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ORIGINAL ARTICLE

Sedentary behaviors and their relation to anthropometric variables and body fat in schoolchildren

Conductas sedentarias y su relación con variables antropométricas y grasa corporal en escolares

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What do we know about the subject matter of this study?

A sedentary lifestyle has been recognized as one of the determinant components of obesity and, in the last decade, has become an increasingly relevant research topic.

What does this study contribute to what is already known?

It is the first national study that reports the time spent by Costa Rican schoolchildren on sedentary behaviors during the day and its association with health-related variables.

Abstract

Objective: To evaluate the association between time spent on sedentary behaviors with anthropometric variables and the percentage of body fat. **Subjects and Method:** 43 schoolchildren (72% male) participated, aged between 6 and 9 years. Anthropometric measurements were weight, height, body mass index, arm circumference, waist circumference, subscapular skinfold, tricipital skinfold, arm muscle circumference, arm area, arm muscle area, arm fat area, and waist-to-height ratio. The percentage of body fat was measured using an isotopic technique considered the gold standard(deuterium). The average time spent on sedentary behaviors recorded by self-report, during three non-consecutive weekdays were school activity, extracurricular work at home, watching television, using electronic devices screens, and sedentary recreational activities. **Results:** 32% of the subjects were eutrophic considering the percentage of body fat. 52% of daily time is spent on sedentary activities with no significant differences between boys and girls, 12.4 h vs 13.37, respectively. Time spent watching television was significantly associated ($p < 0,05$) with greater values of the anthropometric variables [weight, body mass index, waist circumference, waist-to-height ratio, skinfold (subscapular and tricipital)], and body fat percentage. **Conclusion:** The time spent watching television is associated with an increase in body fat. There is an urge to promote recreational activities that involve an increase in moderate and intense physical activity in schoolchildren.

Keywords:
Anthropometry;
Sedentary Behaviors;
Schoolchildren;
Body Fat;
Screen Time

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Abbreviations

- Arm Area (AA)
- Arm Fat Area (AFA)
- Arm Muscle Area (AMA)
- Arm Circumference (AC)
- Waist Circumference (WC)
- Arm Muscle Circumference (AMC)
- Sedentary Behaviors (SB)
- Energy Expenditure (EE)
- Waist-To-Height Ratio (WHtR)
- Body Mass Index (BMI)
- Deuterium Oxide (D2O).
- Subscapular Skinfold (SS)
- Tricipital Skinfold (TS)
- Body Fat Percentage (BF%)

Introduction

Worldwide, in the public health sphere, the increase in childhood overweight and obesity of concern and is associated with an increased risk of obesity in adulthood[1].

In Costa Rica, there is a 34% prevalence of overweight and obesity in school children, representing a shocking figure due to its impact on the decrease in life expectancy and quality of life[2]. According to the Centers for Disease Control and Prevention (CDC) of the U.S., the increase in childhood obesity could mean that in the next generations, for the first time in history, children will live fewer years than their parents[3].

Although obesity etiology is multifactorial, a sedentary lifestyle is one of the most important factors in its genesis and development[4]. The increase in sedentary lifestyles in schoolchildren is associated with changes in physical activity (PA) patterns caused by the lack of areas for exercise, increased feelings of insecurity in public spaces, and school day length[5].

In addition, the use of new technologies (computer, video games, cell phones, internet), that children and adolescents are increasingly resorting to, promotes low energy expenditure[5] and is associated with increased intake of high-calorie foods[6]. Therefore, sedentary behaviors (SB) are not simply activities with a lower level of PA taking place at school, at home, or during leisure time; they constitute a set of individual behaviors in which sitting or lying down becomes the predominant posture.

Regardless of the population group, it has been determined that the increase in time spent in SB is associated with an increment in chronic disease risk factors, independent of socio-demographic and dietary factors[4,7]. In a systematic review, an association between SB and cardiovascular risk factors was reported, showing that the main deleterious effects of a sedentary lifestyle were found in markers of glycemia and insulin resistance[8]. Although SB are a risk factor for overall health, the beneficial effects of PA may be affected by the SB a person engages in during the day[4,9]. However, the relationship between SB and anthropometric or body composition variables has been little studied in children[10], so its study is important for obesity prevention.

