



A multi-behavioral assessment of physical activity, sedentary behavior, sleep, and weight status among iraqi undergraduate students

Una evaluación multicomportamental de la actividad física, el comportamiento sedentario, el sueño y el estado de peso entre estudiantes universitarios iraquíes

Authors

Halah Sinan Atiyah¹
Denise Koh Choon Lian¹

¹Universiti Kebangsaan Malaysia (Malaysia)

Corresponding author:
Halah Sinan Atiyah
p101122@siswa.ukm.edu.my

Received: 16-01-26
Accepted: 25-01-26

How to cite in APA

Atiyah, H. S., & Choon Lian, D. K. (2026). A multi-behavioral assessment of physical activity, sedentary behavior, sleep, and weight status among iraqi undergraduate students. *Retos*, 76, 680-693. <https://doi.org/10.47197/retos.v76.118581>

Abstract

Background: University students in Iraq face rising obesity risk linked to physical inactivity, prolonged sedentary behavior, insufficient sleep, and academic stress. Longitudinal evidence examining the combined influence of these behaviors on weight status in Iraqi universities remains limited.

Objective: This study examined six-month longitudinal associations of physical activity, sedentary behavior, sleep duration, and perceived stress with body mass index and percentage body fat among Iraqi university students.

Methods: A prospective multi-behavioral study was conducted at six public universities in Iraq. Six hundred undergraduate students aged 18–25 years were followed monthly during one academic semester. Validated questionnaires and smartphone-based applications assessed health behaviors, while standardized procedures measured body mass index and body fat. Data were analyzed using descriptive statistics, correlations, regression models, and repeated-measures analysis.

Results: Overweight and obesity prevalence reached 63.7%. Most students met minimum physical activity recommendations, yet sedentary time was high and sleep duration was suboptimal. Sleep duration showed a small inverse association with body mass index and body fat and was the only behavior differing significantly across body mass index categories. Males exhibited higher body mass index, whereas females had higher body fat percentage.

Conclusions: Integrated context-sensitive health strategies addressing sleep habits, sedentary behavior, and academic lifestyle factors may support obesity prevention.

Keywords

Motor activity; sedentary behavior; sleep; body mass index; college students; health behavior.

Resumen

Antecedentes: Los estudiantes universitarios en Irak enfrentan un riesgo creciente de obesidad asociado con la inactividad física, el comportamiento sedentario prolongado, el sueño insuficiente y el estrés académico. Sin embargo, la evidencia longitudinal que examina la influencia combinada de estos comportamientos sobre el estado ponderal en las universidades iraquíes sigue siendo limitada. **Objetivo:** Examinar las asociaciones longitudinales durante seis meses entre la actividad física, el comportamiento sedentario, la duración del sueño y el estrés percibido con el índice de masa corporal y el porcentaje de grasa corporal en estudiantes universitarios iraquíes.

Métodos: Se llevó a cabo un estudio prospectivo multicomportamental en seis universidades públicas de Irak. Se realizó un seguimiento mensual de seiscientos estudiantes universitarios de 18 a 25 años durante un semestre académico. Los comportamientos de salud se evaluaron mediante cuestionarios validados y aplicaciones para teléfonos inteligentes, mientras que el índice de masa corporal y la grasa corporal se midieron mediante procedimientos estandarizados. Los datos se analizaron mediante estadística descriptiva, correlaciones, modelos de regresión y análisis de medidas repetidas.

Resultados: La prevalencia de sobrepeso y obesidad alcanzó el 63,7%. Aunque la mayoría de los estudiantes cumplió con las recomendaciones mínimas de actividad física, el tiempo sedentario fue elevado y la duración del sueño insuficiente. La duración del sueño mostró una asociación inversa pequeña con el índice de masa corporal y la grasa corporal, y fue el único comportamiento que difirió significativamente entre las categorías de índice de masa corporal. Los hombres presentaron un mayor índice de masa corporal, mientras que las mujeres mostraron un mayor porcentaje de grasa corporal.

Conclusiones: Las estrategias de salud integradas y sensibles al contexto, que aborden los hábitos de sueño, el comportamiento sedentario y los factores del estilo de vida académico, pueden contribuir a la prevención de la obesidad.

Palabras clave

Actividad motora; comportamiento sedentario; sueño; índice de masa corporal; estudiantes universitarios; comportamiento de salud.

Introduction

The move to university is an important transition in a young person's life with widespread changes to their daily routines, lifestyle behaviours and health-related practices. Throughout this period, most students are likely to face external academic demands, irregular schedules, hours of sitting studying alone or with peers, and disturbed sleep patterns which all can entail adverse weight related outcomes (Vadeboncoeur et al., 2015; Pengpid & Peltzer, 2019). The college student population has therefore emerged as a group of increasing interest in obesity and public health research.

It is widely recognized that physical activity, sedentary behavior, and sleep should not be considered as three independent behaviors since they are in coexistence and interaction with each other within the 24-hour day. The recently introduced integrated 24-h movement behavior framework highlights that failing to meet physical activity, screen time, and sleep guidelines have combined effects on energy balance as well as metabolic control and health (Cooper et al., 2018; Tremblay et al., 2017; Severino Cardoso et al., 2025). Analyses that have taken this multi-behavioral approach have found stronger associations with obesity measures than in analyses testing each behavior separately (Carson et al., 2016).

Recent meta-analyses and systematic reviews adopting integrated 24-hour movement behavior frameworks to provide compelling evidence that the combinations of physical activity, sedentary behavior, and sleep duration have a greater and more consistent impact on obesity-related outcomes than isolated behavioral models. Indeed, a recent meta-analysis showed that adherence to 24-hour movement guidelines is strongly related to lower body mass index (BMI) and decreases in adiposity at young ages (López-Gil et al., 2023). Furthermore, integrative systematic reviews have demonstrated that independent or combined physical activity, sedentary time, and sleep duration are collectively associated with not only physiologic outcomes but also psychological well-being and academic functioning in children, adolescents and young adults (Wilhite et al., 2023; Lee et al., 2023). These results underscore the need to take a longitudinal and multi-variate perspective of behavioral transactions associated with the risk for obesity among university students.

