Participants were scored between 0 and 3 based on their responses to symptom-related questions, which offered response options such as “not at all,” “several days,” “more than half the days,” and “nearly every day.” The severity of depression is determined based on the sum of responses to each question on the PHQ-9 screening tool.

Scores ranging from 1 to 4 are categorized as "Minimal depression," while scores between 5 and 9 indicate "Mild depression." "Moderate depression" is classified for scores between 10 and 14, "Moderately severe depression" for scores between 15 and 19, and "Severe depression" for scores between 20 and 27. The PHQ-9 tool includes depression criteria derived from the DSM-IV (Brenner et al., 1999). For the purpose of this study, a total score of 15 or higher was utilized as the threshold to identify the presence of depression, with scores above this threshold indicating more than moderate depression.

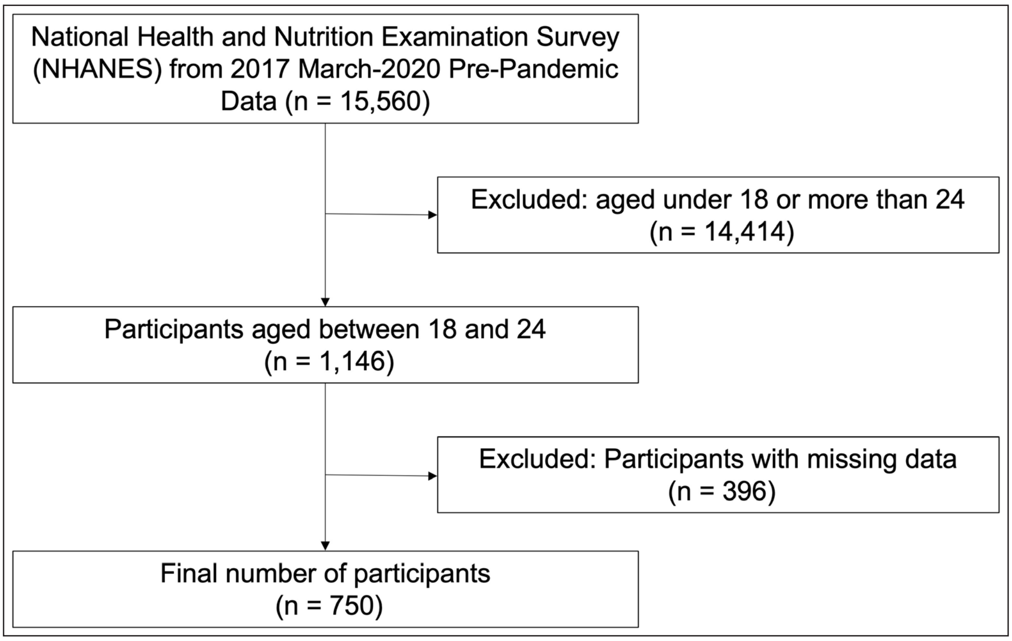

Figure 1 Flow diagram for the selection of study participants.

	TOTAL (n = 750)			MEN (n =381)			WOMEN (n =369)		
	NON-DEP (n = 670)	DEP (n = 80)	*p*-VALUE	NON-DEP (n = 354)	DEP (n = 27)	*p*-VALUE	NON-DEP (n = 316)	DEP (n = 53)	*p*-VALUE
Age (years)	21.3 ± 0.1	21.1 ± 0.3	0.338	21.3 ± 0.1	20.6 ± 0.4	0.069	21.4 ± 0.1	21.3 ± 0.3	0.873
Height (cm)	169.0 ± 0.5	167.3 ± 1.5	0.287	175.2 ± 0.5	175.9 ± 2.1	0.754	162.5 ± 0.6	162.6 ± 1.1	0.939
Body weight (kg)	77.3 ± 1.4	84.6 ± 3.8	**0.047***	84.2 ± 1.7	88.4 ± 6.2	0.474	70.1 ± 2.2	82.5 ± 4.3	**0.002****
BMI (kg/m^2)	27.0 ± 0.5	30.3 ± 1.4	**0.022***	27.3 ± 0.5	29.0 ± 2.4	0.503	26.6 ± 0.8	31.1 ± 1.5	**0.002****
Alcohol (%)	4.7 ± 0.9	13.5 ± 4.1	**0.005****	6.8 ± 1.3	30.5 ± 10.4	**0.001****	2.5 ± 1.2	4.3 ± 2.6	**0.496**
Smoking (%)	22.0 ± 2.7	41.4 ± 6.6	**0.009****	30.9 ± 3.3	51.2 ± 12.7	0.125	13.0 ± 2.7	36.1 ± 8.7	**0.004****

Table 1 Descriptive Characteristics of the Participants according to the Presence of Depression and Sex.

2.3. PHYSICAL ACTIVITY

The Global Physical Activity Questionnaire (GPAQ) comprised of 16 questions is used to evaluate PA in distinct domains, including work, transport, and recreational activities. The questionnaire assesses five specific domains of PA: vigorous-intensity work, moderate-intensity work, transport-related activities, vigorous-intensity recreation, and moderate-intensity recreation. Participants were asked to provide their responses for each domain without being given specific options concerning the frequency or duration of their PA. Data collected through the questionnaire were analyzed using the guidelines provided by the World Health Organization (WHO) for GPAQ analysis (*Global physical activity questionnaire (GPAQ) analysis guide. Geneva: World Health Organization*, 2012). Based on our calculations, individuals' caloric consumption was approximately four times higher during moderate PA and eight times higher during vigorous PA, in comparison to when they were sedentary. To determine the total energy expenditure of participants using the GPAQ data, we attributed four metabolic equivalents (METs) to the duration of moderate activity and eight METs to the duration of vigorous activity.

- Vigorous intensity activity: occupational (MET) = 8.0 × vigorous intensity physical activity (day/week) × 1-day vigorous intensity physical activity (minutes/day)
- Moderate intensity activity: occupational (MET) = 4.0 × moderate intensity physical activity (day/week) × 1-day moderate intensity physical activity (minutes/day)

- Vigorous intensity activity: recreational (MET) = 8.0 × vigorous intensity physical activity (day/week) × 1-day vigorous intensity physical activity (minutes/day)
- Moderate intensity activity: recreational (MET) = 4.0 × moderate intensity physical activity (day/week) × 1-day moderate intensity physical activity (minutes/day)
- Transport (MET) = 4.0 × transport physical activity (day/week) × 1-day transport physical activity
- Total Physical Activity (MET) = vigorous intensity activity: occupational + moderate intensity activity: occupational + vigorous intensity activity: recreational + moderate intensity activity: recreational + transport.

