

Compliance of pedometer-derived physical activity recommendations and step accumulation patterns in Chilean children from low-income areas

Cumplimiento de las recomendaciones de actividad física derivadas del podómetro y patrones de acumulación de pasos en niños chilenos de áreas de bajos ingresos

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Abstract. Background: Device measured physical activity (PA) allow better understanding on how PA is accrued during days. The purpose of this study was to describe pedometer-derived PA levels and patterns by gender in a population of Chilean children. Methods: 100 children were randomly selected from two low-income neighborhoods in Santiago, Chile. PA was measured with a wrist-worn pedometer for 7 consecutive days. Steps were summarized as total steps per hour and steps per day. PA hourly-patterns were compared across subgroups by age, gender, residence type and nutritional status. Results: 85 participants provided valid data (40 boys, 7.9±2.64 years, 47.8% overweight/obese). On an average day, children accumulated 11692.8±6061.8 steps with no differences between sexes (p=0.14). However, boys accumulated more steps in the morning and lunchtime than girls. Only 35.3% of the sample met PA guidelines (active), with no differences by sex (p=0.39). Active children in weekdays were more likely to meet the guidelines in weekend days (adjusted OR: 4.70, CI 95% 1.67-13.20) than those inactive in weekdays. Conclusion: PA guidelines compliance was relatively low. Step accumulation patterns differed between and within days including differences by gender in the morning and lunch time. This information may be used for designing feasible and equitable strategies for increasing the chances for meeting PA recommendations in both girls and boys.

Keywords: pedometer, physical activity assessment, community-based research, health behavior.

Resumen. Antecedentes: los métodos objetivos para medir la actividad física (AF) permiten una mejor comprensión de cómo se acumula la AF durante días. El propósito de este estudio fue describir los niveles y patrones de AF derivados del podómetro en una población de niños chilenos. Métodos: 100 niños participaron de dos barrios de bajos ingresos seleccionados al azar en Santiago de Chile. AF se midió con un podómetro de pulsera durante 7 días consecutivos. Los pasos se resumieron como pasos totales por hora y pasos por día. Los patrones de AF por hora se compararon entre los subgrupos por edad, sexo, tipo de residencia y estado nutricional. Resultados: 85 participantes proporcionaron datos válidos (40 niños, 7.9±2.64 años, 47.8% con sobrepeso / obesidad). En un día normal, los niños acumularon 11692.8±6061.8 pasos sin diferencias entre sexos (p = 0.14). Sin embargo, los niños acumularon más pasos en la mañana y mediodía que las niñas. Solo el 35.3% de la muestra cumplió con las recomendaciones de AF (activo), sin diferencias por sexo (p = 0.39). Los niños activos en los días de semana tenían más probabilidades de cumplir con las recomendaciones en los días de fin de semana (OR ajustado: 4.70, IC 95% 1.67-13.20) que los inactivos en los días de la semana. Conclusión: El cumplimiento de las recomendaciones de AF fue relativamente bajo. Los patrones de acumulación de pasos difieren entre y durante el día, incluyendo diferencias según sexo en relación a la acumulación de pasos en la mañana y almuerzo. Esta información puede ser utilizada para diseñar estrategias equitativas para aumentar las posibilidades de cumplir con las recomendaciones de AF tanto para niñas como para niños.

Palabras clave: podómetro, evaluación de la actividad física, investigación basada en la comunidad, comportamiento saludable.

Introduction

The evidence have consistently supported the numerous health benefits of physical activity (PA) in children (Leinaar, Alamian, & Wang, 2016; Steinbeck, 2001; Strong et al., 2005), including benefits on cognitive processes (Tandon et al., 2016), socialization, self-esteem and self-concept (Rhodes & Smith, 2006). PA is a determining factor in the energy consumption, therefore, it is essential for maintaining energy balance and weight control (Westerterp & Plasqui, 2004). These benefits are reflected in a positive dose-response relationship between PA and health (Janssen & Leblanc, 2010). To be optimally benefited from PA, it is recommended for children to perform at least 60 minutes of moderate-to-vigorous PA (MVPA) per day (World Health Organization, 2010).