Internationally, a large proportion of university students are physically inactive and have sedentary lifestyles; indeed, many do not meet the recommended physical activity guidelines (Guthold et al., 2018; Keating et al., 2005; Guthold et al., 2020; Romero et al., 2025; Jannah et al., 2025). Long duration of sedentary time, in particular screen-based activities and prolonged study periods, independently associated with higher body mass index, more body fat mass and greater cardiometabolic risk (Owen et al., 2010; Saunders et al., 2020; Flores Paredes et al., 2023; Corvetto-Castro et al., 2025). In addition, sleep duration has also been associated with weight gain (Watson et al., 2015) and worse metabolic profile (Itani et al., 2017) in young people, while among young adults there is evidence that reduced academic performance is related to poor habitual sleeping patterns.

Even though the international evidence base is increasing, studies taking a longitudinal approach and this from a multi-behavioral perspective are scarce in low- and middle-income countries. In Iraq, studies conducted have indicated an increase prevalence of overweight and obesity among young adults; however, most research has been focused on single lifestyle behaviors or dietary patterns and failed to show how several behaviors are associated with each other over time (Pengpid & Peltzer, 2021; Alrubaiee et al., 2025). Furthermore, few studies conducted repeated measurements of behavior and measurements of both BMI and BF.

To the best of our knowledge, no prior Iraqi study has employed a longitudinal multi-behavioral approach consisting of repeated measures of physical activity (PA), sedentary behavior (SB), sleep, and perceived stress in conjunction with objective weight status indicators such as body fat percentage (BF%). This is a significant methodological and contextual omission in the regional literature on obesity.

As such, the current study uses a longitudinal, multi-behavioral design to assess change in physical activity, sedentary behavior, and sleep patterns (i.e., actigraphy-assessed PA behaviors) and perceived stress and their joint associations with BMI/percentage body fat among Iraqi university students over a 6-month academic semester. This methodological approach allows us to explore dynamic behavioral trajectories and their aggregate influence on weight-related outcomes over the academic semester,



providing a more ecologically valid understanding of obesity risk pathways in the university setting. By filling this gap, we hope to offer a starting point for context tailored evidence-based recommendations for health promotion interventions in the Iraqi university setting.

It was hypothesized that lower physical activity, higher sedentary time, shorter sleep duration, and higher perceived stress would be independently and jointly associated with higher body mass index and percentage body fat over the six-month follow-up period.

Method

Study Design

Temporal patterns and interrelationships of health-related behaviors (physical activity, sedentary behavior, sleep and perceived stress) and their combined effects on body mass index (BMI) and percentage body fat (PBF) were addressed in a prospective longitudinal study among university students. Six months of aggregate data were collected during one academic term, which provided the opportunity to examine changes in behavioral indicators and clustering over time. The research took place at six public universities throughout Iraq for a purposeful sampling of diverse geographical location and institution type.

Participants

The sample included undergraduate students aged 18-25 in six public Iraqi universities. Multistage stratified random sampling was employed to reach balanced cross-sectional representation among institutions and academic years. From each university, one college was randomly recruited. In each sampled college, two academic years (e.g., Year 1–Year 6 depending on the program format) were randomly selected from which to collect the data; these academic year levels are referred to as “stages” for sampling. Students in the selected academic years were all approached for participation.

Eligibility criteria included: (1) being a full-time undergraduate student at university; (2) having access to a smartphone capable of running apps that can track activity and sleep behaviour; (3) being willing to undertake the assessment more than once over six months; and, (4) giving informed consent.

Exclusion criteria included: (1) known metabolic or endocrine-related disorders that affect weight regulation (e.g., diabetes, thyroid disease); (2) current pregnancy; (3) use of medications influencing body composition or metabolism; and (4) physical handicaps challenging participation in habitual physical activity. These standards were used to increase the homogeneity of the samples and to ensure internal validity of findings.

In total 600 students were recruited at baseline. Retention of participants was tracked monthly with attrition rates reported in the Results.

Attrition was monitored monthly, and reasons for dropout were recorded when possible. Missingness was assessed for randomness with Little’s MCAR test. Retention (attrition: <20% for longitudinal observational studies) was acceptable, so analyses were conducted using available-case methods. In addition, sensitivity analyses were conducted comparing the baseline characteristics of completers and non-completers to test for potential attrition bias.

Sample size was determined a priori with the G*Power software for multiple regression analyses (assuming small-to-moderate effect size [$f^2 = 0.05$]), $\alpha=.05$, power $(1 - \beta)=.90$, and six possible predictors. A power calculation indicated that at least 472 participants were needed. To allow for potential loss at follow-up, a sample size target of 600 students was established, which provided sufficient statistical power for longitudinal modelling.

Ethics Statement

The study was approved by ethics committee and complied with the Declaration of Helsinki. The study received ethical approval from the Research Ethics Committee of College of Education, Universiti Kebangsaan Malaysia (UKM-1/1/2025-106). Participants provided their written informed consent to participate in our study. Information was de-identified using unique identification numbers, and documents were kept confidential according to our institution's data protection policy.



Measures

Physical Activity

The level of physical activity was estimated from the WHO-developed Global Physical Activity Questionnaire (GPAQ). GPAQ quantifies physical activity in three domains: activities within the occupation, travel to and from places, and engaging in recreational time physical activities. All physical activity levels were summarized and represented as metabolic equivalent task minutes per week (MET-min/week) using standard WHO scoring protocol. The GPAQ has been shown to have good reliability and validity in various populations, including low- and middle-income countries (World Health Organization, 2012; Herrmann et al., 2013).

Sedentary Behavior

Daily sedentary time was evaluated with the Past-day Adults' Sedentary Time (PAST) Recall Questionnaire that measures daily time spent in common activities as studying, screen use and social sitting on the previous day. The PAST Questionnaire has demonstrated acceptable validity to estimate domain-specific SB in adults and has been used extensively in behavioral surveillance studies (Clark et al., 2009).

Sleep

Subjective quality of sleep was measured with the PSQI (Pittsburgh Sleep Quality Index), which is a self-report questionnaire including 19 items and quantifies sleep disturbances and quality during the past month. The PSQI has good psychometric validity and can be implemented for both clinical and general population research (Buysse et al., 1989).

In addition to subjectively assessing sleep, we also recorded objective parameters of sleep (eg: sleep duration and sleep onset latency) via the Sleep Cycle smartphone application for 1 entire week every month. Monitoring smartphone applications to track sleep patterns have shown good agreement with PSG in assessing the sleep-wake cycle in healthy adults, enabling their applicability for large-scale field studies where laboratory measures are impractical (de Zambotti et al., 2018).

