Variability of physical activity in Chilean children aged 4-10: a study by accelerometry

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SUMMARY

Introduction. When compared to popular questionnaires, accelerometry provides more reliable information regarding physical activity. Thus, the objective has been to document the variability of physical activity in Chilean children in relation to age, gender, nutritional status and days of the week, and to determine how many of them meet the recommendation for moderate to vigorous physical activity for more than an hour a day.

Population and methods. One hundred and nine (109) school children aged 4-10 (67 boys, 42 girls) wore an accelerometer for 2, 3 or 4 consecutive days. Of them, 30 were obese (BMI >95th percentile by age and gender). In each subject, levels of physical activity were expressed in counts per minute (cpm) and means (SD) of cpm/hour. Moderate to vigorous physical activity was defined by the daily sum of cpm >900.

Results. Daytime physical activity had a mean of 21,697 (662) cpm/hour with considerable variation from one child to another, and from one time of the day to another in the same child. Individual cpm/hour was significantly associated to moderate to vigorous physical activity (R = 0.954). Differences were found between girls and boys ($p < 0.01$) and between obese and non-obese children ($p < 0.01$). There were no differences between children <6 years and >9 years ($p = 0.12$). There was a slight difference between weekdays and weekends. Fifty-six (56) of 67 boys (83.6%) and 24 of 42 girls (57.1%) met the recommendation for moderate to vigorous physical activity for more than 60 minutes a day.

Conclusion. There is a physical activity deficit in Chilean school children under 10 years, particularly in girls and obese kids.

Key words: *school children, physical activity, accelerometry, obesity.*

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INTRODUCTION

The amount of physical activity is extremely variable from one child to another. It depends on genetic factors, age, gender, weather conditions, existing advocacy actions, as well as the child's family social, cultural and economic status, among other factors. In the context of the increasing global sedentary lifestyle of our time, children are less active than in past decades under normal living conditions. This is important since childhood obesity has become a major health issue among Chilean children and because physical inactivity is a determinant of overweight.[1,2]

In recent years, essentially in the US and Europe, studies analyzing children's physical activity have multiplied, whether conducted using:

a) indirect calorimetry or doubly labeled water measurement (considered as a standard, but less suitable for field studies, i.e., epidemiological studies); b) questionnaires and reminders; and, above all, c) motion sensors, specifically, accelerometers.[3] All publications agree that men are more active than women and that obese people are less active than non-obese individuals.

In Chile, data were obtained essentially by questionnaires.[4-6] In 2006, a simple questionnaire of habitual physical activity associated with a 0-10 score was validated in children aged 8-13, and it showed good concordance with the accelerometry.[7] Another study, by Vasquez et al.,[8] reported the accelerometric physical activity of obese children aged 3-5.

An accelerometer, an objective and non-reactive method that is relatively easy to use, allows quantifying movement at any time and detects different levels of physical activity, from sedentary to vigorous. Faced with a large number of international publications on physical activity in children using accelerometers, and the recommendation that children should spend at least an hour a day doing moderate to vigorous activities,[9-11] we think it appropriate to continue measuring the physical activity of Chilean children

with this practical technique well-tolerated by school children. A pilot project of the Institute of Nutrition and Food Technology (*Instituto de Nutrición y Tecnología de Alimentos, INTA*) of Chile on prevention of obesity in school children[12] gave us the opportunity to study the physical activity of children aged 4-10 by accelerometry, with the objective of documenting its variability and the fulfillment of recommendations in this area.

POPULATION AND METHODS

Subjects of this study were chosen by convenience due to material limitations, as a subsample of 586 school children aged 4-10 who participated in a pilot project of INTA. The latter, published by Kain et al.[12] and titled "Prevention of obesity in preschoolers and school children of public schools of a district in Santiago de Chile: pilot project 2006," consisted of implementing a long-term educational intervention for students and teachers.

This study was approved by the INTA Ethics Committee and developed between April and July of 2006. The protocol was explained to the children's parents, who were asked to sign an informed consent.

