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RESEARCH ARTICLE

# Physical activity in a group of school-age children in Mexico City: associated factors and cut-off points measured by accelerometry

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## ABSTRACT

**Background.** At any age, physical activity is critical to maintaining health. Different physical activity guidelines have been formulated to improve the health of children and adolescents. We undertook this study to analyze the differences in physical activity levels in school children during the day and week and to determine whether two recommendations of physical activity (frequency and duration vs. cumulative duration) in school-age children identify differences in physical fitness and fatness.

**Methods.** Seventy-one school children participated. Children wore a tri-axis accelerometer (ActiGraph) for 7 consecutive days. Minutes spent on moderate or vigorous physical activity (MVPA) were estimated. Two criteria were used to define whether a child is active: ≥60 min of MVPA/day and 300 min of MVPA/week. Nutritional status was assessed using the body mass index (BMI) and physical fitness with the FITNESSGRAM protocol.

**Results.** It was shown that 12.5% of school children were active according to 60 min MVPF/day criterion and 55.5% with 300 min MVPF/week criteria. School children were more active during school recess and afternoons on weekdays and afternoons and nights on weekends. Boys were more actives than girls. The time spent on vigorous and moderate activities was positively correlated with aerobic fitness ($r = 0.23$, $p = 0.057$ and $r = 0.32$, $p = 0.007$, respectively). There was a positive correlation between the time spent on sedentary activities and body fat ($r = 0.343$, $p = 0.003$) and negative with light and moderate activities ($r = -0.249$, $p = 0.003$; $r = -0.249$, $p = 0.013$, respectively). School-age children classified as active according to 300 min of MVPA/week criteria showed better aerobic capacity.

**Conclusions.** The proportion of active school-age children differs according to the physical activity criterion. It was shown that physical activity varied according to gender and time of day. The time spent on high intensity activities appears to have an influence on aerobic fitness of school children.

**Key words:** school children, nutritional status, physical activity, accelerometer.

## INTRODUCTION

At any age, physical activity (PA) is critical to maintaining health.[1] It has been documented that PA in children contributes to weight loss and body fat, lowers cholesterol and triglyceride levels,[2] strengthens the immune and musculoskeletal systems and also reduces anxiety and depression, increases academic performance, improves relationships, and improves concentration, memory and behavior in school.[3]

Different PA guidelines have been formulated to improve the health of children and adolescents. WHO[4] guidelines state that, every day, one must be do at least 60 min of moderate to vigorous intensity PA (MVPA). It has also been clarified how healthy it is for children to be active all or most days of the week.[5] These recommendations emphasize both frequency (all or most days of the week) as well as duration (at least 60 min/day). In contrast, adult guidelines recommend a cumulative 150 min of MVPA per week, which can be achieved with different combinations of length and frequency.[4]

However, there is little evidence for establishing any recommendation on the ideal frequency with which the students should carry out PA and, therefore, research is



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needed in this regard.[6] One needs to know, in health terms, whether it is sufficient that children carry out a cumulative 300 min a week of PA (regardless of the number of days) or if they need to do PA most, or almost all, days of the week and if making this distinction would refine the current recommendations.

In Mexican children, PA has been assessed with questionnaires,[7] by observation,[8] pedometers[9] and accelerometers,[10,11] either within or outside the school environment during a different number of days/week. Indirect methods such as questionnaires and observation have the disadvantage that they overestimate the levels of PA.[12] Conversely, accelerometers are precise instruments that allow for a quantitative assessment of PA.[13] Furthermore, in children the PA is spontaneous and sporadic, qualities that can be recorded by the accelerometers. However, few studies have been carried out by this method in the Mexican population in children <6 years of age.[10,11] This study aimed to analyze differences in PA levels according to gender and age of the students as well as during weekdays and weekends and to determine if the two methods to implement PA recommendations (frequency and duration vs. cumulative duration) in students allow the identification of differences in fitness and adiposity.

## SUBJECTS AND METHODS

The study was conducted with children during the morning shift of a public elementary school located in the Coyoacan area in Mexico City. Children 6- to 12-years of age participated. All parents of participants gave their informed consent. It was imperative that children did not present any health or medical condition that would prevent them from physical activity. Therefore, a health questionnaire was administered prior to participation. Although 91 children were evaluated, only data from 71 children were analyzed with complete information. The project was approved by the Research Committee of the Division of Biological Sciences and Health, after consideration of all ethical aspects. In all cases, assent of the children and written informed consent of the guardian were requested.