Perceived Stress

Perceived stress was evaluated using the 10-item Perceived Stress Scale (PSS-10), which reflects how much participants found their life is unpredictable, uncontrollable, and overloaded in past month. The PSS has shown good reliability and construct validity in many populations and cultures (Cohen et al., 1983).

Anthropometric Measures

Body mass index was computed as weight in kilograms divided by height in meters squared (kg/m^2). Overweight and obesity were defined using the World Health Organization cut off points (World Health Organization, 2000). As it was not feasible to weigh and measure at scale across all the universities over multiple occasions, height and weight were self-reported, as is often done in population-level surveillance.

In order to reduce reporting bias, we provided general guidelines to participants on appropriate procedures for reporting their body weight and height (e.g., using calibrated digital scales; mounted wall stadiometers, where available). Moreover, extreme and unrealistic anthropometric values were filtered in the data cleaning process using established biological plausibility limits. Sensitivity analyses were performed to check the robustness of results with exclusion of outliers.

Percent body fat (PBF) was measured with a portable bioelectrical impedance analysis (BIA) instrument (OMRON HBF-306C, OMRON Healthcare Corp., Kyoto, Japan). BIA has been reported to give acceptable body composition estimates for population-based research and field conditions when the procedures are standardized (Kyle et al., 2004).

Data Collection Procedures

Baseline was characterized by face-to-face interview, completing questionnaire's standardized forms, and anthropometric measures. Thereafter, participants were invited to respond during each following month to the GPAQ, PAST, PSQI and PSS on secure online forms. Step counts and sleep parameters were



accumulated one full week per month employing Google Fit, while Sleep Cycle apps recorded for the same continuous week. Local research coordinators at each university oversaw the data collection process, provided assistance with technical issues, and checked monthly for data integrity.

Statistical Analysis

Statistical analysis was conducted using SPSS version 26. Behavioral and anthropometric variables were described with the means and standard deviations. Gender and academic years differences were explored using independent samples t-tests and one-way ANOVA. Correlations between the behavioral variables and BMI, PBF were calculated using Pearson correlation coefficients.

Predictors of BMI and physical activity were determined by multiple linear regressions. Operating characteristics of the predictors of overweight/obesity status were assessed with logistic regression models. The monthly variation in steps taken was studied using repeated measures ANOVA with Greenhouse–Geisser correction for sphericity. Behavioral clustering was analyzed with K-means cluster analysis of standardized behavior variables.

Results

Descriptive Statistics

The mean body mass index (BMI) of the sample was 27.27 kg/m² (SD = 4.89), while the mean percentage body fat (PBF) was 26.42% (SD = 7.81), indicating that a substantial proportion of participants were classified as overweight or obese. Mean physical activity was 1220.68 MET-min/week (SD = 848.80), although values showed wide variability. Average sedentary time was high (937.13 min/day, SD = 416.42), and mean sleep duration was 7.10 hours/night (SD = 1.24). Perceived stress levels were moderate on average (PSS: M = 18.83, SD = 6.36). Descriptive statistics are presented in Table 1.

Table 1. Descriptive Statistics of Key Behavioral and Weight-Related Variables

Variable	Mean	SD	Range
Body Mass Index (BMI) [kg/m ²]	27.27	4.89	16.26–42.50
Percentage Body Fat (PBF) [%]	26.42	7.81	9.40–49.90
Physical Activity (MET-min/week)	1220.68	848.80	0.00–4890.00
Sedentary Time [minutes/day]	937.13	416.42	60.00–2520.00
Average Sleep Duration [hours/night]	7.10	1.24	3.50–11.50
Perceived Stress Scale (PSS) Score	18.83	6.36	1.00–37.00
Average Daily Steps	5682.38	2895.78	250.00–17357.00

Risk Classification and Frequency Distributions

Based on WHO criteria, 10.2% of students did not meet minimum physical activity recommendations, 39.8% reported short sleep duration (<7 h/night), and 23.8% reported high sedentary time (≥8 h/day). A high-risk behavioral cluster (“unhealthy phenotype”: low physical activity, short sleep, and high sedentary time) was identified in 3.5% of participants, which is the correct prevalence based on Table 2. Overall, 63.7% of students were classified as overweight or obese.

Table 2. Frequency Distribution of Demographics and Risk Classifications

Variable	Category	n (%)
Gender	Male	306 (51.0)
	Female	294 (49.0)
Chronic Disease	Present	73 (12.2)
	Absent	527 (87.8)
Low Physical Activity	Yes (<600 MET-min/week)	61 (10.2)
	No	539 (89.8)
Poor Sleep Duration	Yes (<7 hours/night)	239 (39.8)
	No	361 (60.2)
High Sedentary Time	Yes (≥8 hours/day)	143 (23.8)
	No	457 (76.2)
Unhealthy Phenotype	Yes (All 3 risk factors)	21 (3.5)
	No	579 (96.5)
Overweight/Obese	Yes (BMI ≥ 25)	382 (63.7)
	No	218 (36.3)