In this study, participants' PA levels were categorized into four groups based on their MET (metabolic equivalent) minutes per week: inactive (0–249 MET min/week), somewhat active (250–499 MET min/week), active (500–999 MET min/week), and very active (>1000 MET min/week). These categories were determined using well-established thresholds for PA (Olson et al., 2023).

2.4. ENERGY INTAKE

NHANES assessed nutritional outcomes using a 24-hour recall method, involving in-home interviews with participants, followed up by phone. The interviews took place in private rooms equipped with measuring tools and guides to facilitate accurate reporting of food intake amounts. Skilled interviewers utilized a computer-assisted dietary interview system, incorporating an automated multiple-pass method with standardized probes (Moshfegh et al., 2008), to collect information about the type and amount of all foods and beverages consumed on the day preceding the recall interview. The analysis focused on the daily intake of total energy, carbohydrates, proteins, and fats. Energy intake was measured in kcal, with carbohydrates and proteins calculated as 4 kcal per 1 g and fat as 9 kcal per 1 g. To ensure data accuracy, a sensitivity analysis was conducted to identify participants who were either low-energy reporters or over-energy reporters, applying the Goldburg cut-off. For one recall day, the lower 95% cut-off was 0.87, while the upper 95% cut-off was 2.75 (Black, 2000). In this study, energy intake was classified by dividing it by the estimated energy requirement (EER). The EER represents the average dietary energy intake necessary to maintain energy balance in healthy individuals of specific age, gender, weight, height, and PA level consistent with good health. To calculate the EER, we utilized the Institute of Medicine (IOM) equations based on body mass index, age, and sex. The Physical Activity Levels (PAL) were then employed to estimate energy requirements and predict various levels of PA. Values below 20% of EER (<0.8) were categorized as lower intake, while values above 1.2 were considered higher (Wang et al., 2008).

2.5. STATISTICAL ANALYSIS

In this study, continuous variables were presented as means and standard errors. The Kolmogorov-Smirnov test was utilized to examine the normal distribution of outcome-variable data. An independent t-test was conducted to compare PA levels and energy intake between the non-depressed and depressed groups between men, women, and the total sample. Two-way analyses of variance (ANOVA) were applied to assess the differences in PA levels and energy intake among participants with and without depression, as well as between sex. Effect sizes were calculated using partial eta-squared ($\eta 2$). If the two-way ANOVA revealed a significant interaction effect, the Bonferroni post-hoc test was employed to compare the sex-specificity of dependent variables within each group (with and without depression) separately. IBM SPSS version 26.0 for Windows was used for all statistical analyses, and the significance level was set at 0.05.

3. RESULTS

3.1. PA LEVELS AND ENERGY INTAKE FACTORS BY SEX

Table 2 presents the average values of PA levels and energy intake factors by sex and total sample. It offers a comprehensive overview of PA levels and energy intake factors, meticulously categorized by sex. The PA factors were classified into four levels: "Inactive," "Somewhat active," "Active," and "Very active." The frequency distribution was examined according to sex. Among the 18–24 age group of young adults, 589 participants were categorized as "Very active" (327 men and 262 women), while the remaining participants belonged to "Inactive," "Somewhat active," and "Active." There were 161 participants in total (54 men and 107 women) in the other three categories. Regarding energy intake factors, they were divided into three levels based on estimated energy requirements (EER), and the frequency distribution was also analyzed according to sex. In the 18–24 age group, 519 participants classified as "Lower energy intake" (261 men and 258 women), while the remaining young people belonged to "Moderate energy intake" and "Higher energy intake," with a total of 105 participants (48 men and 57 women).

FACTORS	TOTAL	n	MEN	n	WOMEN	n
Physical activity factors	**MET min/Week (Mean ± SE)**					
Inactive (0–249 MET min/week)	26.5 ± 8.4	92	17.1 ± 9.8	29	31.6 ± 10.0	63
Somewhat active (250–499 MET min/week)	400.9 ± 17.7	26	413.9 ± 28.7	9	392.0 ± 19.4	17
Active (500–999 MET min/week)	763.3 ± 21.2	43	763.8 ± 28.9	16	763.1 ± 23.3	27
Very active (>1000 MET min/week)	8474.2 ± 466.0	589	10133.1 ± 722.4	327	6644.8 ± 328.8	262
Energy intake factors	**Energy intake/EER (Mean ± SE)**					
Lower energy intake (energy intake/EER < 0.8)	0.4 ± 0.0	519	0.4 ± 0.0	261	0.4 ± 0.0	258
Moderate energy intake (0.8 ≤ energy intake/EER ≤ 1.2)	0.9 ± 0.0	81	0.9 ± 0.0	36	0.9 ± 0.0	45
Higher energy intake (energy intake/EER > 1.2)	1.5 ± 0.0	24	1.4 ± 0.1	12	1.5 ± 0.1	12

Table 2 Classification of Physical Activity Levels and Energy Intake.

Values are expressed as means ± standard errors. MET = metabolic equivalents of task, EER = estimated energy requirements.

3.2. EXPLOREING THE INTERPLAY OF DEPRESSION, SEX, AND PHYSICAL ACTIVITY PATTERNS

Transitioning to Table 3, we delve into the intriguing associations between PA, depression, and sex. Table 3 displays the differences in PA levels between individuals with and without depression, as well as by sex. For the entire group, a significant difference was observed in "Vigorous Recreational Activity" ($p < 0.001$) between individuals with and without depression. Moreover, a significant interaction between the presence or absence of depression and sex was found for the PA aspects of "Vigorous Recreational Activity" ($p < 0.001$) and "Moderate Recreational Activity" ($p < 0.01$). Further analysis with the Bonferroni post-hoc test revealed specific group differences. Men with depression exhibited significantly lower levels of "Vigorous Recreational Activity" ($p < 0.001$) compared to their counterparts without depression. Similarly, women with depression had significantly lower levels of "Vigorous Recreational Activity" ($p < 0.001$) than women without depression. Additionally, women without depression demonstrated significantly lower levels of "Vigorous Recreational Activity" ($p < 0.001$) than men without depression. On the other hand, men with depression had significantly higher levels of "Moderate Recreational Activity" ($p < 0.01$) than men without depression, while women without depression showed significantly lower levels of "Moderate Recreational Activity" ($p < 0.01$) than men without depression. Finally, women with depression exhibited significantly lower levels of "Moderate Recreational Activity" ($p < 0.001$) compared to men with depression.