PA was measured with a triaxial accelerometer ActiGraph GT3X (3.8 cm x 3.7 cm x 1.8 cm and 27 g) that the child placed around the waist with an elastic belt for 7 consecutive days. The children were instructed to wear the accelerometer from the time of awakening and to take it off at bedtime. The accelerometers were programmed in 10-sec intervals. For the analysis, students who wore the accelerometers for at least 4 days were included (minimum of 2 days between week and at least one day during the weekend), with a minimum recording of 8 h/day. When there were consecutive >20 min in "zero", data were excluded from the analysis, assuming that the child could have removed the accelerometer. The average days that the children wore the accelerometer were 4.30 during the week and 1.68 during the weekend. The average time they wore it during the day was 12.39 h (12.73 h during the week and 11.56 h during the weekend). The number of children who wore the accelerometers for 4, 5, 6 and 7 days was 6, 13, 26 and 26, respectively. In order to determine the level of PA, data were recorded at 1-min intervals. Activity was classified as sedentary with <500 counts; mild 500-1999 counts, moderate 2000-2999 counts and vigorous >3000 counts.[14] The average counts per minute (cpm) was obtained by dividing the total counts between the total time the accelerometer was used (min.) For quantifying healthy PA (minutes of MVPA) that students carried out, minutes of MVPA were added. Two criteria were used to define whether or not a child was active. In the first place, the duration (minutes/day) was taken into consideration as well as the frequency (a minimum of days during the week). Active children were classified as those who had >60 min/day on average of MVPA for at least 5 days. Because not all children wore the accelerometer for 7 days, the percentage of days they met the recommendations with respect to the total days the accelerometer was worn was estimated (number of days they performed an hour of MVPA was divided between the number of days they wore the accelerometer and the result was multiplied by 100) using as 70% as a cut-off point, which would correspond to covering the recommendation for 5 days if they had worn the accelerometer for 7 days. In the second criteria, only the cumulative duration was taken into consideration, i.e., the number of days that the children did MVPA did not matter. Three hundred minutes per week of MVPA was taken as a cut-off point for identifying active children. This indicator was also adjusted by the number of days that the children wore the accelerometer.

Physical condition was evaluated according to the protocol described in FITNESSGRAM®. This evaluates six key areas of physical ability that represent the three general components of good physical condition: (1)

aerobic ability, (2) body composition and (3) strength, resistance and muscular flexibility (divided into four areas: strength and abdominal resistance; strength and extensor flexibility of the trunk; strength and upper body resistance and flexibility). According to the reference standards, children were classified according to two levels of performance for each test: (1) within the boundary of healthy condition and (2) needs improvement, i.e., is not found within the boundary of a healthy condition (aerobic tests and body composition are divided into moderate and high risk).[15]

Nutritional status was assessed with the body mass index (BMI = kg/m$^2$) using the reference and cut-off points of the WHO.[16] The Z score of the BMI for age was estimated by considering the Z score: 0.99 or less as normal, >1 to 1.99 as overweight, and >2.00 as obesity. Using the equations published by Slaughter et al.,[17] we estimated the percentage of body fat (%BF). In males it was % BF = 0.735 (PCT + PCPA in mm) + 1.0, in women, % BF = 0.610 (PCT + PCPA in mm) + 5.1, where PCT is the tricipital skin fold and the PCPA is the skin fold of the calf.

To determine if there were differences in cpm according to the gender and age of the children, Student t test was used for independent variables, whereas for determining if there were differences between the days of the week and the weekends, Student t-test was estimated for related variables. The average time that the children used the accelerometer throughout the week days as well as the time of moderate and vigorous PA was calculated as well as the mean of the cpm during weekdays. Pearson correlation coefficients were obtained to estimate the relationship of the time spent on sedentary, mild, moderate and vigorous activities. The proportion of children considered to be active according to the two criteria used was calculated. It was evaluated whether the two criteria would allow for identification of the differences on the tests for physical condition and body fat. For this, Student t test was used for independent variables. Statistically significant differences were considered when the value of $p \leq 0.05$. Statistical analyses were performed using SPSS v.15.0.