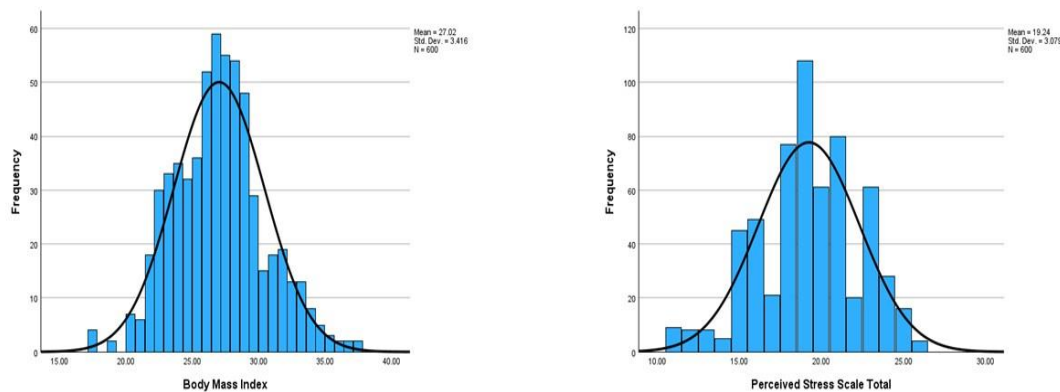


Graphical Exploration of Behavioral and Weight-Related Patterns

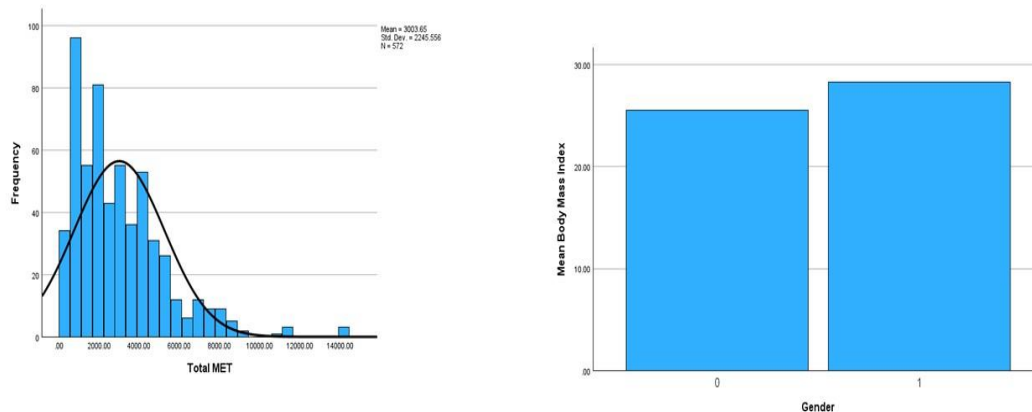
Visual analyses supported statistical findings. The BMI distribution was slightly right-skewed, with most students in the overweight category (25–30 kg/m²). PSS scores were close to normalized distribution, whereas total MET had a strong positive skew (a minority had very high values, and most were close to 0, low values).

Gender differences (Figure 1d) showed that the mean BMI of males was significantly greater. A scatterplot (Figure 2a) showed no strong linear correlation between BMI and MET, but overweight tended to be prevalent at a higher level of BMI, while lower activity was more common at a higher BMI level.

Figure 1. Distributions and group comparisons for key behavioral and weight-related indicators among Iraqi university students.



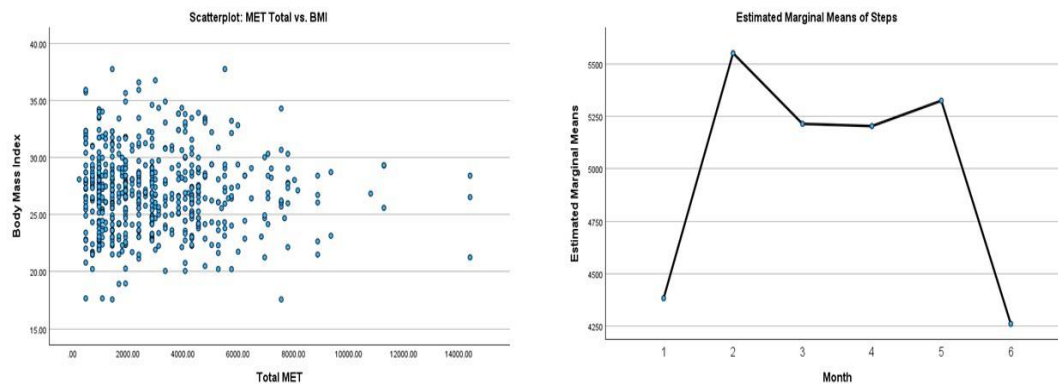
(a) Distribution of Body Mass Index (BMI). The histogram shows a right-skewed pattern (b) Distribution of Perceived Stress Scale concentrated in the overweight range. (PSS) scores, peaking in the moderate range.



(c) Distribution of total physical activity (Total MET). A right-skew indicates low (d) Mean BMI comparison by gender, showing higher BMI in males.

The six-month step counts (Fig. 2b) notably presented a cycle pattern, with an initial increase, a plateau from mid-semester on, and a decrease at the end of the period. These patterns highlight the influence of academic timing on student health behaviors and identify high-BMI, low-activity students for intervention.

Figure 2. Behavioral variability among Iraqi university students. (a) Total MET vs. BMI scatterplot. (b) Temporal trend in step counts during the academic semester



(a) Scatterplot showing the relationship (b) Estimated marginal means of step counts between Total MET and Body Mass Index over six months. Step counts peak mid (BMI). No strong linear trend was observed. semester and decline thereafter.

Correlation Analysis

Pearson correlation analyses revealed small but statistically significant inverse associations between sleep duration and BMI ($r = -0.127$, $p = 0.003$), as well as between sleep duration and PBF ($r = -0.102$, $p = 0.015$). No significant linear associations were observed between total physical activity (MET-min/week) or sedentary time and BMI or PBF (Severino Cardoso et al., 2025). The weak correlation between physical activity and BMI ($r = -0.062$) suggests limited linear association within this sample. Correlation coefficients are presented in Table 3.

Table 3. Pearson Correlation Matrix for Health Behaviors and Weight-Related Variables

Variable	MET	Sedentary Time	PSS	Sleep	BMI	PBF
MET	1.00	0.02	-0.04	-0.11**	-0.06	-0.03
Sedentary Time		1.00	-0.00	-0.03	0.05	0.02
PSS			1.00	0.02	0.02	0.00
Sleep Duration				1.00	-0.13**	-0.10*
BMI					1.00	0.75**
PBF						1.00

Note. * $p < .05$, ** $p < .01$ (two-tailed).

Gender Differences in Behavioral and Weight-Related Measures

Independent samples t-tests indicated significant gender differences in body composition. Males exhibited higher BMI values, whereas females showed significantly higher PBF ($p < 0.001$ for both). No statistically significant gender differences were observed in physical activity levels or perceived stress scores. Results are summarized in Table 4.

Table 4. Comparison of Key Health Indicators by Gender

Variable	Male (Mean \pm SD)	Female (Mean \pm SD)	t-value	p-value
Body Mass Index (BMI)	28.53 \pm 4.88	25.95 \pm 4.39	6.77	<0.001
Percentage Body Fat (PBF)	23.11 \pm 6.33	29.95 \pm 7.71	-11.42	<0.001
Physical Activity (MET-min/week)	1248.61 \pm 819.27	1191.91 \pm 878.67	0.84	0.402
Perceived Stress Scale (PSS) Score	18.46 \pm 6.33	19.22 \pm 6.39	-1.21	0.231

Effect size estimates were computed to evaluate the effect sizes of differences observed as well as the statistical significance testing. There was a large gender difference in BMI (Cohen's $d = 0.55$), and very large in percentage body fat (Cohen's $d = 0.98$), indicating high practical significance. By contrast, the effect sizes of physical activity and perceived stress differed in trivial size ($d < 0.10$) supporting no relevant generic behavioral differences.