3.3. EXPLOREING THE INTERPLAY OF DEPRESSION, SEX, AND ENERGY INTAKE PATTERNS

In Table 4, our focus shifts to the intricate relationship between PA, depression, and energy intake. Table 4 presents the differences in energy intake between individuals with and without depression, as well as by sex. In the entire group, individuals with depression exhibited significantly lower energy intake than those without depression. Specifically, there were significant differences for "Total energy intake" ($p < 0.01$), "Carbohydrate intake" ($p < 0.05$), "Protein intake" ($p < 0.001$), and "Fat intake" ($p < 0.05$). Moreover, a significant interaction between the presence or absence of depression and sex was observed for "Total energy intake," "Carbohydrate intake," "Protein intake," and "Fat intake." Further analysis with the Bonferroni post-hoc test showed specific group differences. Men with depression had significantly lower "Total energy intake," "Carbohydrate intake" (all $p < 0.05$), and "Protein intake" ($p < 0.01$) than men without depression. On the other hand, women with depression had significantly lower "Protein intake" ($p < 0.01$) than women without depression. Additionally, women without depression exhibited significantly lower "Total energy intake," "Carbohydrate intake," "Protein intake" (all $p < 0.001$), and "Fat intake" ($p < 0.01$) than men without depression.

PHYSICAL ACTIVITY (MET MIN/WEEK)	GROUP	TOTAL	SEX		ANOVA			
			MEN	WOMEN	*F*-VALUE		*p*-VALUE (η^2)	POWER
Vigorous Work	Non-Dep	2538.6 ± 258.0	3620.4 ± 205.3	1237.4 ± 207.1	S	**11.203*** **	0.000(0.001)	0.992
	Dep	2553.1 ± 851.5	3305.0 ± 683.4	2143.2 ± 504.6	D	1.614	0.204(0.000)	0.246
	p-value	0.988			S × D	1.099	0.333(0.000)	0.245
Moderate Work	Non-Dep	2108.1 ± 231.0	2526.263 ± 117.2	1682.3 ± 118.3	S	**34.599*** **	0.000(0.004)	1.000
	Dep	2564.4 ± 460.5	3466.6 ± 390.3	2072.6 ± 288.2	D	**12.642*** **	0.000(0.001)	0.945
	p-value	0.380			S × D	0.612	0.542(0.000)	0.153
Transport	Non-Dep	271.1 ± 35.0	346.0 ± 38.0	194.7 ± 38.4	S	1.251	0.286(0.000)	0.274
	Dep	321.4 ± 93.3	329.1 ± 126.5	317.1 ± 93.4	D	2.051	0.152(0.000)	0.299
	p-value	0.636			S × D	0.643	0.526(0.000)	0.159
Vigorous Recreational Activity	Non-Dep	1557.8 ± 144.1	1831.8 ± 55.4	1278.8 ± 55.8‡‡‡	S	**63.411*** **	0.000(0.008)	1.000
	Dep	546.5 ± 139.9	528.2 ± 184.3†††	556.4 ± 136.1†††	D	**76.588*** **	0.000(0.005)	1.000
	p-value	< **0.001*** **			S × D	**24.089*** **	0.000(0.003)	1.000
Moderate Recreational Activity	Non-Dep	460.9 ± 50.6	539.7 ± 33.9	380.6 ± 34.2‡‡	S	**28.061*** **	0.000(0.004)	1.000
	Dep	576.0 ± 135.2	923.7 ± 112.7††	386.5 ± 83.2‡‡‡	D	**6.774** **	0.009(0.000)	0.740
	p-value	0.476			S × D	**5.041** **	0.006(0.001)	0.819
Total Physical Activity	Non-Dep	7645.9 ± 416.6	9561.2 ± 424.9	5607.8 ± 438.3	S	**9.931*** **	0.000(0.003)	0.985
	Dep	7275.2 ± 1141.8	9382.0 ± 1426.5	6107.4 ± 1062.0	D	0.379	0.538(0.000)	0.094
	p-value	0.753			S × D	0.259	0.772(0.000)	0.091

Table 3 Levels of Physical Activity according to the Presence of Depression and sex.

Values are expressed as means standard errors; Dep, depression. Main effect = S (Sex) and D (Depression), Interaction effect = S × D (Sex × Depression), * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, † $p < 0.05$, †† $p < 0.01$, ††† $p < 0.001$ compared with Non-Dep values, ‡ $p < 0.05$, ‡‡ $p < 0.01$, ‡‡‡ $p < 0.001$ compared with men's values. Two-way analysis of variance following Bonferroni post-hoc test.

FACTORS	GROUP	TOTAL	SEX		ANOVA			
			MEN	WOMEN	*F*-VALUE		*p*-VALUE (η^2)	POWER
Total energy intake (kcal)	Non-Dep	2178.6 ± 56.6	2044.7 ± 52.6	1665.1 ± 52.8‡‡‡	S	**7.904*** **	0.000(0.001)	0.954
	Dep	1806.6 ± 126.6	1946.6 ± 284.9†	1540.2 ± 207.7	D	**6.113***	0.013(0.000)	0.696
	p-value	**0.009** **			S × D	**6.150** **	0.002(0.001)	0.891
Carbohydrate intake (kcal)	Non-Dep	1003.4 ± 23.5	1096.4 ± 51.9	902.0 ± 28.6‡‡‡	S	**7.156*** **	0.000(0.001)	0.933
	Dep	846.4 ± 68.2	893.1 ± 114.9†	828.8 ± 85.5	D	**4.521***	0.034(0.000)	0.566
	p-value	**0.032***			S × D	**4.567***	0.010(0.001)	0.777
Protein intake (kcal)	Non-Dep	337.0 ± 13.0	373.0 ± 22.9	297.6 ± 8.5‡‡‡	S	**8.816*** **	0.000(0.001)	0.972
	Dep	251.1 ± 16.4	285.4 ± 26.5††	238.2 ± 19.5††	D	**13.909*** **	0.000(0.001)	0.962
	p-value	<**0.001*** **			S × D	**8.830*** **	0.000(0.001)	0.972
Fat intake (kcal)	Non-Dep	798.7 ± 24.3	841.8 ± 44.6	751.6 ± 21.7‡‡	S	2.956	0.052(0.000)	0.577
	Dep	684.3 ± 56.5	727.2 ± 62.3	668.2 ± 76.9	D	2.788	0.095(0.000)	0.386
	p-value	0.064			S × D	**3.737***	0.024(0.001)	0.686

Table 4 Energy Intake according to the Presence of Depression and sex.