The objective of this study was to identify the association of time spent in sedentary behaviors during the day with anthropometric variables and body fat in Costa Rican schoolchildren aged 6 to 9 years.

Subjects and Method

Subjects

One hundred three (103) schoolchildren of both sexes (54 boys and 49 girls) aged 6 to 9 years (7.7 ± 1.1 years) from two public elementary schools in the Metropolitan Area of the San José province, Costa Rica. According to the information provided by the schools, the students were from families from middle socioeconomic strata. The only exclusion criterion was the report of any illness, acute or chronic, at the time of the study. The selected sample was non-probabilistic and included all schoolchildren whose parents authorized their participation by signing the informed consent form.

The study protocol was elaborated following the Declaration of Helsinki[11] and approved by the Scientific Ethical Committee of the University of Costa Rica.

Anthropometric Evaluation

Weight, height, arm circumference, waist circumference, and subscapular and tricipital skinfold were measured. Body mass index (BMI) was calculated using weight and height. The recommendations of the International Standards for Anthropometric Assessment Manual[12] by the International Society for the Advancement of Kinanthropometry (ISAK) were considered for the selection of anthropometric measurements, techniques, and measuring instruments.

Weight was measured with a SECA portable electronic scale (Hamburg, Germany) with a 150 kg capacity and a 0.01 kg accuracy. Height was measured with a portable stadiometer Holtain Ltd. (Dyfed, UK), with a 200 cm capacity and a 0.1 cm accuracy. Skinfolds were measured using a Lange Skinfold Caliper (Beta Technology Inc.; Maryland, USA), with a 67 mm capacity and a 1 mm accuracy. Circumfe-

rences were measured with a Holtain tape, metallic and inextensible, with a 200 cm capacity and a 0.1 cm accuracy. All measurements were performed three times each and their average was considered as the final measurement.

The variables arm circumference and tricipital skinfold, arm muscle circumference, arm area, arm muscle area, and arm fat area were calculated according to the formulas proposed by Frisancho[13]. The waist-to-height ratio was determined by the formula WHtR = Waist circumference (cm) / Height (cm), considering 0.5 as a cut-off point to define the risk of cardio-metabolic diseases[14].

Body fat measurement

Body fat was measured using the deuterium dilution technique. This technique allows the calculation of total body water, which subsequently facilitates the determination of fat-free mass and fat mass. Total body water was measured by determining the deuterium concentration according to the Plateau protocol. This protocol considers two measurement points: a basal biological sample before isotope intake and another post-dose sample at the end of the isotope equilibrium period (three hours) in body fluids[15]. For the study, saliva (2 ml) was used as the biological sample.

For the collection of the basal sample and administration of deuterium, the schoolchildren were fasting for 12 hours and urinated once, during which time they did not engage in vigorous PA. After the collection of the basal sample, a dose of 12 g of deuterium oxide 99 atom% was administered in 20 ml of sterile water for the schoolchildren to drink to ensure total intake of the deuterium. During the equilibrium period (three hours after isotope intake), the schoolchildren did not eat or drink nor perform PA or urinate. Saliva samples were collected using sterilized cotton swabs. The sample was then placed in 10 ml syringes to collect the fluid in clean plastic tubes with a screw cap. The samples were stored at -70°C for further analysis.

From total body water, fat-free mass was calculated, based on the hydration coefficients for children proposed by Fomon et al.[16]. Fat mass was calculated as the difference between fat-free mass and body weight. Saliva samples were analyzed using a HYDRA isotope ratio mass spectrometer (Europe Scientific, Crewe, UK).

Nutritional status assessment

It was determined using the BMI indicator and the percentile curves for the percentage of body fat according to sex and age proposed by McCarthy et al (17). For the BMI indicator, Z-scores were used, according to sex and age, and the classification was as follows: underweight (BMI < -1 SD), normal for the weight (BMI between -1 and + 1 SD), overweight (BMI +1 and +2 SD), and obese (BMI > +2 SD) (18). The cut-off points for the classification of nutritional status used in the body fat percentage curves were as follows: 2nd percentile (undernutrition), 50th percentile (adequate weight), 85th percentile (overweight), and 95th percentile (obesity)[17].