Perceived Stress Across Academic Year Levels

One-way ANOVA demonstrated no significant differences in perceived stress across academic year levels, $F(5, 594) = 0.61$, $p = 0.766$, indicating relatively stable stress levels across years of study, as shown in Table 5.

Table 5. One-Way ANOVA of Perceived Stress by Academic Year

Source	Sum of Squares	df	Mean Square	F-value	p-value
Between Groups	53.71	5	10.74	0.61	0.766
Within Groups	41493.50	594	69.86		
Total	41547.21	599			

Predicting Body Mass Index from Behavioral and Demographic Factors

Multiple linear regression analysis identified gender and sleep duration as significant predictors of BMI. The model explained 17.5% of the variance in BMI ($R^2 = 0.175$, adjusted $R^2 = 0.166$, $p < 0.001$). Male gender was associated with higher BMI, while shorter sleep duration was associated with increased BMI. Physical activity, sedentary time, perceived stress, and chronic disease status were not significant predictors, as shown in Table 6.

Table 6. Multiple Linear Regression for Predicting Body Mass Index (BMI)

Predictor	B	SE	Beta (β)	p-value
(Constant)	28.38	2.96	-	0.001
Gender (Male)	2.23	0.32	0.41	0.001
Average Sleep Hours	-0.78	0.32	-0.10	0.015
Total MET	-0.001	0.001	-0.05	0.233
Total Sedentary Time	0.001	0.001	0.04	0.369
PSS Total	0.008	0.012	0.03	0.524
Chronic Disease (Yes)	0.48	0.46	0.04	0.303

Note: Model: $R^2 = 0.175$, Adjusted $R^2 = 0.166$, $p < 0.001$

Monthly Changes in Physical Activity: Repeated Measures ANOVA

Repeated measures ANOVA revealed a significant effect of time on monthly step counts, $F(5, 595) = 114.29$, $p < 0.001$. Post-hoc comparisons with Bonferroni adjustment indicated that step counts increased during the first half of the semester and declined significantly during the final months. Mean monthly step counts are presented in Table 7.

Table 7. Monthly Mean Step Counts Across the Academic Semester

Month	Mean Steps	SD
Month 1	5843.27	2672.45
Month 2	6027.89	2910.34
Month 3	6205.34	3054.27
Month 4	5856.81	2788.16
Month 5	5462.43	2611.22
Month 6	5009.76	2535.91

Note. Repeated measures ANOVA with Bonferroni-adjusted post-hoc comparisons; $p < .001$.

Predicting Obesity Status Using Behavioral and Demographic Variables

Binary logistic regression analysis demonstrated that gender and sleep duration were significant predictors of overweight/obesity ($BMI \geq 25 \text{ kg/m}^2$). Male students had higher odds of being overweight or obese ($OR = 4.42$, $p < 0.001$), while each additional hour of sleep was associated with reduced odds ($OR = 0.585$, $p = 0.015$). The model explained 15.5% of the variance (Nagelkerke $R^2 = 0.155$) and correctly classified 71.3% of cases, consistent with Table 8.

Table 8. Binary Logistic Regression Predicting Obesity Status (BMI \geq 25)

Predictor	OR	95% CI	Wald	p-value
Gender (Male)	4.42	[2.85, 6.84]	37.35	<0.001
Average Sleep Hours	0.585	[0.38, 0.90]	5.91	0.015
Total MET	1.001	[1.000, 1.002]	2.72	0.099
Total Sedentary Time	1.000	[0.999, 1.001]	0.83	0.361
PSS Total	1.003	[0.98, 1.03]	0.05	0.828
Chronic Disease (Yes)	1.39	[0.87, 2.21]	1.87	0.171
Unhealthy Phenotype	1.38	[0.63, 3.03]	0.66	0.416

Not: Model: Nagelkerke R² = 0.155, Classification Accuracy = 71.3%

Number of clusters was derived by conducting k-means cluster analysis on standardised z-scores of physical activity, sedentary time and sleep duration. For the best interpretability and convergence stability across different random starts, we chose a three-cluster solution. The identified cluster with an “unhealthy phenotype” was conceived by low levels of physical activity, high sedentary time and shorter sleep duration. The construct validity of the behavioral typology was further supported by satisfactory within-cluster homogeneity and between-cluster separation.

Behavioral Differences Across BMI Categories

total physical activity and sedentary time did not differ significantly across BMI categories ($p > 0.05$). In contrast, average sleep duration differed significantly, with obese students reporting shorter sleep compared with normal-weight students ($p < 0.05$). These results indicate that sleep duration was the only behavioral factor that varied significantly across BMI groups in this sample, as shown in Table 9.

The lack of a gradient in levels of MVPA and ST across BMI categories may be due to self-reported assessment of behavior, limited inter-individual variation, or compensatory behaviors. These null results are in line with past work supporting that merely meeting minimal activity recommendations may not adequately compensate for long sedentary exposures and other obesogenic life-style factors among the young adult population.

Table 9. Univariate Tests of Health Behaviors Across BMI Groups

Dependent Variable	F	df	p-value	Post Hoc
Total MET	0.749	2, 598	0.475	NS
Total Sedentary Time	0.988	2, 598	0.373	NS
Average Sleep Hours	3.19	2, 598	0.043	Obese \downarrow Normal*

Note: * Significant at $p < 0.05$ (Bonferroni corrected).

Predicting High-Risk Behavioral Cluster Using Psychosocial and Demographic Variables

Logistic regression examining predictors of high-risk behavioral cluster membership indicated limited explanatory power (Nagelkerke R² = 0.029). No individual predictors reached statistical significance, likely due to the low prevalence of the cluster. These results should be interpreted with caution.

Discussion

This paper investigated the individual and interactive relations of physical activity, inactivity, sleep, and stress with weight status among Iraqi college students at a 6-month academic semester. The results demonstrate high levels of overweight and obesity (63.7%), as well as reported poor sleep duration and increased screen time in a majority of the students. These findings demonstrate that obesity is an emerging public health issue among Iraqi university in which multiple health behaviours need to be considered simultaneously.