Most countries in Latin America are lacking in evidence about PA levels and compliance of PA recommendations in young population (Hallal et al., 2012). Most evidence have been mainly derived from self-report instruments (Aguilar-Farias et al., 2018; Bauman et al., 2012). However, objectives methods for measuring PA based on accelerometers and pedometers are more accurate to determine total PA volumes (Strath, Pfeiffer, & Whitt-Glover, 2012). Objective tools for measuring PA are relatively more expensive and require trained researchers for data analysis compared with self-report methods, which may partially explain limited data availability derived from these devices in Latin America. Despite this, some Latin American countries such as Colombia, Brazil and Mexico have reported PA data with accelerometers at population level in children (da Silva et al., 2014; Katzmarzyk et al., 2015; Medina, Barquera, Katzmarzyk, & Janssen, 2015). Another alternative is the use of pedometers as they deliver PA data as measured in total steps

accumulated during a given time (e.g. minute, hour, day). Pedometers not only measure PA in an objective, non-invasive and accurate fashion, but also at lower cost than most accelerometers (Butte, Ekelund, & Westerterp, 2012). It is well-recognized that walking is a simple, natural and accessible option for being physically active within a day (Cristi-Montero, 2013). Therefore, PA recommendations can also be expressed in recommended steps per day (13000 steps/day for boys, 12000 steps/day for girls) (Rowlands & Eston, 2005). Using this principle, a study conducted in Chile in 6-9 aged school children reported that 33% of boys and 15% of girls met the PA recommendations as measured with pedometer in week days (Moreno, Cano, Orellana, & Kain, 2015). While, only 17% of boys and 9% of girls met the PA recommendation on weekend days (Moreno et al., 2015). These gender discrepancies have been observed in self-reported PA in Chilean children as well (Aguilar-Farias et al., 2016; Aguilar-Farias et al., 2018).

Objective devices provide higher resolution than self-report methods. Some pedometers, for example, not only provide total steps per day, but also they inform how these steps were accrued during an hour, day or week (i.e. PA patterns). Studies have reported differences on daily PA patterns and volumes between sexes (Vander Ploeg, Wu, McGavock, & Veugelers, 2012), independent of nutritional status (Deforche, De Bourdeaudhuij, D'Hondt, & Cardon, 2009), as well as, have reported differences in seasonal patterns (Kolke, Steene-Johannessen, Andersen, & Anderssen, 2009), in class periods and out of class (Aguilar-Farias, Martino-Fuentealba, & Espinoza-Silva, 2015; Beck, Chard, Hilzendege, Hill, & Stroebel-Benschop, 2016), and variations in school and weekend days (Aguilar-Farias et al., 2015; Steele et al., 2010). However, these variations have been different across nations. Therefore, objectively measured PA patterns may facilitate detection of opportunity windows for generating targeted actions for children, particularly for this age group as they are in a critical period before starting adolescence in which PA, generally, start to decrease in

both genders (Jago et al., 2018).

Due to the limited evidence available with device measured PA in Chile and their potential benefit to better understand how PA is accumulated within a day or week (Aguilar-Farias et al., 2016), the purpose of this study was to describe compliance of pedometer-derived PA recommendations and step accumulation patterns in a population of children from two low-income neighborhoods of the Region Metropolitana de Santiago, Chile.