Recording sedentary behaviors

To estimate the time spent on SBs, a non-validated self-report was created for parents to describe the type of SB and the time spent by the child on each one during three non-consecutive days during the week. The days on which the SB were recorded were the same for all schoolchildren. The following were considered as SB: 1) Classes at the school: time spent sitting in class. Time spent during breaks was not included; 2) Extracurricular activities at home: time spent sitting at home doing homework; 3) Watching television: time spent sitting or lying down watching television; 4) Use of screens for entertainment: time spent sitting or lying down using computers, cell phones, video games, among others; and 5) Sedentary recreational activities: time spent sitting or lying down listening to music, playing board games, or reading a book that was not a school assignment. Parents and their children received an induction by the researchers on the correct recording of the SB.

Statistical analysis

Kolmogorov-Smirnov tests were performed to determine if the variables had a normal distribution. A descriptive analysis of the anthropometric characteristics and body fat of the schoolchildren was performed. The differences between averages of the measured variables were analyzed using the t-test for independent samples. A Pearson correlation coefficient analysis was applied to identify the association between the time dedicated to each of the SB with the anthropometric measurements and BF%. A $p < 0.05$ was considered significant. All values are reported as means and standard deviations. Data analysis was performed using Statistical Package for Social Science®, version 22 (SPSS; Chicago, IL, USA).

Results

Although 103 schoolchildren (54 boys and 49 girls) entered the study, only 41% (31 boys and 12 girls) completed the requested information. Girls presented statistically significant higher values for age, anthropometric variables (arm circumference, tricipital skin-

Table 1. Anthropometric characteristics and body fat of the schoolchildren

Variables	Total (n = 43) $\bar{x} \pm SD$	Males (n = 31) $\bar{x} \pm SD$	Females (n = 12) $\bar{x} \pm SD$	p
Age (years)	7.7 ± 0.8	7.4 ± 0.8	8.1 ± 0.6	0.005*
Weight (kg)	28.3 ± 6.5	27.5 ± 6.0	30.6 ± 7.5	0.16
Height (m)	124.2 ± 5.8	123.6 ± 5.5	125.9 ± 6.5	0.24
BMI (kg/m^2)	18.1 ± 3.0	17.8 ± 2.9	19.0 ± 3.3	0.23
WC (cm)	60.7 ± 8.1	59.9 ± 7.8	63.0 ± 8.9	0.26
AC (cm)	21.0 ± 3.0	20.4 ± 2.8	22.5 ± 3.1	0.04*
TS (mm)	14.7 ± 6.4	13.4 ± 6.4	17.9 ± 5.5	0.03*
SS (mm)	8.8 ± 4.7	7.9 ± 4.4	11.2 ± 4.8	0.04*
AMC (mm)	164.3 ± 18.8	162.46 ± 16.31	169.12 ± 24.41	0.30
AA (mm^2)	3601.3 ± 1055.2	3401.1 ± 970.1	4118.7 ± 1131.4	0.04*
AMA (mm^2)	2177.6 ± 519.9	2122.1 ± 431.2	2321.1 ± 702.9	0.37
AFA (mm^2)	1423.7 ± 743.2	1278.9 ± 726.4	1797.6 ± 677.2	0.03*
WHtR	0.60 ± 0.08	0.59 ± 0.08	0.63 ± 0.09	0.26
BF (kg)	8.5 ± 5.1	7.3 ± 4.4	11.7 ± 5.9	0.009*
BF (%)	26.8 ± 11.1	24.8 ± 10.8	32.2 ± 10.8	0.05*

BMI: Body mass index, WC: Waist circumference, AC: Arm circumference, TS: Tricipital skinfold, SS: Subscapular skinfold, AMC: Arm muscle circumference, AA: Arm area, AMA: Arm muscle area, AFA: Arm fat area, WHtR: Waist-To-Height Ratio, BF: Body fat. P values are shown to compare the averages between sex.

fold, subscapular skinfold, arm area, and arm fat area), and body fat (table 1).