## RESULTS

There were 56.4% ($n$ = 40) of the children who were female; 42.2% were 6- to 9-years of age ($n$ = 30) and 57.7% ($n$ = 41) 10- to 12-years of age. With respect to nutritional status according to BMI for age, 2.8% had low birth weight ($n$ = 2), 62.0% normal weight ($n$ = 44), 14.1% overweight ($n$ = 10) and 21.1% obese ($n$ = 15).

The average cpm/day was 432.7 (Table 1). Males reported a higher number of cpm than females, both when considering all days ($p$ = 0.024) and on weekdays ($p$ = 0.056), although in the latter case the differences were marginal. Similarly, older children had lower cpm than younger children, both in total days ($p$ = 0.014) and during weekdays ($p$ = 0.032).

Although the average time in which the children wore the accelerometers was always <11 h (Table 2), the time was shorter on weekends. Days with higher values of cpm were Wednesday, Thursday and Saturday, whereas days with lower values were Tuesday and Friday. The days where more time was spent on MVPA were Friday and Saturday, whereas the days with less time spent on these activities were on Tuesdays and Sundays.

From Monday to Friday, the students had the highest number of counts at 11 and 14 h, corresponding to the recess periods and after school (Figure 1).* After school hours, the peak cpm was at 17:00 h. After that time, the average counts fell steadily. On weekends it was observed that the AF increased as the day progressed. Children were most active during the afternoon, and the largest number of counts occurred at 17:00 followed by 21:00 h.

The time spent in MVPA was positively related with the number of laps in the PACER test ($p$ = 0.016) (Table 3). Aerobic capacity ($VO_2$ max) was positively related to the time devoted to vigorous ($p$ = 0.057) and moderate PA ($p$ = 0.007), but negatively with time spent in sedentary activities ($p$ = 0.000) and light activities ($p$ = 0.000). The time for light activities was negatively associated with fewer number of "push-ups" ($p$ = 0.048) and sit-ups (r = -0.23, $p$ = 0.054). There was a positive correlation between body fat and time spent on sedentary activities (r = 0.34, $p$ = 0.003), but negative with time in light ($p$ = 0.036) and moderate PA ($p$ = 0.013).

There were 12.5% ($n$ = 9) of the students who were considered active according to the criterion of 60 min of MVPA most days, whereas this proportion was 55.6% ($n$ = 40) with the criterion of 300 min cumulative MVPA week.

* In the majority of public primary schools in the Federal District, recess takes place at 10:30 a.m. and lasts for 30 min. School employees end their day at 12:30 p.m. or at 2 p.m. in cases where their shift is extended.

Those inactive with each criterion were 87.3% ($n$ = 62) and 43.5% ($n$ = 31), respectively.

The classification criteria of 300 min of cumulative MVPA per week identified differences in aerobic capacity expressed as $VO_2$ max ($p$ = 0.051) (Table 4). The 60-min MVPA criterion most days allowed for identification in differences in body fat percentage, although the differences were marginally significant ($p$ = 0.093).

## DISCUSSION

The present study had as its objective to measure the PA in school-age children with accelerometry, a method that has been used infrequently in Latin America. Women were consistently less active than men, a fact that was systematically observed.[18-20] These gender differences could be due to sociocultural norms because girls are encouraged to carry out passive activities, whereas boys are encouraged to carry out physical activities via sports or games that imply physical competition.[21] It was also found that PA decreased with age, a trend that was observed in various studies in a European population.[18,19,22] This may be due to the fact that as age advances, children replace games that require body movements with the use of technology (television, computer, video games). On average, school-age children dedicated 36 to 51 min/day on moderate to vigorous activities, a time that was less than what is recommended (60 min AFMV/day).[23]

It was found that the highest number of cpm recorded occurred during school recess, suggesting that children should continue to be encouraged to engage in active playtime during that period of the day to raise their PA.

**Table 1.** Counts per minute according to gender and age

| | | Total | During weekdays | Weekend | |
|---|---|---|---|---|---|
| | *n* | Mean ± SD | Mean | Mean | $p^1$ |
| Total population | 71 | 432.7 ± 149.7 | 427.2 ± 174.1 | 446.5 ± 232.9 | 0.547 |
| Gender | | | | | |
| Male | 31 | 478.1 ± 176.4 | 472.0 ± 203.6 | 493.2 ± 294.7 | 0.729 |
| Female | 40 | 397.6 ± 115.0 | 392.5 ± 140.3 | 410.3 ± 165.9 | 0.586 |
| $p^2$ | | 0.024 | 0.056 | 0.138 | |
| Age | | | | | |
| 6-9 years | 30 | 483.2 ± 168.4 | 478.7 ± 187.7 | 494.3 ± 213.7 | 0.700 |
| 10-12 years | 41 | 395.8 ± 123.8 | 389.5 ± 155.2 | 411.5 ± 242.7 | 0.644 |
| $p^3$ | | 0.014 | 0.032 | 0.140 | |

[1]Comparison of weekdays with weekend days. [2]Comparison between genders. [3]Comparison between age groups. SD, standard deviation.