Anthropometry: Weight and height were measured using a SECA 0.1 kg-0.1 cm precision scale to assess the body mass index (BMI). Obesity was defined by a BMI ≥95th percentile for age and gender, according to the reference of CDCNCHS 2002.

Protocol: On Thursday morning, after children had started their school day and together with an anthropometry, Actiwatch AW64 accelerometers were placed on children, who wore them with a semi-elastic belt on the right hip. The belts were removed the following Monday when children returned to class.

Accelerometry: The Actiwatch AW64 measures 27 x 25 x 9 mm and weighs 16.3 g. This miniaturized device consists of a piezoelectric translator and a microprocessor that transforms multidirectional accelerations into quantitative signals, which are recorded in the memory. The results are expressed in counts per minute (cpm). In order to consider a daytime activity log as valid, at least 7.5 h of data were required. Following the international recommendation,[13] cpm periods equal to zero for more than 20 minutes were excluded, since the student could have taken off the belt. For the total days and for each separate day, the sum of cpm was divided by the number of hours recorded; this is how we obtained a mean "cpm/hour" value. A similar reduction of data has been employed by Page et al.[14] and by Pate et al.[15] to standardize very dissimilar accelerometer values in days and hours/day.

For each subject, the time used in different levels of intensity of physical activity was also estimated. The number of minutes a day with cpm >900 was rated as moderate to vigorous physical activity as classified by Puyau et al.,[16] thus determining the number of subjects who had moderate to vigorous physical activity for 60 minutes or more a day.

For physical activity at night, we selected all the records that showed activity (cpm >25), for more than 60 minutes after 9.00 pm.

Statistics: Data were processed using the software Stata 11. A p-value <0.05 was considered significant. We performed a Shapiro-Wilk test to verify data normality, and the differences were determined by the Student's t test and ANOVA using the post hoc test by Scheffe. For the association of quantitative data, we used Pearson's correlation and the χ^2 test for qualitative data.

RESULTS

One hundred and twenty-eight boys and girls aged 4-10 entered the study. Of them, 19 were excluded for having incomplete daily records (less than 7.5 h), Actiwatch technical failures or dropout after one day. The remaining 109 cases were analyzed, 38 had four days of recordings (from Thursday to Sunday) and 26 had three days (from Thursday to Saturday). There were 45 who had only two valid days of accelerometry (different days); however, their incorporation was accepted for analysis because the average daily hours recorded and cpm/hour were not significantly different from the cases with three or four days of recordings.

The results of these 109 cases are presented in *Tables 1, 2 and 3* and in *Figure 1*. We found that the individual cpm/hour was closely associated to moderate to vigorous physical activity/day: R= 0.954 (Pearson).

Table 1 shows the mean cpm/hour values, moderate to vigorous physical activity (minutes/day) and the number of subjects with ≥60 minutes/day of moderate to vigorous physical activity, with significant difference between boys and girls. Individual daytime physical activities varied considerably from one subject to another: the difference between the highest and the lowest value obtained was of 42,017 cpm/hour.

As described in *Table 2*, age had no influence

on physical activity, but a slight downward trend between the extreme categories "<6 years" and ">9 years" was detected.

In *Table 3*, physical activity is classified according to nutritional status, with a significant difference in cpm/hour and moderate to vigorous physical activity (minutes/day) between children with a normal nutritional status and obese children. The 30 obese children were less active than the 63 with normal nutritional state.

In *Figure 1* physical activity (cpm/hour) of Thursdays and Fridays is compared with that of Saturdays and Sundays, for the 38 children who recorded data on four consecutive days. We note that there is a great individual variability, with many girls and boys who decreased their physical activity over the weekend, while others increased it.

On average, physical activity decreased slightly, but significantly ($p < 0.001$) over the weekend: cpm/hour= 16,210 (8694) versus 22,249 (7743) during the week. However, there was certain correlation between weekdays and weekends, both in the total group (R= 0.64) as in the boys (R= 0.66), but much less in girls (R= 0.26).