When assessing nutritional status by BMI, it was observed that 40% of the subjects were overweight or obese, which increased to 67% when considering body fat percentage. Both methods coincided that the group of girls presented the highest prevalence of obesity (table 2).

In relation to the time dedicated to SB, there were no significant differences between boys and girls (12.4 h - 13.37 h, respectively), which is equivalent to 51.6% and 54.1% of the total time in each group. The main SB recorded in which the schoolchildren spent more time were the school day (390 ± 0.0 min) and homework assigned by the school (145.4 ± 69.1 min). The subjects spent less time watching television and using screens for entertainment (127.3 ± 67.0 min) than school activities at home (145.4 ± 69.1 min), however, boys spent more time watching television and using screens for entertainment (table 3).

Table 2. Prevalences (%) of the nutritional status of Costa Rican schoolchildren aged 6 to 9 years according to the BMI indicator and the McCarthy classification method

Indicador	Males (n = 31) (%)	Females (n = 12) (%)	Total (n = 43) (%)
BMI			
Under weight	0.0	0.0	0.0
Normal	67.7	41.6	60.5
Overweight	6.5	16.7	9.3
Obesity	25.8	41.7	30.2
McCarthy			
Under weight	0.0	0.0	0.0
Normal	32.2	33.3	32.5
Overweight	3.22	0.0	2.3
Obesity	64.5	66.6	65.1

Tabla 3. Time dedicated to sedentary behaviors carried out by schoolchildren

Activity (min)	Total (n = 43) x̄ ± SD	Males (n = 31) x̄ ± SD	Females (n = 12) *x* ± SD	p
Going to school	390 ± 0.0	390 ± 0.0	390 ± 0.0	N/A
Watching TV	99.4 ± 46.8	95.8 ± 50.2	108.7 ± 36.8	0.4
Use of Screens	27.9 ± 43.2	34.8 ± 44.6	10.0 ± 34.6	0.09
Extracurricular	145.4 ± 69.1	149.6 ± 68.7	134. 5 ± 71.6	0.5
Recreational Sedentary	90.8 ± 83.5	73.7 ± 60.0	135.0 ± 117.5	0.10

Table 4. Correlation between time spent watching television with anthropometric variables and percentage of body fat

Variable	Watching television	
	r	p
Weight (kg)	0.51	0.001
BMI (kg/m2)	0.52	0.001
WC (cm)	0.54	0.001
TS (mm)	0.46	0.002
SS (mm)	0.43	0.004
AFA (mm2)	0.48	0.001
WHtR	0.54	0.001
BF (kg)	0.43	0.003
BF (%)	0.34	0.027

BMI: Body mass index, WC: Waist circumference, TS: Tricipital skinfold, SS: Subscapular skinfold, AFA: Arm fat area, WHtR: Waist-To-Height Ratio, BF: Body fat.

When analyzing the association between the time spent in SB with the value of anthropometric variables (weight, BMI, waist circumference, waist-to-height ratio, tricipital and subscapular skinfolds, arm fat area) and the percentage of body fat, it was observed that the time spent watching television was the only SB that showed a significant association ($p < 0.05$) (table 4).

Discussion

The results of this study allowed us to determine that the sample of schoolchildren dedicated to SB 753 minutes on average, equivalent to 52% of the time per day, which agrees with Leiva et al.[4], who estimates that currently between 55% and 70% of the time per day is dedicated to sedentary activities[4]. Such behavior was also described two decades ago by Strauss et al.[19], who found that schoolchildren between 10 and 16 years of age spent more than 50% of their daily time on SB.

Regarding the time spent watching television in the sample studied, this was less than that of schoolchildren from other nations. For example, overweight Latin American schoolchildren, in general, spend more than 5 hours a day watching television[20], which is similar to that reported in Chilean children, but higher than that found in North American children (between 3 and 4 hours a day)[21], while in European countries such as Greece, children spend more than 2 hours a day[22].