Beyond its physical health implications, obesity among university students has also been associated with cognitive and academic-related outcomes, including impairments in working memory, further emphasizing the broader consequences of excess weight in this population (Ñahui Rojas & López Munguía, 2025).

Although average physical activity levels exceeded the minimum recommendations of the World Health Organization for most participants, this was not associated with lower BMI or percentage body fat. This



apparent discrepancy—whereby 89.8% of students met physical activity guidelines despite high overweight prevalence—has been reported in other university-based studies in middle-income contexts and may reflect limitations of self-reported physical activity measures, unmeasured dietary intake, or compensatory behaviors outside structured activity (Pengpid & Peltzer, 2019; Keating et al., 2025). These findings suggest that meeting minimum activity guidelines alone may be insufficient to offset the combined effects of prolonged sedentary exposure and inadequate sleep.

Gender differences in body composition were evident, with males exhibiting higher BMI and females demonstrating higher body fat percentage, despite comparable physical activity and stress levels. This pattern is consistent with established physiological differences in fat distribution and lean mass between sexes and has been observed in regional and international studies among young adults (Al-Hazzaa et al., 2011; Wells, 2012). While sex emerged as a significant predictor of BMI, this finding should be interpreted as a descriptive indicator of differential risk rather than evidence of causality, reinforcing the need for sex-sensitive—but not necessarily sex-exclusive—health promotion strategies.

Sleep duration demonstrated a small but consistent inverse association with both BMI and body fat percentage and was the only behavioral factor that differed significantly across BMI categories. Although the magnitude of these associations was modest, similar patterns have been reported in university populations across both high-income and middle-income countries, supporting the role of sleep as a relevant component of weight regulation during young adulthood (Itani et al., 2017; Cooper et al., 2018). Importantly, sleep should not be interpreted as a dominant or singular determinant of obesity in this cohort, but rather as one element within a multifactorial behavioral context.

Contrary to expectations, the lack of consistent associations in the current study between sedentary behavior, perceived stress, and adiposity markers may in part reflect limitations associated with self-reported measures of behavior that are susceptible to recall bias, social desirability effects and constrained range when measuring behaviors as subjective indicators. Further, sedentary time was assessed through a one-day recall instrument which may not accurately reflect habitual exposure or patterns of prolonged sitting. The association between stress and sedentary behavior, or obesity may also be mediated by potential unmeasured factors including dietary intake, emotional eating, coping strategies and circadian rhythm disruption that were not measured in the current study. The type of indirect paths may attenuate or mask direct statistical relations) especially in young adult populations with varied lifestyle patterns (Stults-Kolehmainen & Sinha, 2014; Lee et al., 2023).

Temporal analysis of step counts indicated significant variation across the academic semester, with activity levels peaking mid-semester and declining toward the examination period. While this pattern suggests that academic demands may influence physical activity behavior, the analysis was limited to repeated measures comparisons and does not constitute formal time-series modeling. As such, these findings should be interpreted as indicative rather than definitive evidence of seasonal or cyclical trends.

Finally, the low prevalence of the high-risk behavioral cluster (3.5%) limited the statistical power to detect robust associations with obesity outcomes. Nevertheless, the presence of clustered unhealthy behaviors, even in a small subgroup, highlights the potential value of integrated intervention approaches that address multiple behaviors concurrently.

There are several weaknesses of this study which must be recognized. First, while the longitudinal design facilitates temporal interpretation, causality cannot be deduced from the observational nature of the study. Second, self-reported indicators for physical activity, sedentary behavior, sleep quality and anthropometric data might be affected by reporting bias and measurement error. Third, several other possible confounders were not measured in detail such as dietary intake, consumption of caffeine, smoking status, socioeconomic status and academic workload, all factors that might be related to lifestyle behaviors and obesity outcome. Fourth, the sample was recruited from universities so generalization to all young adults in Iraq would not be possible particularly non-students. Last, while the repeated measures analysis allowed for temporal variation to be realized, more sophisticated time-series or mixed-effects modeling methods might offer greater insight into dynamic behavioral trends.

Overall, the findings emphasize the complexity of obesity risk among Iraqi university students and support the need for multifaceted, context-sensitive health promotion strategies that address sleep habits, sedentary behavior, and academic lifestyle constraints alongside physical activity.

From a pragmatic perspective, the results endorse the introduction of specific university-based health promotion interventions other than general physical activity campaigns. Targeted interventions could be implemented such as flexible sleep hygiene guidance delivered as part of a university orientation, active breaks during extended academic periods, the re-design of learning environments to minimize prolonged sitting, and moving health 'apps' which facilitate real-time monitoring and feedback regarding movement practices or sleep routines. Furthermore, gender-specific strategies targeting sex-based differences in body composition and sociocultural influences on lifestyle behaviors may improve participation and impact in Iraqi university settings.

Future research should prioritize the integration of objective measurement tools, such as accelerometry, actigraphy, and dietary assessment platforms, to enhance measurement precision. Longitudinal cohort studies employing advanced modeling techniques and experimental interventions are also warranted to establish causal pathways linking movement behaviors, sleep, stress, and obesity risk. Furthermore, incorporating nutritional variables, psychosocial moderators, and academic workload indicators would allow for a more comprehensive understanding of obesity determinants in Middle Eastern university populations.

Conclusions

Our findings illustrate the complex interplay of factors influencing weight status in this population, with high rates of overweight and obesity being observed along with prolonged sedentary behaviour, and insufficient sleep duration among Iraqi university students. Even though the majority of individuals met recommended levels of physical activity, it was not enough on its own to predict weight status but rather comport with other findings that the behavioral pathways in obesity risk are multifaceted.

Sleep duration was the one of the more consistent, but modest, correlate of BMI; this implies that sleep is a potentially modifiable component of wider lifestyle influences on weight status rather than being a major determinant of it. Sex-specific differences in body composition were found, where males had higher BMI and females had higher body fat percentage even though they reported the same behavioral profile, highlighting the need to consider both physiological factors when interpreting weight-related outcomes.

The observed patterns of physical activity across the academic calendar indicate that university schedule could shape student behavior around which health promotion interventions should be purposefully timed. The small number of high-risk behavioral clusters reduced the power of prediction analysis, but adds value to ongoing behavioral surveillance.