For one to four days, 88 students (53 boys, 35 girls) went to bed after 10.00 pm; 52 of them did so after 11 pm, and 23, after midnight. Among them, we added a total of 184 "night" hours, for which physical activity was 17,072 (12,071) cpm/hour. Fridays and Saturdays were a little less active, but the difference with Thursdays and Sundays was not significant.

DISCUSSION

This study (one of the first in our subcontinent) showed that physical activity of school children under 10 years has important variability from one subject to another. The information obtained, which was objective and non-reactive, has allowed us to appropriately determine whether the children assessed met the recommendation for

TABLE 1. *Accelerometric values of physical activity for 109 participants (mean, SD)*

	Total	Boys	Girls
n	109	67	42
cpm/hour	21,697 (7662)	24,226 (7969)*	17,662 (5030)*
MVPA min/day	90 (50)	106 (54)*	64 (29)*
Number of cases with ≥60 min/day of MVPA	80	56**	24**

*T Student $p < 0.05$
** χ^2 $p < 0.05$
MVPA: moderate to vigorous physical activity.

TABLE 2. *Accelerometric values of physical activity: variation according to age (mean, SD)*

Years	<6	6-6.9	7-7.9	8-8.9	≥9
n	11	20	28	29	21
cpm/hour	23,241 (6410)	21,615 (5115)	21,658 (7175)	23,552 (9616)	18,868 (7709)
MVPA min/day	92 (41)	88 (34)	91 (47)	101 (65)	72 (47)
Number of subjects with ≥60 min/day of MVPA	9	17	21	20	13

MVPA: moderate to vigorous physical activity.

TABLE 3. *Accelerometric values of physical activity according to nutritional status (mean, SD)*

	Normal	Overweight	Obesity
n	63	16	30
cpm/hour	23,912 (7147)*	19,884 (9716)	18,012 (5713)*
MVPA min/day	102 (45)*	82 (72)	67 (38)*
Number of cases with ≥60 min/day of MVPA	54**	9**	17**

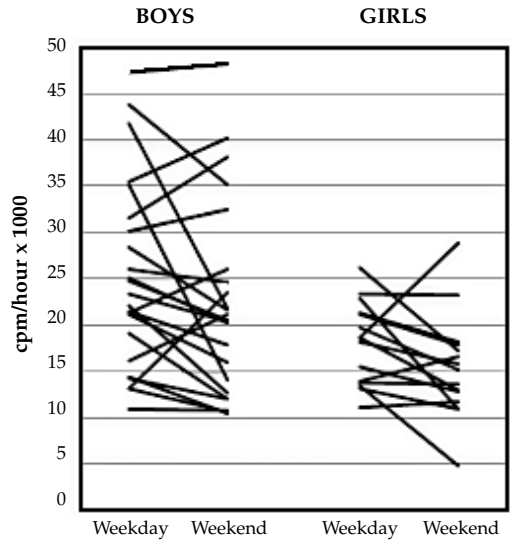
*ANOVA $p < 0.05$
** χ^2 $p < 0.05$
MVPA: moderate to vigorous physical activity.

moderate to vigorous physical activity for more than one hour a day. Additionally, contrary to the questionnaires, accelerometry provided information on physical activity almost during the entire waking time.

The results of this study should be interpreted with caution, given the relatively small size of the sample. In recent years, studies on physical activity by accelerometry have been published with many more subjects, up to over a thousand children, such as in the study by Nyberg et al.[17] However, other relevant studies have reported a number of cases similar to ours.[14,18,19]

Furthermore, we analyzed daily logs of physical activity for only two to four days, having established three days as initial pattern; however, cpm/hour values in two-day records were not significantly different from those collected for a larger number of days. According to Trost et al., at least seven days would be needed to appropriately estimate children's routine physical activity, but for children under 10, four days could be enough.[13] Future studies of physical activity in our country will be possible with the use of motion sensors for 7 or more days, and exercising caution for the selection of subjects and families, while taking into account the difficulties presented by low-income families.