Methods

Design

The study sample of this cross-sectional study comes from randomly selected low-income neighborhoods in the Peñalolen district of Santiago, Chile between August-October 2014. A low-income neighborhood was defined as part of the two lowest income quintiles in Chile. Neighborhood selection considered environmental and socioeconomic features described elsewhere (Cortinez-O’Ryan, Albagli, Sadarangani, & Aguilar-Farias, 2017). The participants were a objectively measured subsample of the pre-post trial called «Juega en tu Barrio» (Play in your Neighborhood) consisting in a play street program implemented on weekdays, for promoting PA among 4-to-12 year old children of low socioeconomic status (Cortinez-O’Ryan et al., 2017). Baseline data obtained from the intervention and control neighborhoods were analysed in the current study to avoid the intervention’s effect.

During data collection, each child and their family were visited three times for 1) providing information and recruitment, 2) signing written informed consent, completing a questionnaire and attaching a wrist-worn pedometer, and 3) collecting the wrist-worn pedometer. The study received approval from the Ethics Committee of the Universidad Metropolitana de Ciencias de la Educacion, Chile.

Measurements

Demographic data were obtained from the questionnaire completed by each participant’s responsible adult. Anthropometric variables (weight and height) were obtained with a portable measuring station (Seca 220, seca Deutschland, Germany). Body mass index (BMI) was estimated with weight in kilograms divided by height in meters squared. Nutritional status was classified as underweight, normal, overweight and obese based on BMI-for-age from the World Health Organization (WHO) reference standards (World Health Organization). Participants living in both, houses (61%) and apartments (39%) were recruited during August and September 2014. The houses faced the street and without or limited backyards. Apartments were located in gated four-story buildings with some protected open space for play.

Physical activity

Pedometer-determined PA was assessed with Movband (Movable, USA), a wrist-worn accelerometer that was placed on the participant’s non-dominant side. The device has shown excellent reliability and concurrent validity when compared with other widely used accelerometers (Barkley, Rebold, Carnes, Glickman, & Kobak, 2014; Fadel et al., 2015). Participants wore the Movband for 7 consecutive days and were asked to remove the pedometer only in water-based activities. Movbands were charged, synchronized and downloaded on the same computer to avoid time mismatches. Data were extracted in total steps per hour as allowed on the Movable online software. The participants were asked to complete a logbook every day to record their pedometer wearing time and waking hours.

Pedometer data reduction

Data from logbooks were merged with pedometer records for deleting non-wearing time. Pedometer-determined PA was considered valid if the participant wore the device for at least 10 hours in 3 weekdays and 1 weekend day (Rich et al., 2013). Steps were summarized as total steps per hour as well as total steps per day. Mean steps per hour on average day, weekdays and weekends for each participant were also

calculated for comparisons across subgroups. Mean total steps on an average day were calculated as follows: ((Mean total steps in weekdays x 5) + (mean total steps in weekend days x 2) / 7). While mean total steps per weekday and weekend day were also calculated in a similar method, but only including their respective days. Participants who met the pedometer-determined PA recommendations or ‘physically active’ were defined as those children that recorded at least 13000 steps per day for boys, and 12000 steps per day for girls (Rowlands & Eston, 2005). For the PA hourly-pattern analysis, mean total steps per hour on an average day, average weekday and average weekend day were calculated for each participant and compared across subgroups by age, gender, residence type and nutritional status.

Statistical analysis

Data were tested for normality with Shapiro-wilk. Means and standard deviation were used for describing normally distributed data, while median and quartiles were used for non-normally distributed data. Categorical data were shown as percentages. Differences between sexes for continuous data were assessed with Student T-test and multivariate Kolmogorov-Smirnov test depending on their distribution, while categorical data were assessed with chi-square test. Multivariate regression was used to assess the association for both 1) mean steps per day (average day, weekday, weekend day), and 2) PA recommendation compliance with gender, age, nutritional status, number of siblings, number of friends and residence type, respectively. All statistical analyses were performed using Stata 13.0 (StataCorp. College Station, TX, USA) and $p < 0.05$ was considered statistically significant.