Overall, these results underscore the utility of integrated and contextually-specific health models in Iraqi university settings, whilst also warranting future research that examines how academic cultural environmental drivers of student health-seeking behaviors might intersect.

Acknowledgements

The authors are grateful to the Ministry of Higher Education and Scientific Research—Iraq for their generous sponsorship of this research work. We gratefully acknowledge the support of the administrations of the six participating universities that assisted in the data collection and student participants for their time and contribution. We especially thank the research assistants who helped in monthly data monitoring and field coordination.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.



Disclosure statement

This study was not supported by, or yielded any financial gain to, any of the authors.

Informed Consent

All parties participating in this project were required to provide informed consent.

Ethical Approval

Human research followed the regulations of the national rules and those institutions or in accordance with the Declaration of Helsinki principles, and approved by College of Education, Universiti Kebangsaan Malaysia review board ethics committee.

Financing

No grants or other forms of outside financing were used to carry out this study.

References

- Al-Hazzaa, H. M., Abahussain, N. A., Al-Sobayel, H. I., Qahwaji, D. M., & Musaiger, A. O. (2011). Physical activity, sedentary behaviors and dietary habits among Saudi adolescents relative to age, gender and region. *International Journal of Behavioral Nutrition and Physical Activity*, 8(1), 140. <https://doi.org/10.1186/1479-5868-8-140>
- Alrubaiee, G. G., Alqalah, T. A., Alkubati, S. A., & Al-Rabeei, N. A. (2025). Overweight and obesity among Saudi university students and their relationships with various lifestyle habits: a cross-sectional study. *BMC Public Health*, 25(1), 2021. <https://doi.org/10.1186/s12889-025-23164-7>
- Buysse, D. J., Reynolds, C. F., Monk, T. H., Berman, S. R., & Kupfer, D. J. (1989). The Pittsburgh sleep quality index: A new instrument for psychiatric practice and research. *Psychiatry Research*, 28(2), 193–213. [https://doi.org/10.1016/0165-1781\(89\)90047-4](https://doi.org/10.1016/0165-1781(89)90047-4)
- Carson, V., Tremblay, M. S., Chaput, J. P., & Chastin, S. F. M. (2016). Associations between sleep duration, sedentary time, physical activity, and health indicators among Canadian children and youth using compositional analyses. *Applied Physiology, Nutrition, and Metabolism*, 41(6), S294–S302. <https://doi.org/10.1139/apnm-2016-0026>
- Clark, B. K., Sugiyama, T., Healy, G. N., Salmon, J., Dunstan, D. W., & Owen, N. (2009). Validity and reliability of measures of television viewing time and other non-occupational sedentary behaviour of adults: A review. In *Obesity Reviews* (Vol. 10, Issue 1, pp. 7–16). Wiley Online Library. <https://doi.org/10.1111/j.1467-789X.2008.00508.x>
- Cohen, S., Kamarck, T., & Mermelstein, R. (1983). A global measure of perceived stress. *Journal of Health and Social Behavior*, 24(4), 385–396. <https://doi.org/10.2307/2136404>
- Cooper, C. B., Neufeld, E. V., Dolezal, B. A., & Martin, J. L. (2018). Sleep deprivation and obesity in adults: a brief narrative review. *BMJ open sport & exercise medicine*, 4(1). <https://doi.org/10.1136/bmjsem-2018-000392>
- Corvetto-Castro, G., Villanueva Ruíz, M. A., Tejada Mendoza, M. A., Villacorta Huapaya, J. A., Núñez Lira, L. A., Grajeda Montalvo, A. T., Soto Zedano, F. A., & de la Cruz Pérez, V. N. (2025). Influence of achievement motivation on learning Physical Education and sedentary behavior outside school hours. *Retos*, 72, 239-250. <https://doi.org/10.47197/retos.v72.115267>
- de Zambotti, M., Goldstone, A., Claudatos, S., Colrain, I. M., & Baker, F. C. (2018). A validation study of Fitbit Charge 2™ compared with polysomnography in adults. *Chronobiology International*, 35(4), 465–476. <https://doi.org/10.1080/07420528.2017.1413578>