Values are expressed as means standard errors; Dep, depression. Main effect = S (Sex) and D (Depression), Interaction effect = S × D (Sex × Depression), * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, † $p < 0.05$, †† $p < 0.01$, ††† $p < 0.001$ compared with Non-Dep values, ‡ $p < 0.05$, ‡‡ $p < 0.01$, ‡‡‡ $p < 0.001$ compared with men's values. Two-way analysis of variance following Bonferroni post-hoc test.

4. DISCUSSION

This research study aimed to explore variations in levels of PA and energy intake based on sex-specific differences and the presence of depression among young adults in the United States. The objective was to gain insights into the interplay between these variables. Regarding PA levels, a noteworthy discrepancy in "Vigorous Recreational Activity" ($p < 0.01$) emerged between individuals with and without depression. When stratified by sex, both men and women with depression displayed significantly reduced engagement in "Vigorous Recreational Activity" ($p < 0.01$) compared to the non-depressed counterparts, individually. In relation to energy intake, it was observed that young adults experiencing depression had notably lower energy consumption than those not experiencing depression. Upon sex-based analysis, men with depression exhibited notably diminished "Total Energy Intake," "Carbohydrate Intake" ($p < 0.05$), and "Protein Intake" ($p < 0.01$) in comparison to the non-depressed men counterparts. Similarly, women with depression had significantly lower "Protein Intake" ($p < 0.01$) compared to women without depression. In summary, our findings underscore the necessity for tailored approaches in implementing strategies for PA and nutrition, taking into account sex differences, as part of treatment measures for depression.

Our analysis revealed no notable contrast in "Total Physical Activity" between individuals with and without depression within the overall cohort. Nevertheless, the subset of participants with depression exhibited a decreased level of 'Vigorous Recreational Activity' compared to those without depression. Our study's findings closely aligned with prior research involving elderly populations. Elevating both the length and intensity of physical activities associated with recreation among older adults has the potential to contribute to reduced depression scores (Mumba et al., 2021). Furthermore, in a cross-sectional investigation involving 14,381 adults, Schuch et al. identified that even modest quantities of PA during recreational time yielded positive effects (Schuch et al., 2021). Based on data from an NHANES 2011–2014 a cross-sectional study (Rutherford et al., 2022), it can be noted that adults who achieved 150 minutes of recreational PA per week exhibited fewer depressive symptoms compared to those who did not reach this threshold. Finally, a number of meta-analyses (Korczak et al., 2017; Kvam et al., 2016) have indicated that engaging in recreational physical activities, including sports and exercise, can decrease depressive symptoms and mitigate the risk of other mental disorders. The findings suggest that recreational PA might offer greater advantages in alleviating depression when compared to physical activities related to work or travel (Rutherford et al., 2022).

Several potential mechanisms contribute to the observed relationship between PA and depression within specific domains. First, recreational PA is more likely to be perceived as an enjoyable, self-directed pursuit in comparison to PA undertaken in other contexts like work- or transport-related PA (White et al., 2017). Recreational PA tends to be pursued for the sake of pleasure, as opposed to work- or transport-related PA, which often involves obligatory tasks or external rewards, thus emphasizing extrinsic rather than intrinsic motivation. This distinction results in varying degrees of mental health benefits (Ryan & Deci, 2000). Drawing from the self-determination theory, engaging in PA pursuits driven by enjoyment aligns with autonomous and intrinsic motivation (Ryan & Deci, 2000), inclined to yield psychological contentment through autonomy, competence, and relatedness, consequently fostering mental well-being (Weinstein & Ryan, 2010). Second, transport- and potentially work-related PA are often solitary endeavors, diminishing their potential to enhance an individual's sense of belonging. In contrast, recreational PA frequently incorporates social interactions, which contribute positively to mental well-being (Bailey & McLaren, 2005). Furthermore, PA has been observed to evoke feelings of self-mastery and self-efficacy by accomplishing challenging tasks (Craft & Perna, 2004; Paluska & Schwenk, 2000). Given that work- and transport-related physical activities typically involve simpler activities like walking, they may offer fewer opportunities for achieving self-mastery (Sohn et al., 2007). The present study did not reveal any significant distinction in "Moderate Recreational Activity," but did identify noteworthy differences solely in "Vigorous Recreational Activity". Several studies have indicated participating in specifically high PA is correlated with decreased risk of new-onset depression, have a preventative effect, and result in more substantial enhancements in mood and more pronounced reductions in symptoms of depression when contrasted with exercises of moderate intensity (Pearce et al., 2022). Thus, with our findings, it would be advantageous of those in the emerging adulthood stage experiencing depression to participate in moderate to high PA to decrease depression symptoms and those who are not already diagnosed with depression to participate in moderate to high PA to prevent the onset of depression.

