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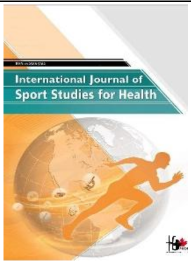

A Cross-Sectional Study of Physical Activity, Body Composition, and Biochemical Parameters in Adolescents from Western Mexico

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ABSTRACT

Objective: Physical inactivity is associated with excessive fat mass accumulation, increasing the risk of insulin resistance, hyperglycemia, hyperinsulinemia, and the development of metabolic and cardiovascular diseases. Therefore, this study aimed to evaluate body composition, biochemical parameters, and physical activity levels among adolescents in western Mexico.

Methods and Materials: A total of 58 adolescents (16.4 ± 0.71 years) participated in this study. Physical activity levels were assessed using the 27-item International Physical Activity Questionnaire (IPAQ). Based on the World Health Organization (WHO) recommendations, participants were classified as inactive (<420 minutes/week of moderate-to-vigorous physical activity [MVPA]) or active (≥420 minutes/week of MVPA). Body composition was assessed using electrical bioimpedance analysis, and biochemical parameters were determined from blood samples.

Findings: The findings showed that 38% of the adolescents were physically inactive. Body mass index (BMI) differed significantly between active (24.8 ± 5.25) and inactive adolescents (21.7 ± 4.13) ($p = 0.021$). Regarding biochemical parameters, total protein levels were significantly higher in the active group (79.30 ± 4.64) compared with the inactive group (76.86 ± 4.26) ($p = 0.050$).

Conclusion: The present study highlights the importance of engaging in moderate-to-vigorous physical activity to maintain healthy body composition and reduce risk factors associated with metabolic and cardiovascular diseases among adolescents.

Keywords: *Physical Activity, Body Composition, Fat Mass, Lean Mass, Biochemical Parameters, Adolescents.*

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1. Introduction

Regular PA is widely recognized as a health-related behavior associated with multiple physiological and psychological benefits across the lifespan (1). Adherence to global PA recommendations has been consistently associated with favorable cognitive outcomes and a lower prevalence of chronic and noncommunicable diseases (2). Accordingly, higher levels of PA have been linked to a lower prevalence of conditions such as cardiovascular disease, hypertension, type 2 diabetes, cancer, and depression (1).

Physical inactivity during adolescence represents a critical public health challenge in Mexico, as this developmental stage is pivotal for solidifying lifelong habits. Insufficient physical activity during this period heightens the risk of developing obesity and chronic metabolic diseases. Consequently, fostering healthy behaviors during these formative years remains the most effective strategy for preventing long-term health complications (3). According to the WHO, adolescents are recommended to engage in at least 60 minutes of moderate-to-vigorous physical activity daily (4). In Mexico, 46.2% of adolescents aged 15–17 years do not meet these recommendations (5), indicating a high prevalence of insufficient PA. Additionally, data from the 2023 National Health and Nutrition Survey (ENSANUT) report that up to 40.4% of adolescents are overweight or obese (6). Physical inactivity has been consistently associated with increased cardiovascular risk, lower cardiorespiratory fitness, and higher levels of adiposity (1).

Observational evidence highlights that PA is an important correlate of cardiometabolic health indicators. Lower levels of PA have been associated with a higher prevalence of risk factors such as obesity, hypertension, reduced high-density lipoprotein cholesterol (HDL-C), and diabetes (7). In Mexico, the prevalence of dyslipidemia has been estimated at 36.7% in the adult population (8). Furthermore, higher levels and intensity of physical activity have been found to be associated with more favorable lipid profiles (9). However, despite these associations, physical activity levels tend to decline during the transition from high school to college, a trend that has been linked to a decline in physical fitness (10).

Given the high prevalence of insufficient PA and its documented associations with adverse health indicators, further research is needed to characterize the relationship between PA and early metabolic and physiological alterations. In this context, identifying differences in health-related parameters according to PA levels may contribute to a better understanding of early risk profiles. Therefore, the aim of this study is to examine the association between physical activity levels and body composition and biochemical parameters in adolescents.