FIGURE 1. *Comparison of cpm/hour for weekdays (Thursday and Friday) with week-end days (Saturday and Sunday) in 15 girls and 23 boys (averages for two days)*



Of the initial sample of 128 participants, 19 were excluded, which represents 14.8%, a similar value to our previous study (17.2%).[7] With prolonged accelerometry periods, these figures could be considerably higher, such as in the Van Coevering et al. publication, in the US,[20] where dropouts up to 55% have been reported, and even with notable loss of sensors.

As expected, our results show that boys are more active than girls, and obese school children are less active than non-obese ones, confirming the numerous data of literature from around the world. Physical activity did not decline between ages 5 to 10, as has been recently reported in Swedish boys and girls, both during school days and on weekends.[17] The difference between Chilean children and Swedish children of the same age (if confirmed by future studies) could be explained by different educational and cultural habits and traditions: in Chile there is more free outdoor play, less scheduled activities, perhaps even fewer school hours. Janssens[11] has described how, from preschool age (as of 2 years) to adolescence (up to 16-18 years), the essentials of physical activity go progressively from free spontaneous activity, based on games and command of motor skills, to directed activity, scheduled by sports and studies.

This transition seems to take place later in Chilean children than in Swedish children. Furthermore, global levels of physical activity may rise between ages 3-8, as suggested by another report from Sweden,[21] even though it may seem contrary to the above.

In the sample studied, there is globally little difference in physical activity between the week (school days as Thursday and Friday) and the weekend, but with great individual variations, both in girls and boys. In children under 10 years, studies have reported more physical activity over the weekend,[18,22] less activity,[17] or similar physical activity.[19,23] These differences could be attributed to the special circumstances of recording (season, family customs, etc.). Tendency towards less physical activity on weekends actually becomes general after ages 10-11.[17,22]

Moreover, in these school children, we evidenced considerable physical activity in hours of the night, after 10 pm, although data is not conclusive since the details of the occupation of these night hours are unknown. However, it is possible to point out that the waking pattern of these school children differs from that of Northern European children, whose bedtime is stricter (around 9 pm).

Finally, accelerometry has allowed us to determine, with greater precision than questionnaires, the amount of children who spend, on average, more than 60 minutes a day doing moderate to vigorous physical activity.[9-11] A significant number of school children achieved this goal: 73.4% in total, and even 83% in boys, percentages that are higher than those of older Chilean boys, which was only 62%.[7] However, in comparison, 93% of Hispanic children of Texas and 85% of girls aged 4-8 spend more than 60 minutes a day doing moderate to vigorous physical activity, per the Anglo-Saxon recommendation for children and teenagers between ages 6 and 18.[24]

A study conducted in three European countries (Denmark, Estonia and Portugal) concluded that children who spend an average of 90 minutes a day doing moderate to vigorous physical activity have a lower cardiovascular risk (measured by a set of seven factors) and better health.[25] Sixty minutes would not be enough according to these authors. However, the 90-minute goal may seem utopian and discouraging from a behavioral perspective, and the 60-minute goal seems more realistic and achievable in the current conditions.[11]

Currently, questionnaires are less reliable for assessing physical activity in children and adolescents, whatever the model or instrument. Several meta-analyses of studies on questionnaires, especially self-reports and approximate reports, have been published recently to seriously question their reliability.[26-28] In our country, new studies are required for an objective assessment of physical activity, in children and adolescents of all ages, with accelerometry recordings over more days (that we believe feasible), with greater number of participants, including variables such as social-economic level, season and climate, and considering possible ongoing models of intervention. Such a study will allow appropriate comparisons with international data and recommendations for Chilean childhood.

CONCLUSION

Individual physical activity of Chilean school children under 10 years of age is extremely variable. Girls are less active than boys and obese children are less active than non-obese. Eighty-three per cent of the students (but only 57% of girls) meet the recommendation for moderate to vigorous physical activity -the healthiest kind- for more than one hour a day.

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