Our investigation revealed that young adults with depression exhibited markedly reduced consumption of "Total energy intake", "Carbohydrate intake", and "Protein intake" compared to their non-depressed counterparts. Notably, among men grappling with depression there was a significant decline in "Total energy intake", "Carbohydrate intake", and "Protein intake" observed in contrast to men without depression. Conversely, in women dealing with depression there was a significant reduction solely in "Protein intake" observed in contrast to women without depression. The convergence of these insights emphasizes the pivotal role of energy intake, especially protein, in not only fostering physical growth and repair, but also in holding substantial promise for alleviating depressive symptoms among individuals (Jacka et al., 2017). Several studies indicated a potential inverse relationship between dietary protein intake (Nanri et al., 2014; Rubio-Lopez et al., 2016; Wolfe et al., 2011) and the likelihood of depression (references 65–67). Furthermore, a cross-sectional investigation involving a subset of NHANES data from 2007 to 2014 uncovered an adverse correlation between total protein intake and depressive symptoms among male individuals under 45 years of age in the United States (Li et al., 2020). An essential connection lies in the body's utilization of a specific protein, known as tryptophan, to synthesize serotonin, often referred to as the "feel-good" hormone. Although serotonin's involvement in depression is acknowledged, the intricacies of its mechanisms remain enigmatic and require further elucidation. However, the prospect of enhancing serotonin levels through dietary intervention presents an avenue worthy of exploration, holding promise for potential therapeutic benefits (Cowen & Browning, 2015).

It is important to consider certain limitations when interpreting the outcomes of this study. Initially, we assessed young adults with depression, yet we were unable to incorporate the timing or duration of depression onset. Second, while we gauged PA levels through survey data, the absence of heart rate measurements or accelerometer data may introduce errors. Self-reported data pertaining to PA, exemplified by data gathered via the GPAQ, may be susceptible to instances of overestimation. A discernible tendency was observed among individuals exhibiting high levels of PA, wherein they exhibited a heightened propensity to overstate their PA levels as assessed by the GPAQ (Cleland et al., 2014). Third, our study predominantly reported observed differences without uncovering causal connections underlying the interplay of PA and nutrition. Moreover, the reliance on the 24-hour dietary recall approach might not holistically represent long-term dietary patterns. The 24-hour recall method entails retrospective inquiry into an individual's food and beverage consumption over the previous day or 24 hours. Nonetheless, a solitary 24-hour recall may not effectively encapsulate an individual's habitual diet. The study's strength lies in its pioneering analysis of the interrelation between depression prevalence and PA levels, along with energy intake, among young adults in the United States. An additional distinctive facet is the segmentation of data by sex, enabling a comprehensive exploration of the nuances between genders. Finally, our findings hold potential to contribute to the ongoing discourse concerning the intricate nexus between depression and health behaviors.

5. CONCLUSION

To summarize, our study underscores the domain-specific nature of the relationship between physical activity and depression, revealing a link between reduced depressive symptoms and engagement in recreational physical activities. Therefore, interventions tailored to promoting recreational physical activity hold promise for enhancing mental health and mitigating depression, as opposed to interventions targeting general, work-related, or transport-related physical activities. Our findings exhibit distinct association patterns based on sex. In men, young adults with depression exhibited significantly lower levels of vigorous recreational activity compared to their non-depressed counterparts. Additionally, individuals with depression displayed notably reduced total energy, carbohydrate, and protein intake. Among women, those experiencing with depression similarly displayed diminished vigorous recreational activity and protein intake when compared to those without depression. These disparities underscore the necessity for sex-specific approaches when implementing strategies for physical activity and nutrition, in a concerted effort to prevent depression. Men might benefit from interventions aimed at enhancing energy intake, while both men and women could benefit from programs focused on increasing vigorous recreational activity. Present-day trends involving personal devices, smartphones, activity trackers, and applications for monitoring physical activity and energy intake present novel avenues for researchers and healthcare practitioners to educate and engage clients, ushering in innovative ways to promote healthy lifestyles.

DATA ACCESSIBILITY STATEMENT

The dataset can be downloaded from National Health and Nutrition Examination Survey website (https://wwwn.cdc.gov/nchs/nhanes/).

ACKNOWLEDGEMENTS

This study analyzed the data provided by the National Health and Nutrition Examination Survey 2017–2020 pre pandemic data, conducted by the Centers for Disease Control and Prevention.

COMPETING INTERESTS

The authors have no competing interests to declare.

AUTHOR AFFILIATIONS

Youngjun Lee orcid.org/0009-0001-3915-1389
Michigan State University, US

Janet Hauck orcid.org/0000-0002-1281-0161
Michigan State University, US

Darice Brooks orcid.org/0009-0001-1720-9674
Michigan State University, US

REFERENCES

Adan, R. A. H., van der Beek, E. M., Buitelaar, J. K., Cryan, J. F., Hebebrand, J., Higgs, S., Schellekens, H., & **Dickson, S. L.** (2019). Nutritional psychiatry: Towards improving mental health by what you eat. *Eur Neuropsychopharmacol*, *29*(12), 1321–1332. DOI: https://doi.org/10.1016/j.euroneuro.2019.10.011

Amsalem, D., Dixon, L. B., & **Neria, Y.** (2021). The coronavirus disease 2019 (COVID-19) outbreak and mental health: current risks and recommended actions. *JAMA Psychiatry*, *78*(1), 9–10. DOI: https://doi.org/10.1001/jamapsychiatry.2020.1730

Babyak, M., Blumenthal, J. A., Herman, S., Khatri, P., Doraiswamy, M., Moore, K., Craighead, W. E., Baldewicz, T. T., & **Krishnan, K. R.** (2000). Exercise treatment for major depression: maintenance of therapeutic benefit at 10 months. *Psychosom Med*, *62*(5), 633–638. DOI: https://doi.org/10.1097/00006842-200009000-00006

Bailey, M., & **McLaren, S.** (2005). Physical activity alone and with others as predictors of sense of belonging and mental health in retirees. *Aging Ment Health*, *9*(1), 82–90. DOI: https://doi.org/10.1080/13607860512331334031

Bertram, H. (2020). Adolescence—A Cultural-Sociological Perspective. *Educating Adolescents Around the Globe: Becoming Who You Are in a World Full of Expectations*, 3–11. DOI: https://doi.org/10.1007/978-3-030-37900-1_1

Black, A. E. (2000). Critical evaluation of energy intake using the Goldberg cut-off for energy intake:basal metabolic rate. A practical guide to its calculation, use and limitations. *Int J Obes Relat Metab Disord*, *24*(9), 1119–1130. DOI: https://doi.org/10.1038/sj.ijo.0801376

Blumenthal, J. A., Babyak, M. A., Doraiswamy, P. M., Watkins, L., Hoffman, B. M., Barbour, K. A., Herman, S., Craighead, W. E., Brosse, A. L., Waugh, R., Hinderliter, A., & **Sherwood, A.** (2007). Exercise and pharmacotherapy in the treatment of major depressive disorder. *Psychosom Med*, *69*(7), 587–596. DOI: https://doi.org/10.1097/PSY.0b013e318148c19a

Brenner, R., Madhusoodanan, S., Korn, Z., & **Spitzer, M.** (1999). Acute anxiety and depression induced by loss of sensation and muscle control after botulinum toxin A injection. *South Med J*, *92*(7), 738. DOI: https://doi.org/10.1097/00007611-199907000-00030

Caspersen, C. J., Powell, K. E., & **Christenson, G. M.** (1985). Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Public health reports*, *100*(2), 126.