2. Methods and Materials

2.1 Participants

A cross-sectional study was conducted. To determine the minimum number of participants, the formula for comparing two proportions was used, with a power level of 0.95 and an alpha level of 0.10, based on the proportion of prediabetes reported in previous studies (11, 12). Given the exploratory nature of the study and its cross-sectional design, a significance level of 0.10 was adopted to enhance statistical sensitivity for detecting potential associations, while acknowledging the increased risk of Type I error. The sample consisted of 58 adolescents (16.4 ± 0.71 years of age; 67.4 ± 17.00 kg; 168.2 ± 9.67 cm) 28 males (16.4 ± 0.74 years of age; 74.4 ± 13.56 kg; 175.6 ± 7.71 cm) and 30 females (16.4 ± 0.70 years of age; 60.8 ± 17.46 kg; 161.3 ± 5.15). High school students were invited to participate. Exclusion criteria included noncommunicable diseases, musculoskeletal limitations, and pregnancy. Before starting the study, parents and participants were informed of the study's objectives and procedures at meetings. Parents signed an informed consent form, while minors signed a letter of assent. The study was approved by the Research and Research Ethics Committee of the State Cancer Institute of Colima, with registration number: CEICANCL220223-ANVSDGL-01.

2.2 Protocol

Participants were evaluated in the Ecology Laboratory during the morning under previously instructed conditions. PA levels were assessed using the long-form version of the IPAQ, which consists of 27 items and evaluates five domains: work-related activity, transportation, domestic tasks, outdoor activities, and sedentary behavior. The questionnaire captures three PA dimensions—intensity (light, moderate, or vigorous), frequency (days per week), and duration (time per day)—to estimate total weekly minutes of moderate-to-vigorous physical activity (MVPA). For its application in adolescents, minor language adaptations were implemented in accordance with a previously proposed approach aimed at improving comprehension without altering the structure or content of the instrument; this modified approach has been validated in a multicenter adolescent population, aimed at improving comprehension without altering the structure or content of the instrument; this modified approach has been previously validated in a multicenter adolescent population (HELENA study) (13). Cut-off points were established according to the World Health Organization (WHO) recommendations for this age group: inactive (<420 minutes/week of MVPA) and active (≥420 minutes/week of MVPA) (4).

Body weight, lean mass (LM), and fat mass (FM) were assessed using a multi-frequency bioelectrical impedance body composition analyzer (InBody 120, South Korea). Participants stood barefoot on two foot electrodes while holding two hand electrodes. Measurements were taken with minimal clothing, without socks or metallic objects, and after an 8-hour fast. Height was measured using a wall-mounted stadiometer (SECA 206, Switzerland). The measurement was performed without shoes, with the back and heels against the wall and feet together, by an ISAK Level I certified technician following the guidelines of the International Society for the Advancement of Kinanthropometry (ISAK) (14). Body mass index (BMI) was calculated using the Quetelet formula (15): BMI = weight (kg)/height^2 (m^2) (Eq. 1).

For the determination of biochemical parameters, blood samples were collected in the morning after an 8-hour fast via brachial venipuncture. Samples were then processed, and serum concentrations of total cholesterol, triglycerides, HDL cholesterol, glucose, uric acid, urea, magnesium, creatinine, calcium, total bilirubin, direct bilirubin, aspartate transaminase (AST), alanine aminotransferase (ALT), alkaline phosphatase (ALP), albumin, were determined using commercial assay kits (Biosystem Laboratories, Barcelona, Spain) and an automated A15 spectrophotometer, following the manufacturer's instructions.

For estimation of insulin resistance, we used the product of trigly- cerides and glucose (TyG) calculated as follows (16): Ln [fasting triglycerides (mg/dL) × fasting glucose (mg/dL) 2] (Eq. 2).

2.3 Statistical Analysis

Participant characteristics and physical activity (PA) levels were summarized using frequencies and percentages. Data distribution was formally assessed via the Shapiro–Wilk test; accordingly, continuous variables were expressed as mean ± standard deviation (SD). To evaluate differences in body composition and biochemical profiles between active and inactive cohorts, independent samples t-tests were employed, with statistical significance predefined at $p \leq 0.05$.

To mitigate the risk of Type I error inflation inherent in multiple biochemical comparisons, this study adopted a magnitude-based inference approach. Beyond null hypothesis significance testing, results were interpreted based on 95% Confidence Intervals (95% CI) and Cohen's (d) effect sizes. This framework prioritizes the precision of estimates and the clinical relevance of findings over dichotomous p value interpretations. Effect sizes were interpreted as small (0.2), medium (0.5), or large (0.8), consistent with established statistical recommendations for identifying biologically meaningful signals in physiological datasets. All computational procedures and effect size estimations were conducted using Jamovi software (Version 2.4.8; Sydney, Australia).