**Table 2.** Time using the accelerometer, counts per minute and MVPA according to weekdays

| | | | MVPA | | | |
|---|---|---|---|---|---|---|
| | HR | CPM | | | Range | |
| | Mean ± SD | Mean ± SD | Mean | SD | Minimum | Maximum |
| Monday | 12.5 ± 2.1 | 432.9 ± 292.0 | 44.2 | 39.7 | 0.0 | 176.0 |
| Tuesday | 12.6 ± 2.0 | 388.0 ± 248.0 | 33.6 | 31.2 | 0.0 | 139.0 |
| Wednesday | 12.2 ± 2.0 | 464.4 ± 238.6 | 41.2 | 28.0 | 0.0 | 114.0 |
| Thursday | 13.6 ± 1.8 | 467.3 ± 229.6 | 47.2 | 31.1 | 0.0 | 124.0 |
| Friday | 12.8 ± 2.0 | 382.7 ± 324.0 | 51.5 | 36.8 | 0.0 | 168.0 |
| Saturday | 11.9 ± 2.0 | 467.1 ± 296.8 | 44.1 | 38.0 | 0.0 | 186.0 |
| Sunday | 11.3 ± 2.0 | 425.9 ± 300.8 | 36.5 | 38.0 | 0.0 | 161.0 |

HR, hours registered (time using the accelerometer in hours); CPM, counts per minute; MVPA, time (minutes/day) dedicated to moderate and vigorous activities; SD, standard deviation.

It was also observed that weekend mornings are another time when children tend to be active. It is likely that spontaneous or unstructured play explains this increase during the weekend.

Consistent with the literature, the increase in time spent in sedentary activities was associated with lower aerobic capacity and a higher percentage of body fat.[24] In contrast, time spent engaged in MVPA was associated with lower body fat and greater cardiopulmonary capacity.[6] These results clearly demonstrate the positive effects PA has on the physical health of children. However, it is unclear whether there is any limit or threshold at which these benefits are most evident.

The percentage of active children changed substantially in accordance with the criteria used: taking into consideration 300 cumulative minutes per week of MVPA,

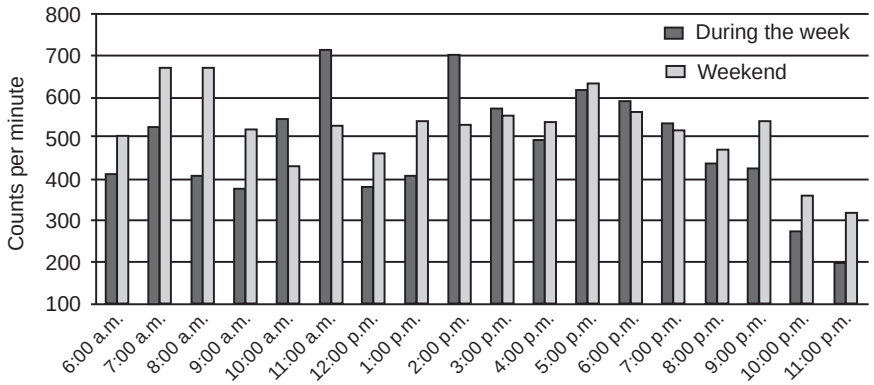


**Figure 1.**

Average counts per minute during the weekdays and weekends.