Results

In total 100 children were measured, out of which 85 (40 boys) provided complete and valid data for pedometer-determined PA. The mean age was 7.9 years (SD: 2.64, range 3-13) and 47.8% of the sample was overweight. No differences between sexes were observed for age, BMI and nutritional status. Sample characteristics are displayed in Table 1.

Step accumulation per day

On an average day children accumulated 11692.8 ± 6061.8 steps with no differences between sexes ($p = 0.14$, Table 2). No statistical differences were found either for mean total steps on weekdays ($p = 0.13$) and on weekends ($p = 0.45$) between sexes. Also, no differences were

Table 1.
Sample characteristics

	Total (N=85)	Male (N=40)	Female (N=45)	P
Age (years), Mean (SD)	7.9 (2.64)	8.2 (2.64)	7.6 (2.63)	0.33
BMI (kg·m ⁻²), Mean (SD)	19.8 (4.41)	19.8 (4.96)	19.8 (4.01)	0.96
Nutritional status (%)				
Normal	52.2	53.4	51.3	0.56
Overweight	18.8	23.3	15.4	
Obese	29.0	23.3	33.3	
Number of siblings	1.3 (1.23)	1.2 (1.11)	1.4 (1.34)	0.50
Number of friends	4.5 (4.79)	4.9 (5.46)	4.1 (4.06)	0.41
Residence type (%)				
House	61.0	51.0	70.6	0.045
Apartment	39.0	49.0	29.4	

SD: standard deviation
Student’s t-test and multivariate Kolmogorov-Smirnov test were used for continuous variables and chi-square test for categorical data

Table 2.
Mean total steps per day and percentage of children who met the pedometer-determined PA recommendations by sex.

	Total	Male	Female	p
Steps on an average day (steps/day)				
Mean	11692.8	12731.7	10769.4	0.14
(SD)	(6061.8)	(7180.1)	(4754.0)	
Steps on weekdays (steps/day)				
Mean	11888.7	13020.8	10882.3	0.13
(SD)	(6472.55)	(7830.73)	(4840.09)	
Steps on weekend (steps/day)				
Mean	10680.7	11263.6	10152.1	0.45
(SD)	(6536.37)	(6751.23)	(6368.42)	
Active children (%)	35.3	40.0	31.1	0.39
Active children on weekdays (%)	40.0	45.0	35.6	0.38
Active children on weekend (%)	28.0	28.2	27.9	0.98

SD: standard deviation; PA: physical activity
Student’s t-test and multivariate Kolmogorov-Smirnov test were used for continuous variables and chi-square test for categorical data

observed between mean total steps on weekdays and weekend days (11888.7±6472.6 vs 10680.7±6536.4 steps/day; $p=0.23$).

Compliance of pedometer-derived PA recommendations

Only 35.3% of the sample met the recommendation for pedometer-determined PA on an average day, with no statistical differences between weekdays and weekend days ($p=0.10$). Also, despite more boys than girls met the PA recommendation, no statistical difference was observed between them ($p=0.39$).

When using multivariate regression analysis for estimating odds ratio for meeting pedometer-derived PA recommendations, no differences were found when adjusting by gender, age, nutritional status, number of siblings, number of friends and residence type. However, those children who met the PA recommendations in weekdays were more likely to meet the guidelines in weekend days (adjusted OR: 4.70, CI 95% 1.67-13.20) than those inactive in weekdays.

Step accumulation patterns

Step accumulation patterns were different in some hours of the day between boys and girls (Figure 1) on an average day, weekday and weekend days. Overall, step accumulation patterns on an average day fluctuated during the day with a peak at lunch time (1055.8±475.8 steps/hour) and steady decline throughout the afternoon (Figure 1). On an average day, step accumulation patterns differed between sexes with boys accruing more steps per hour than girls in the morning at 8:00-8:59 (514.1±415.9 vs 274.8±278.4 steps/hour, $p=0.002$), 9:00-9:59 (566.3±397.4 vs 408.5±320.0 steps/hour, $p=0.046$), and at lunch time from 13:00-13:59 (1195.9±512.1 vs 931.3±407.4 steps/hour, $p=0.01$) to 14:00-14:59 (922.0±438.7 vs 676.7±336.7 steps/hour, $p=0.005$) (Figure 2).