3. Results

A total of 58 adolescents participated in the study, of whom 51.7% (n = 30) were female, and 48.3% (n = 28) were male. According to the IPAQ results, 62% (n = 36) were classified as physically active, with 31% (n = 18) being females and 31% (n = 18) males. In contrast, 38% (n = 22) of the adolescents were classified as physically inactive, with a higher proportion of inactive females (20.7%, n = 12) compared to males (17.3%, n = 10) (Table 1).

Table 1. Physical activity level by sex (n=58).

	Women		Men		Total	
Physical activity level	n	%	n	%	n	%
Active	18	31.0	18	31.0	36	62.0
Inactive	12	20.7	10	17.3	22	38.0

Note: Values are presented as frequency and percentage. Cut-off points for active and inactive categories were based on WHO guidelines. Totals are summed horizontally.

A significant difference was found in BMI, which was higher in the active group (24.8±5.25) compared to the inactive group (21.7±4.13), t (56) =2.37, p=0.021, d=0.640.

In terms of body weight, similar results were observed between active (70.5±16.82) and inactive participants (62.2±16.39). No statistically significant differences were found in FM between active (20.8±11.79) and inactive (17.1±8.04) groups, nor in LM, which was the same for both groups (27.6±6.19) (Table 2). No other significant differences were observed in the remaining biochemical parameters according to PA level.

Table 2. Body composition according to PA level

	PA level						
	AC (n=36)	IN (n=22)	Total (n=58)	*p* value (CI)	t	df	d
Body Weight (kg)	70.5±16.82	62.2±16.39	67.35±17.00	0.071 (-.71 to 17.34)	1.84	56	.499
BMI (kg/m^2)	24.8±5.25	21.7±4.13	23.64±5.05	0.021$^{\beta}$ (.47 to 5.74)	2.37	56	.640
FM (kg)	20.8±11.79	17.1±8.04	19.42±10.60	0.201 (-2.02 to 9.40)	1.29	56	.350
LM (kg)	27.6±6.19	24.7±7.66	26.49±6.86	0.120 (-.77 to 6.57)	1.58	56	.428

PA: Physical Activity; AC: active; IN: inactive; BMI: Body Mass Index; FM: Fat Mass; LM: Lean Mass; CI: confidence interval; T: statistical value; df: degrees of freedom; d: effect size with Cohen's. Data are presented as mean ± standard deviation. $^{\beta}$ Significant difference between active and inactive ($p \leq 0.05$) with an independent Student's t-test.

Table 3. Biochemical parameters according to AF level

	PA level						
	AC (n=36)	IN (n=22)	Total (n=58)	p value (CI)	t	df	d
TG (mg/dL)	85.35±49.97	72.96±31.75	80.65±44.06	0.303 (-11.48 to 36.26)	1.04	56	0.281
GL (mg/dL)	71.99±7.53	68.38±8.44	70.62±8.01	0.096 (-.66 to 7.89)	1.69	56	0.458
TyG index	4.29±0.26	4.21±0.22	4.26±0.25	0.235 (-.05 to 0.21)	1.20	56	0.325
TC (mg/dL)	163.02±36.44	157.63±26.77	160.98±32.96	0.550 (-12.57 to 23.56)	0.60	56	0.162
HDL (mg)	65.20±11.46	65.96±12.66	65.49±11.83	0.813 (-7.23 to 5.70)	-.23	56	-0.064
UA (mg/dL)	6.76±2.10	6.16±2.31	6.53±2.18	0.312 (-.58 to 1.78)	1.02	56	0.276
Urea (mg/dL)	22.46±6.47	24.30±8.37	23.16±7.23	0.352 (-5.76 to 2.08)	-.93	56	-0.253
Mg (mg/dL)	2.38±0.29	2.25±0.26	2.33±0.28	0.111 (-.02 to 0.27)	1.61	56	0.438
Cr (mg/dL)	0.96±0.15	0.98±0.19	0.97±0.17	0.715 (-.10 to .07)	-.36	56	-0.099
Ca (mg/dL)	11.20±1.78	10.68±1.37	11.00±1.64	0.248 (-.37 to 1.40)	1.16	56	0.315
AST (U/L)	37.82±16.01	35.66±12.53	37.00±14.71	0.591 (-5.86 to 10.18)	0.54	56	0.146
ALT (U/L)	27.62±28.67	20.29±11.92	24.84±23.88	0.260 (-5.58 to 20.24)	1.13	56	0.307
ALB (g/L)	49.33±3.66	48.13±2.88	48.87±3.41	0.198 (-.64 to 3.03)	1.30	56	0.352