**Table 3.** Association among different levels of intensity of physical activity and components of the physical condition

| | Sedentary activities** | | Light activities** | | Moderate activities** | | Vigorous activities** | |
|---|---|---|---|---|---|---|---|---|
| Physical activity* | r | *p* | r | *p* | r | *p* | r | *p* |
| PACER (number of laps) | 0.12 | 0.314 | -0.06 | 0.639 | 0.16 | 0.194 | 0.29 | 0.016 |
| PACER ($VO_2$ max, ml/kg/min) | -0.45 | 0.000 | -0.42 | 0.000 | 0.32 | 0.007 | 0.23 | 0.057 |
| Sit-ups (repetitions) | 0.09 | 0.471 | -0.23 | 0.054 | -0.06 | 0.618 | 0.16 | 0.179 |
| Push-ups (repetitions) | 0.08 | 0.495 | -0.24 | 0.048 | -0.01 | 0.925 | 0.11 | 0.370 |
| Trunk lift (cm) | -0.03 | 0.823 | -0.10 | 0.400 | -0.03 | 0.825 | 0.05 | 0.670 |
| Sitting and reaching (inches) | 0.02 | 0.882 | 0.14 | 0.234 | -0.08 | 0.513 | -0.12 | 0.308 |
| Body fat (percentages) | 0.34 | 0.003 | -0.25 | 0.036 | -0.29 | 0.013 | -0.14 | 0.231 |

*Pearson correlation coefficients reported. **Minutes/day dedicated to each activity. $VO_2$ max, aerobic capacity.

**Table 4.** Differences among active and inactive school-age children with respect to physical condition

| | ≥300 min MVPA/week | | | ≥60 min MVPA during most days | | |
|---|---|---|---|---|---|---|
| | Inactive Mean | Active Mean | *p* | Inactive Mean | Active Mean | *p* |
| PACER (laps) | 12.9 | 14.8 | 0.244 | 13.9 | 14.1 | 0.945 |
| PACER ($VO_2$ max, ml/kg/min) | 42.5 | 44.3 | 0.051 | 43.4 | 44.6 | 0.358 |
| Sit-ups (repetitions) | 20.0 | 23.1 | 0.470 | 21.9 | 20.6 | 0.836 |
| Push-ups (repetitions) | 4.3 | 4.3 | 0.997 | 4.5 | 3.2 | 0.504 |
| Trunk lift (cm) | 22.5 | 24.2 | 0.224 | 23.6 | 22.5 | 0.610 |
| Sit and reach (inches) | 8.0 | 7.9 | 0.766 | 7.9 | 8.0 | 0.928 |
| Body fat (%) | 21.6 | 19.8 | 0.209 | 21.1 | 17.5 | 0.093 |

MVPA, moderate or vigorous physical activity; $VO_2$ max, aerobic capacity.

just over half of the population was active, whereas when defining 60 min of MVPA the majority of days only one-tenth of the population was active. In previous studies in the Mexican population, it had been reported that children and adolescents show a high percentage of inactivity. In the ENSANUT 2012[25] it was observed in children 10 to 14 years of age that 58.6% did no formal or competitive physical activities (exercise or sport) during the previous year, 38.9% carried out one or more activities and 2.5% more than three. Although the methodologies are different between ENSANUT 2012 and the present study (questionnaire vs. accelerometers), and the evaluation criteria to determine whether the child is active or not (does exercise or sports activities in the past year vs. time of MVPA accumulated or by day), we can infer that taking into account the MVPA criteria—informally or formally—and time per day is stricter and more difficult for children to comply.

The criterion of 300 min/week of MVPA to classify children as active and inactive identified differences in cardiopulmonary fitness levels, whereas the criterion of 60 min of MVPA per day most days was more sensitive to identify differences in fat body. This appears to indicate that depending on the physical condition or nutritional state one should maintain or improve upon the time and intensity of PA that are key criteria for the school-age population. In adults it has been established that performing MVPA for at least 30 min on 5 or more days/week reduces the risk of cardiovascular disease,[26] whereas if MVPA is for done for 60 min on most days, it helps maintain a healthy body weight.[27,28]

Among the limitations of this study is the fact that it is a convenience sample with a small size. Due to the nature of the cross-sectional study, one cannot draw firm conclusions about a causal relationship between PA and health events analyzed.

In conclusion, results obtained in this study suggest that in Mexican children the cumulative time of MVPA seems to have an effect on cardiopulmonary capacity, whereas children may possibly be required to do a minimum time (60 min/day) most days to have a healthy body composition. However, more evidence will be needed in the Mexican population (with larger samples and monitoring designs) to agree on the evaluation criteria and to be able to establish whether or not a child is active. In addition, it was confirmed that there is a relationship between a sedentary lifestyle, adiposity and poor physical condition. It is therefore necessary to increase the level of PA of children to reduce their body fat, improve their fitness and therefore improve their health. For this reason, promotion should be made to encourage structured or spontaneous PA, focusing the attention on older boys and girls.

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