Chen, H.-Y., Yarnal, C., & **Bram, B.** (2017). "Borrowing Happiness from the Future": Exploring College Students' Own Experiences on Health-Related Lifestyles. *Journal of College and Character*, *18*(2), 112–129. DOI: https://doi.org/10.1080/2194587X.2017.1300095

Cleland, C. L., Hunter, R. F., Kee, F., Cupples, M. E., Sallis, J. F., & **Tully, M. A.** (2014). Validity of the global physical activity questionnaire (GPAQ) in assessing levels and change in moderate-vigorous physical activity and sedentary behaviour. *BMC Public Health*, *14*, 1–11. DOI: https://doi.org/10.1186/1471-2458-14-1255

Cowen, P. J., & **Browning, M.** (2015). What has serotonin to do with depression? *World Psychiatry*, *14*(2), 158–160. DOI: https://doi.org/10.1002/wps.20229

Craft, L. L., & **Perna, F. M.** (2004). The Benefits of Exercise for the Clinically Depressed. *Prim Care Companion J Clin Psychiatry*, *6*(3), 104–111. DOI: https://doi.org/10.4088/PCC.v06n0301

Cuellar, A., Adams, L., de Jonge, E., Espina, V., Espinoza, L., Fischer, S., Frankenfeld, C., Hines, D., Kornienko, O., & **Lawrence, H.** (2020). The Mason: Health Starts Here Prospective Cohort Study. DOI: https://doi.org/10.21203/rs.3.rs-115934/v1

Depression. (2019). World Health Organization. http://www.who.int/mediacentre/factsheets/fs369/en/index.html

Fancourt, D., Bu, F., Mak, H. W., & **Steptoe, A.** (2020). COVID-19 social study. *Results release*, *22*, 1–31.

Global physical activity questionnaire (GPAQ) analysis guide. (2012). *Geneva: World Health Organization.* http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Global+Physical+Activity+Questionnaire+(GPAQ)+Analysis+Guide#1

Health, U. D. o., & **Services, H.** (2023). *Fact sheet: end of the COVID-19 public health emergency*. US Department of Health and Human Services.

Hochberg, Z. e., & **Konner, M.** (2020). Emerging adulthood, a pre-adult life-history stage. *Frontiers in Endocrinology*, *10*, 918.

Holmes, E. A., O'Connor, R. C., Perry, V. H., Tracey, I., Wessely, S., Arseneault, L., Ballard, C., Christensen, H., Silver, R. C., & **Everall, I.** (2020). Multidisciplinary research priorities for the COVID-19 pandemic: a call for action for mental health science. *The Lancet Psychiatry*, *7*(6), 547–560. DOI: https://doi.org/10.1016/S2215-0366(20)30168-1

Jacka, F. N., Cherbuin, N., Anstey, K. J., & **Butterworth, P.** (2015). Does reverse causality explain the relationship between diet and depression? *J Affect Disord*, *175*, 248–250. DOI: https://doi.org/10.1016/j.jad.2015.01.007

Jacka, F. N., O'Neil, A., Opie, R., Itsiopoulos, C., Cotton, S., Mohebbi, M., Castle, D., Dash, S., Mihalopoulos, C., Chatterton, M. L., Brazionis, L., Dean, O. M., Hodge, A. M., & **Berk, M.** (2017). A randomised controlled trial of dietary improvement for adults with major depression (the 'SMILES' trial). *BMC Med*, *15*(1), 23. DOI: https://doi.org/10.1186/s12916-017-0791-y

Kessler, R. C., Berglund, P., Demler, O., Jin, R., Merikangas, K. R., & **Walters, E. E.** (2005). Lifetime prevalence and age-of-onset distributions of DSM-IV disorders in the National Comorbidity Survey Replication. *Arch Gen Psychiatry*, *62*(6), 593–602. DOI: https://doi.org/10.1001/archpsyc.62.6.593

Keyes, C. L. (2005). Mental illness and/or mental health? Investigating axioms of the complete state model of health. *Journal of consulting and clinical psychology*, *73*(3), 539. DOI: https://doi.org/10.1037/0022-006X.73.3.539

Khalid, S., Williams, C. M., & **Reynolds, S. A.** (2016). Is there an association between diet and depression in children and adolescents? A systematic review. *Br J Nutr*, *116*(12), 2097–2108. DOI: https://doi.org/10.1017/S0007114516004359

Korczak, D. J., Madigan, S., & **Colasanto, M.** (2017). Children's Physical Activity and Depression: A Meta-analysis. *Pediatrics*, *139*(4). DOI: https://doi.org/10.1542/peds.2016-2266

Kvam, S., Kleppe, C. L., Nordhus, I. H., & **Hovland, A.** (2016). Exercise as a treatment for depression: A meta-analysis. *J Affect Disord*, *202*, 67–86. DOI: https://doi.org/10.1016/j.jad.2016.03.063

Lai, J., Ma, S., Wang, Y., Cai, Z., Hu, J., Wei, N., Wu, J., Du, H., Chen, T., & **Li, R.** (2020). Factors associated with mental health outcomes among health care workers exposed to coronavirus disease 2019. *JAMA NETWORK OPEN*, *3*(3), e203976–e203976. DOI: https://doi.org/10.1001/jamanetworkopen.2020.3976

Lai, J. S., Hiles, S., Bisquera, A., Hure, A. J., McEvoy, M., & **Attia, J.** (2014). A systematic review and meta-analysis of dietary patterns and depression in community-dwelling adults. *Am J Clin Nutr*, *99*(1), 181–197. DOI: https://doi.org/10.3945/ajcn.113.069880