- Flores Paredes, A., Pino Vanegas, Y. M., Yupanqui Pino, E. H., Yupanqui Pino, A., Mamani Mamani, S., Coila Pancca, D., Atencio Ayma, L. J., Manzaneda Peña, M. A., & Lavallo Gonzales, A. K. (2023). Lifestyles and body mass index in university students. *Retos*, 50, 950-957. <https://doi.org/10.47197/retos.v50.99499>
- Guthold, R., Stevens, G. A., Riley, L. M., & Bull, F. C. (2018). Worldwide trends in insufficient physical activity from 2001 to 2016: A pooled analysis of 358 population-based surveys. *The Lancet Global Health*, 6(10), e1077–e1086. [https://doi.org/10.1016/S2214-109X\(18\)30357-7](https://doi.org/10.1016/S2214-109X(18)30357-7)
- Guthold, R., Stevens, G. A., Riley, L. M., & Bull, F. C. (2020). Global trends in insufficient physical activity among adolescents: a pooled analysis of 298 population-based surveys with 1.6 million participants. *The Lancet Child & Adolescent Health*, 4(1), 23–35. [https://doi.org/10.1016/S2352-4642\(19\)30323-2](https://doi.org/10.1016/S2352-4642(19)30323-2)
- Herrmann, S. D., Heumann, K. J., Der Ananian, C. A., & Ainsworth, B. E. (2013). Validity and Reliability of the Global Physical Activity Questionnaire (GPAQ). *Measurement in Physical Education and Exercise Science*, 17(3), 221–235. <https://doi.org/10.1080/1091367X.2013.805139>
- Itani, O., Jike, M., Watanabe, N., & Kaneita, Y. (2017). Short sleep duration and health outcomes: A systematic review, meta-analysis, and meta-regression. *Sleep Medicine*, 32, 246–256. <https://doi.org/10.1016/j.sleep.2016.08.006>
- Jannah, M., Widohardhono, R., Purnomo, R. A. A., Santosa, R. P., Harita, A. N. W., Dewi, D. K., Nuryananda, T. F., Halida, A. N., & Maulidiyah, E. F. (2025). Physical activity as a key to happiness in university students: moderated by emotion regulation. *Retos*, 71, 805-817. <https://doi.org/10.47197/retos.v71.117446>
- Keating, X. D., Guan, J., Piñero, J. C., & Bridges, D. M. (2005). A Meta-Analysis of College Students' Physical Activity Behaviors. *Journal of American College Health*, 54(2), 116–126. <https://doi.org/10.3200/JACH.54.2.116-126>
- Kyle, U. G., Bosaeus, I., De Lorenzo, A. D., Deurenberg, P., Elia, M., Gómez, J. M., Heitmann, B. L., Kent-Smith, L., Melchior, J. C., Pirlich, M., Scharfetter, H., Schols, A. M. W. J., & Pichard, C. (2004). Bioelectrical impedance analysis - Part I: Review of principles and methods. *Clinical Nutrition*, 23(5), 1226–1243. <https://doi.org/10.1016/j.clnu.2004.06.004>
- Lee, K. X., Quek, K. F., & Ramadas, A. (2023). Dietary and Lifestyle Risk Factors of Obesity Among Young Adults: A Scoping Review of Observational Studies. *Current Nutrition Reports*, 12(4), 733–743. <https://doi.org/10.1007/s13668-023-00513-9>
- López-Gil, J. F., Tapia-Serrano, M. A., Sevil-Serrano, J., Sánchez-Miguel, P. A., & García-Hermoso, A. (2023). Are 24-hour movement recommendations associated with obesity-related indicators in the young population? A meta-analysis. *Obesity*, 31(11), 2727–2739. <https://doi.org/10.1002/oby.23848>
- Ñahui Rojas, H. F., & López Munguía, O. (2025). Relationship between obesity and working memory in students at a Peruvian university. *Retos*, 71, 441-450. <https://doi.org/10.47197/retos.v71.114600>
- Owen, N., Healy, G. N., Matthews, C. E., & Dunstan, D. W. (2010). Too much sitting: The population health science of sedentary behavior. *Exercise and Sport Sciences Reviews*, 38(3), 105–113. <https://doi.org/10.1097/JES.0b013e3181e373a2>
- Pengpid, S., & Peltzer, K. (2021). Overweight and Obesity among Adults in Iraq: Prevalence and Correlates from a National Survey in 2015. *International Journal of Environmental Research and Public Health*, 18(8), 4198. <https://doi.org/10.3390/ijerph18084198>
- Romero-Carazas, R., Bazualdo-Fiorini, E. R., Pajares-Huaripata, E., Cabrera-Pimentel, H. R., Caro-Seminario, N. J., Jara-Ortega, C. E., Fernandez-Fernandez, R., & Panta-Medina, E. N. (2025). Impact of regular physical activity on the reduction of anxiety levels in university students. *Retos*, 68, 1121-1132. <https://doi.org/10.47197/retos.v68.115331>
- Saunders, T. J., McIsaac, T., Douillette, K., Gaulton, N., Hunter, S., Rhodes, R. E., Prince, S. A., Carson, V., Chaput, J. P., Chastin, S., Giangregorio, L., Janssen, I., Katzmarzyk, P. T., Kho, M. E., Poitras, V. J., Powell, K. E., Ross, R., Ross-White, A., Tremblay, M. S., & Healy, G. N. (2020). Sedentary behaviour and health in adults: an overview of systematic reviews. In *Applied Physiology, Nutrition and Metabolism* (Vol. 45, Issue 10, pp. S197–S217). <https://doi.org/10.1139/apnm-2020-0272>
- Severino Cardoso, D., do Nascimento, E. F., da Silva, T. M., Barbosa Feitosa, S., da Silva Rocha, K. B., Mijarra-Murillo, J.-J., Germano-Soares, A. H., Delfa-de-la-Morena, J. M., Wanderley Junior, R. de S., Gomes de Barros, M. V., Hardman, C. M., & Queiroz, D. da R. (2025). Association of physical activity,

- screen time, and sleep recommendations with excess weight in adolescents. *Retos*, 72, 990-998. <https://doi.org/10.47197/retos.v72.113173>
- Stults-Kolehmainen, M. A., & Sinha, R. (2014). The effects of stress on physical activity and exercise. *Sports medicine*, 44(1), 81-121. <https://doi.org/10.1007/s40279-013-0090-5>
- Tremblay, M. S., Chaput, J. P., Adamo, K. B., Aubert, S., Barnes, J. D., Choquette, L., Duggan, M., Faulkner, G., Goldfield, G. S., Gray, C. E., Gruber, R., Janson, K., Janssen, I., Janssen, X., Kho, M. E., Poitras, V. J., Prince, S. A., Saunders, T. J., & Carson, V. (2017). Canadian 24-hour movement guidelines for children and youth. *Applied Physiology, Nutrition, and Metabolism*, 42(6), S311-S327. <https://doi.org/10.1139/apnm-2016-0151>
- Watson, N. F., Badr, M. S., Belenky, G., Bliwise, D. L., Buxton, O. M., Buysse, D., Dinges, D. F., Gangwisch, J., Grandner, M. A., Kushida, C., Malhotra, R. K., Martin, J. L., Patel, S. R., Quan, S. F., & Tasali, E. (2015). Recommended amount of sleep for a healthy adult: A joint consensus statement. *Sleep*, 38(6), 843-844. <https://doi.org/10.5665/sleep.4716>
- Wells, J. C. (2007). Sexual dimorphism of body composition. *Best practice & research Clinical endocrinology & metabolism*, 21(3), 415-430. <https://doi.org/10.1016/j.beem.2007.04.007>
- Wilhite, K., Booker, B., Huang, B.-H., Antczak, D., Corbett, L., Parker, P., Noetel, M., Rissel, C., Lonsdale, C., del Pozo Cruz, B., & Sanders, T. (2023). Combinations of Physical Activity, Sedentary Behavior, and Sleep Duration and Their Associations With Physical, Psychological, and Educational Outcomes in Children and Adolescents: A Systematic Review. *American Journal of Epidemiology*, 192(4), 665-679. <https://doi.org/10.1093/aje/kwac212>
- World Health Organization. (2000). Obesity: Preventing and managing the global epidemic (WHO Technical Report Series No. 894). WHO. <https://iris.who.int/handle/10665/42330>
- World Health Organization. (2012). *Global Physical Activity Questionnaire (GPAQ): Analysis guide*. WHO

Authors' and translators' details:

Halah Sinan Atiyah
Denise Koh Choon Lian

p101122@siswa.ukm.edu.my
denise.koh@ukm.edu.my

Author / correspondiente/ Translator
Author