Step accumulation patterns during some hours of the day were statistically different when comparing these patterns between weekdays and weekend days in the total sample (Figure 3). Children on weekdays had higher step accumulation per hour than weekend days from 6:00 to 10:59, and 13:00-13:59. While more steps per hour were observed from 22:00 to 00:59 in weekend than weekdays. Mean differences in steps per hour between weekdays and weekend ranged from -314.9 steps/hour at 23:00-23:59 ($p=0.001$) to 348.9 steps/hour at 13:00-13:59 ($p=0.003$).

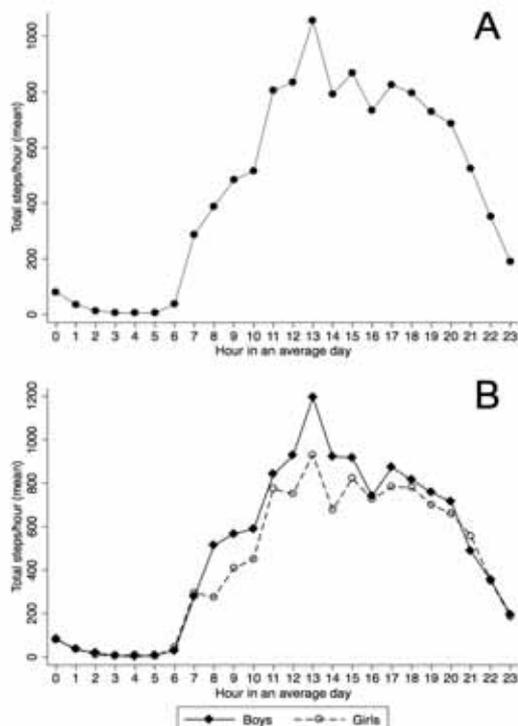


Figure 1. Pedometer-determined physical activity patterns in the total sample (A), and boys and girls (B) on an average day.

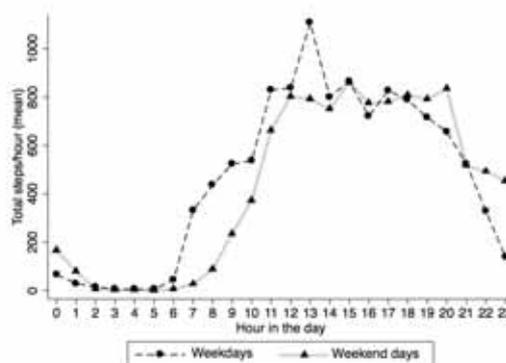


Figure 2. Pedometer-determined physical activity patterns in children on an average weekday and average weekend day.

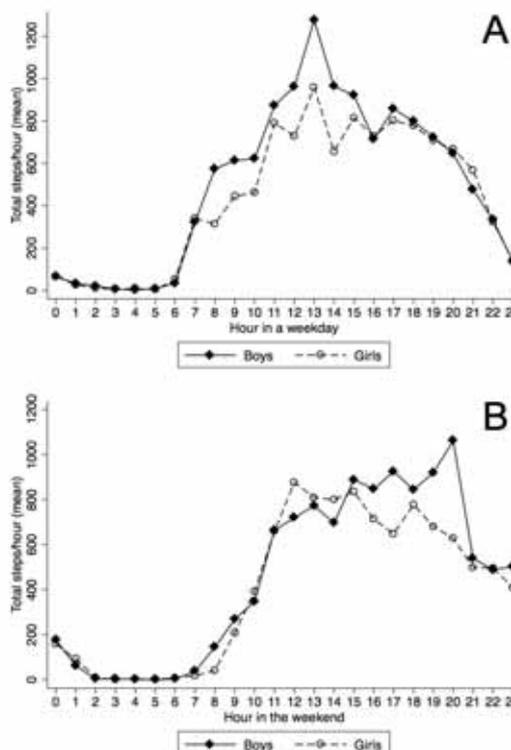


Figure 3. Pedometer-determined physical activity patterns in boys and girls on an average weekday (A) and weekend day (B).