Lassale, C., Batty, G. D., Baghdadli, A., Jacka, F., Sanchez-Villegas, A., Kivimaki, M., & **Akbaraly, T.** (2019). Healthy dietary indices and risk of depressive outcomes: a systematic review and meta-analysis of observational studies. *Mol Psychiatry*, *24*(7), 965–986. DOI: https://doi.org/10.1038/s41380-018-0237-8

Li, Y., Zhang, C., Li, S., & **Zhang, D.** (2020). Association between dietary protein intake and the risk of depressive symptoms in adults. *Br J Nutr*, *123*(11), 1290–1301. DOI: https://doi.org/10.1017/S0007114520000562

Marx, W., Moseley, G., Berk, M., & **Jacka, F.** (2017). Nutritional psychiatry: the present state of the evidence. *Proc Nutr Soc*, *76*(4), 427–436. DOI: https://doi.org/10.1017/S0029665117002026

McGinty, E. E., Presskreischer, R., Han, H., & **Barry, C. L.** (2020). Psychological distress and loneliness reported by US adults in 2018 and April 2020. *JAMA*, *324*(1), 93–94. DOI: https://doi.org/10.1001/jama.2020.9740

McKercher, C., Patton, G. C., Schmidt, M. D., Venn, A. J., Dwyer, T., & **Sanderson, K.** (2013). Physical activity and depression symptom profiles in young men and women with major depression. *Psychosom Med*, *75*(4), 366–374. DOI: https://doi.org/10.1097/PSY.0b013e31828c4d53

McKercher, C. M., Schmidt, M. D., Sanderson, K. A., Patton, G. C., Dwyer, T., & **Venn, A. J.** (2009). Physical activity and depression in young adults. *Am J Prev Med*, *36*(2), 161–164. DOI: https://doi.org/10.1016/j.amepre.2008.09.036

Mitchell, C., McMillan, B., & **Hagan, T.** (2017). Mental health help-seeking behaviours in young adults. *British Journal of General Practice*, *67*, (8–9). DOI: https://doi.org/10.3399/bjgp17X688453

Mojtabai, R., Olfson, M., & **Han, B.** (2016). National Trends in the Prevalence and Treatment of Depression in Adolescents and Young Adults. *Pediatrics*, *138*(6). DOI: https://doi.org/10.1542/peds.2016-1878

Moshfegh, A. J., Rhodes, D. G., Baer, D. J., Murayi, T., Clemens, J. C., Rumpler, W. V., Paul, D. R., Sebastian, R. S., Kuczynski, K. J., & **Ingwersen, L. A.** (2008). The US Department of Agriculture Automated Multiple-Pass Method reduces bias in the collection of energy intakes. *The American journal of clinical nutrition*, *88*(2), 324–332. DOI: https://doi.org/10.1093/ajcn/88.2.324

Moussavi, S., Chatterji, S., Verdes, E., Tandon, A., Patel, V., & **Ustun, B.** (2007). Depression, chronic diseases, and decrements in health: results from the World Health Surveys. *Lancet*, *370*(9590), 851–858. DOI: https://doi.org/10.1016/S0140-6736(07)61415-9

Mumba, M. N., Nacarrow, A. F., Cody, S., Key, B. A., Wang, H., Robb, M., Jurczyk, A., Ford, C., Kelley, M. A., & **Allen, R. S.** (2021). Intensity and type of physical activity predicts depression in older adults. *Aging Ment Health*, *25*(4), 664–671. DOI: https://doi.org/10.1080/13607863.2020.1711861

Nanri, A., Eguchi, M., Kuwahara, K., Kochi, T., Kurotani, K., Ito, R., Pham, N. M., Tsuruoka, H., Akter, S., Jacka, F., Mizoue, T., & **Kabe, I.** (2014). Macronutrient intake and depressive symptoms among Japanese male workers: the Furukawa Nutrition and Health Study. *Psychiatry Res*, *220*(1–2), 263–268. DOI: https://doi.org/10.1016/j.psychres.2014.08.026

National Health and Nutrition Examination Survey. Centers for Disease Control and Prevention. https://wwwn.cdc.gov/nchs/nhanes/

Newman, M. G., & **Zainal, N. H.** (2020). The value of maintaining social connections for mental health in older people. *The Lancet Public Health*, *5*(1), e12–e13. DOI: https://doi.org/10.1016/S2468-2667(19)30253-1

Olson, R. D., Vaux-Bjerke, A., Quam, J. B., Piercy, K. L., Troiano, R. P., George, S. M., Sprow, K., Ballard, R. M., Fulton, J. E., & **Galuska, D. A.** (2023). Physical activity guidelines for Americans. *NADAR! SWIMMING MAGAZINE-Periódico científico em esportes e fitness aquático-natação, pólo aquático, nado sincronizado, saltos ornamentais, travessias aquáticas*.

Paluska, S. A., & **Schwenk, T. L.** (2000). Physical activity and mental health: current concepts. *Sports Med*, *29*(3), 167–180. DOI: https://doi.org/10.2165/00007256-200029030-00003

Pearce, M., Garcia, L., Abbas, A., Strain, T., Schuch, F. B., Golubic, R., Kelly, P., Khan, S., Utukuri, M., & **Laird, Y.** (2022). Association between physical activity and risk of depression: a systematic review and meta-analysis. *JAMA Psychiatry*. DOI: https://doi.org/10.1001/jamapsychiatry.2022.0609

Pfefferbaum, B., & **North, C. S.** (2020). Mental health and the Covid-19 pandemic. *New England Journal of Medicine*, *383*(6), 510–512. DOI: https://doi.org/10.1056/NEJMp2008017

Qiu, J., Shen, B., Zhao, M., Wang, Z., Xie, B., & **Xu, Y.** (2020). A nationwide survey of psychological distress among Chinese people in the COVID-19 epidemic: implications and policy recommendations. *General psychiatry*, *33*(2). DOI: https://doi.org/10.1136/gpsych-2020-100213

Rubio-Lopez, N., Morales-Suarez-Varela, M., Pico, Y., Livianos-Aldana, L., & **Llopis-Gonzalez, A.** (2016). Nutrient Intake and Depression Symptoms in Spanish Children: The ANIVA Study. *Int J Environ Res Public Health*, *13*(3). DOI: https://doi.org/10.3390/ijerph13030352