With the results of this study, we were able to determine a significant association between the time spent watching television with all anthropometric variables and the percentage of body fat. Similar results were previously found in a study where the time spent watching television was associated with BMI, waist circumference, and tricipital skinfold[23].

Although it was expected that, along with the time spent watching television, other SB in this study would be correlated with the variables studied, such results did not occur. This was also identified in the study by Martínez-Gómez et al.[24] who studied SB similar to those of this study and only the time spent watching television was correlated with one of the variables studied (blood pressure).

Regarding the time spent using screens, this was less than the time spent by overweight Latin American children, who spent between 3 and 5 hours a day[20]. The American Academy of Pediatrics (AAP)[25] has recommended that screen time be limited to 2 hours per day. In the case of the subjects of our study, it was determined that the time spent using electronic devices or screen-based hobbies was much less than the AAP recommendation.

Regarding the time spent doing extracurricular activities, it was observed that schoolchildren spend more time sitting at home doing such activities than using screens.

Regarding the time spent by schoolchildren sitting at school, similar results have been identified in schoolchildren in Uruguay and Chile, who spend between 8 and 6 hours sitting, respectively[26]. This confirms that one of the possible causes of children's lack of PA is the long school days[5]. It is important to note that long school days with short recess periods imply changes in the rhythm of life of schoolchildren, causing possible fatigue and limiting them to PA out of school hours.

Another important finding of this study was to identify that the percentile curves for body fat according to sex and age proposed by McCarthy et al.[17] for the assessment of nutritional status is more accurate

than BMI since it underestimated overweight and obesity in the schoolchildren in the study. Previous studies in Costa Rican schoolchildren aged 6 to 9 years confirm the finding that BMI underestimates overweight or obesity[27,28].

It has been determined that a subject with an adequate BMI value can present a high percentage of body fat and an increase in the central fat distribution[14,27-30], which implies that the weight/height ratio does not provide information about body composition, a fundamental aspect in the diagnosis of overweight or obesity in which it is expected to demonstrate the increase in body fat[27].

Regarding the percentage of body fat, the results are consistent with those reported in previous studies with Costa Rican schoolchildren using the deuterium technique, where girls have significantly higher values than boys[27,28].

As the average values obtained for the waist-to-height ratio of both boys and girls, they showed that school children present a risk of developing some type of cardiovascular or metabolic disease[14]. Similar results were reported in the study of Zamora et al.[28] and Bila et al.[31] in Costa Rican and Brazilian schoolchildren aged 6 to 9 years, respectively. In this study, having analyzed the waist-to-height ratio was relevant since a positive association was identified between it and the time spent by schoolchildren watching television, a situation that was also corroborated in the study by Machado-Rodríguez et al.[32].

It is important to note that, to date, this study is one of the first in the Costa Rican school population that explicitly describes the SB that schoolchildren engage in and their association with anthropometric variables and body fat.

Among the main weaknesses of this study are those inherent to its cross-sectional design and the fact that it did not use accelerometers to objectively measure the time dedicated to SB, which did not allow us to reduce the bias associated with data collected through self-reports or questionnaires. In addition, due to methodological and design reasons, we did not estimate SB on weekend days, so it is recommended that this be considered in future studies.

Conclusion

The results of this study allow us to conclude that school children dedicate 52% of their daily time to sedentary activities and that the time spent watching television is associated with an increase in the value of anthropometric variables and body fat. It is important to highlight that the use of BMI underestimates the prevalence of overweight or obesity in schoolchildren. It is recommended to record SBs and their association with not only physical but also physiological and biochemical variables, especially during childhood and adolescence in order to promote measures to prevent the development of overweight and obesity.

Ethical Responsibilities

Human Beings and animals protection: Disclosure the authors state that the procedures were followed according to the Declaration of Helsinki and the World Medical Association regarding human experimentation developed for the medical community.

Data confidentiality: The authors state that they have followed the protocols of their Center and Local regulations on the publication of patient data.

Rights to privacy and informed consent: The authors have obtained the informed consent of the patients and/or subjects referred to in the article. This document is in the possession of the correspondence author.

Conflicts of Interest

Authors declare no conflict of interest regarding the present study.

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