PA: Physical Activity; AC: active; IN: inactive; TG: triglycerides; GL: glucose; TyG index: triglyceride and glucose index; TC: total cholesterol; HDL: high-density lipoproteins; UA: uric acid; Mg: magnesium; Cr: creatinine; Ca: calcium; AST: aspartate aminotransferase; ALT: alanine aminotransferase; ALB: albumin. CI: confidence interval; T: statistical value; df: degrees of freedom; d: Cohen's effect size. Data are presented as mean ± standard deviation. $^{\beta}$ Significant difference between active and inactive ($p \leq 0.05$) with independent Student's t-test.

1. Discussion and Conclusion

Our results demonstrated that, among body composition indicators, only BMI showed a statistically significant difference based on the PA levels reported by adolescents.

Although scientific evidence supports that PA benefits health and reduces cardiovascular risk factors—mainly through improvements in body composition (10)—the most recent ENSANUT 2023 survey (5) reports that 46.2% of adolescents in Mexico are physically inactive. In line with these findings, our study identified 38% of adolescents as inactive, according to WHO criteria.

Regarding body composition, this study identified higher FM values compared to those reported in Croatian adolescents. In our sample, the average FM was 19.42 ± 10.60 kg, whereas Croatian adolescents showed a lower mean value of 13.72 ± 7.68 kg (17). A significant difference in BMI was also observed between physically active (24.8 ± 5.25) and inactive adolescents (21.7 ± 4.13). However, it is important to note the limitations of BMI as an indicator, as it does not distinguish between fat mass and lean mass.

The stability observed in BMI levels in the AF group points to a "BMI paradox" frequently documented in pediatric and adolescent populations (17). This result, seemingly contrary to what one might expect, likely reflects an exercise-induced phenotypic remodeling characterized by a concomitant increase in fat-free mass and a reduction in visceral adiposity. These structural adaptations typically result in a stable total body mass, which masks significant changes in body composition when assessed solely through the weight-to-height ratio (18). Consequently, our findings suggest that improvements in adolescents' metabolic health can occur independently of weight. These observations underscore the need to supplement BMI with direct measures of adiposity and biochemical markers, which serve as more sensitive indicators of the physiological benefits of a physically active lifestyle.

Excess fat mass accumulation during adolescence is associated with increased risk of insulin resistance, hyperglycemia, hyperinsulinemia, and the development of metabolic and cardiovascular diseases. Therefore, engaging in moderate-to-vigorous physical activity exerts a protective effect by reducing fat accumulation and promoting healthier body composition (19-21). On the other hand, no statistically significant differences were identified in the biochemical parameters evaluated.

Despite its contributions, this study is not without limitations. PA was assessed using the long version of the self-reported IPAQ questionnaire, which is susceptible to recall bias and social desirability bias. This subjectivity may lead to misclassification of participants' activity levels, which could underestimate the biological contrast between the cohorts. Future studies should use objective measures to minimize classification errors and improve the accuracy of physical activity level categorization.

In conclusion, studies like this are essential for the early detection, prevention, management, and implementation of programs or activities that promote PA, ultimately impacting adolescent health in the long term. Although adolescents are often considered a "healthy" age group, the origins of some adult chronic diseases begin to develop during this stage. Future research should focus on assessing PSA using various evaluation tools to continue advancing knowledge in this age group.

Authors' Contributions

MZF and LJOM designed and directed the project; FRL, PJFL, and MZF conceived and planned the method; MZF, LJOM, and IPP collected the data; MZF and PJFM analyzed the data; CIGG and JEDV contributed to the interpretation of the results; PJFM and CIGG directed the writing of the manuscript; all authors discussed the results and commented on the manuscript; CIGG, FRL, PJFM, JEDV, and MZF reviewed and edited the final version of the manuscript.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data sharing is available upon request from the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethical Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants. Before participation, all subjects in this study signed an informed consent document approved by the Research and Research Ethics Committee of the State Cancer Institute of Colima (Approval Code CEICANCL220223-ANVSDGL-01).

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