Rutherford, E. R., Vandelanotte, C., Chapman, J., & **To, Q. G.** (2022). Associations between depression, domain-specific physical activity, and BMI among US adults: NHANES 2011–2014 cross-sectional data. *BMC Public Health*, *22*(1), 1618. DOI: https://doi.org/10.1186/s12889-022-14037-4

Ryan, J. M. (2021). Timeline of COVID-19. *COVID-19: Global Pandemic, Societal Responses, Ideological Solutions*. Routledge. DOI: https://doi.org/10.4324/9781003155911

Ryan, R. M., & **Deci, E. L.** (2000). Intrinsic and Extrinsic Motivations: Classic Definitions and New Directions. *Contemp Educ Psychol*, *25*(1), 54–67. DOI: https://doi.org/10.1006/ceps.1999.1020

Sanchez-Villegas, A., Delgado-Rodriguez, M., Alonso, A., Schlatter, J., Lahortiga, F., Serra Majem, L., & **Martinez-Gonzalez, M. A.** (2009). Association of the Mediterranean dietary pattern with the incidence of depression: the Seguimiento Universidad de Navarra/University of Navarra follow-up (SUN) cohort. *Arch Gen Psychiatry*, *66*(10), 1090–1098. DOI: https://doi.org/10.1001/archgenpsychiatry.2009.129

Sanchez-Villegas, A., Toledo, E., de Irala, J., Ruiz-Canela, M., Pla-Vidal, J., & **Martinez-Gonzalez, M. A.** (2012). Fast-food and commercial baked goods consumption and the risk of depression. *Public Health Nutr*, *15*(3), 424–432. DOI: https://doi.org/10.1017/S1368980011001856

Schuch, F. B., Vancampfort, D., Firth, J., Rosenbaum, S., Ward, P. B., Silva, E. S., Hallgren, M., Ponce De Leon, A., Dunn, A. L., Deslandes, A. C., Fleck, M. P., Carvalho, A. F., & **Stubbs, B.** (2018). Physical Activity and Incident Depression: A Meta-Analysis of Prospective Cohort Studies. *Am J Psychiatry*, *175*(7), 631–648. DOI: https://doi.org/10.1176/appi.ajp.2018.17111194

Schuch, F. B., Werneck, A. O., Vancampfort, D., Stubbs, B., Teychene, M., Lotufo, P. A., Bensenor, I., & **Brunoni, A. R.** (2021). Cross-sectional associations of leisure and transport related physical activity with depression and anxiety. *J Psychiatr Res*, *140*, 228–234. DOI: https://doi.org/10.1016/j.jpsychires.2021.05.053

Sofija, E. (2020). Examining the Role of Positive Experiences of Wellbeing in Shaping Lifestyle-Related Thinking and Behaviours Among Emerging Adults.

Sohn, A. J., Hasnain, M., & **Sinacore, J. M.** (2007). Impact of exercise (walking) on blood pressure levels in African American adults with newly diagnosed hypertension. *Ethn Dis*, *17*(3), 503–507. https://www.ncbi.nlm.nih.gov/pubmed/17985505

Stallman, H. M., McDermott, B. M., Beckmann, M. M., Kay Wilson, M., & **Adam, K.** (2010). Women who miscarry: The effectiveness and clinical utility of the Kessler 10 questionnaire in screening for ongoing psychological distress. *Aust N Z J Obstet Gynaecol*, *50*(1), 70–76. DOI: https://doi.org/10.1111/j.1479-828X.2009.01110.x

Wang, J., Luben, R., Khaw, K. T., Bingham, S., Wareham, N. J., & **Forouhi, N. G.** (2008). Dietary energy density predicts the risk of incident type 2 diabetes: the European Prospective Investigation of Cancer (EPIC)-Norfolk Study. *Diabetes Care*, *31*(11), 2120–2125. DOI: https://doi.org/10.2337/dc08-1085

Weinberger, A. H., Gbedemah, M., Martinez, A. M., Nash, D., Galea, S., & **Goodwin, R. D.** (2018). Trends in depression prevalence in the USA from 2005 to 2015: widening disparities in vulnerable groups. *Psychol Med*, *48*(8), 1308–1315. DOI: https://doi.org/10.1017/S0033291717002781

Weinstein, N., & **Ryan, R. M.** (2010). When helping helps: autonomous motivation for prosocial behavior and its influence on well-being for the helper and recipient. *J Pers Soc Psychol*, *98*(2), 222–244. DOI: https://doi.org/10.1037/a0016984

Weng, T. T., Hao, J. H., Qian, Q. W., Cao, H., Fu, J. L., Sun, Y., Huang, L., & **Tao, F. B.** (2012). Is there any relationship between dietary patterns and depression and anxiety in Chinese adolescents? *Public Health Nutr*, *15*(4), 673–682. DOI: https://doi.org/10.1017/S1368980011003077

White, R. L., Babic, M. J., Parker, P. D., Lubans, D. R., Astell-Burt, T., & **Lonsdale, C.** (2017). Domain-Specific Physical Activity and Mental Health: A Meta-analysis. *Am J Prev Med*, *52*(5), 653–666. DOI: https://doi.org/10.1016/j.amepre.2016.12.008

Wolfe, A. R., Arroyo, C., Tedders, S. H., Li, Y., Dai, Q., & **Zhang, J.** (2011). Dietary protein and protein-rich food in relation to severely depressed mood: A 10 year follow-up of a national cohort. *Prog Neuropsychopharmacol Biol Psychiatry*, *35*(1), 232–238. DOI: https://doi.org/10.1016/j.pnpbp.2010.11.011

TO CITE THIS ARTICLE:
Lee, Y., Hauck, J., & Brooks, D. (2023). Sex-Specific Physical Activity Levels and Energy Intake in US Young Adults with Depression: National Health and Nutrition Examination Survey 2017 – 2020 Pre-Pandemic Data. *Physical Activity and Health*, 7(1), pp. 332–344. DOI: https://doi.org/10.5334/paah.305

Submitted: 15 October 2023
Accepted: 29 November 2023
Published: 29 December 2023