Patterns of step accumulation per hour in weekdays by sex showed similar distribution to those described on an average day (Figure 4). In weekdays, boys accumulated more steps per hour than girls at 8:00-8:59 (574.2±450.00 vs 314.0±313.20 steps/hour, $p=0.003$), 12:00-12:59 (961.8±464.85 vs 728.1±414.13 steps/hour, $p=0.016$), 13:00-13:59 (1275.7±553.74 vs 957.4±427.08 steps/hour, $p=0.004$), and 14:00-14:59 (963.1±520.80 vs 656.1±371.40 steps/hour, $p=0.002$). Hourly PA patterns on weekend days were different between boys and girls only at 20:00-20:59 (1061.5±992.18 vs 628.2±682.57 steps/hour, $p=0.02$), which corresponds to the highest accumulation of steps/hour on the day for boys.

Discussion

The present study described compliance of pedometer-derived PA recommendations and step accumulation patterns in children of two low-income neighborhoods in Chile. In our study, the average of accumulated steps per day was 11692, which is lower than reported in other studies in similar age groups from other countries (Cox, Schofield, Greasley, & Kolt, 2006; Craig, Cameron, Griffiths, & Tudor-Locke, 2010; Duncan, Al-Nakeeb, Woodfield, & Lyons, 2007; Rosa et al., 2011), but higher than those observed in another Chilean sample of

adolescents (Parra Saldías, Vega, Fernández, & Ramírez, 2018).

The significant differences reported in international studies that have favored boys (Beltrán Carrillo et al., 2017; Duncan et al., 2007; Gao, Wang, Lau, & Ransdell, 2015) contrast with the lack of statistical difference in mean accumulated daily steps between girls and boys in our study (12731.7 vs 10769.4, $p=0.14$). However, the absolute difference observed (2000 steps/day approx.) was similar to that reported in other study conducted in Canadian population (boys 12259 vs girls 10906) (Craig et al., 2010). This may be partially explained by the wide dispersion of step accumulation patterns in both sexes as well as the relatively small sample size of our study. Another aspect that could have affected these results is that the sample of the study comes from low-income neighborhoods. In Chile, it has been observed that children attending public schools and live in low socioeconomic neighborhood, have less physical education classes, organized sports and reduced access to better quality infrastructure than children of higher socioeconomic level (Aguilar-Farias et al., 2016). These precarious conditions for performing PA may be affecting negatively in similar grade both girls as boys.

In our sample, no differences were observed in PA recommendation compliance rates when comparing and adjusting by different sociodemographic factors, including age. This may be partially explained as the participants were preadolescents and not adolescents in which PA decline and gender differences are exacerbated (Dumith, Gigante, Domingues, & Kohl, 2011). Efforts must be kept to ensure that children should engage and enjoy PA not only in school, but also in out-of-school hours, as participation in PA and perceptions about physical education tend to decrease with age (Brooke, Corder, Griffin, & van Sluijs, 2014; Carcamo-Oyarzun, Wydra, Hernandez-Mosqueira, & Salazar, 2017; Jago et al., 2018). Only a third of the sample met the PA recommendations, with lower compliance in weekend days (27.9% boys and 28.2% girls) than weekdays (45.0% boys and 35.6% girls) as similarly shown in other studies (Moreno et al., 2015; Vander Ploeg et al., 2012). These findings may suggest that the school environment promotes higher PA levels in children than homes or neighborhoods under this context as similarly shown in another study conducted in Chile (Godard, Román, Rodríguez, Leyton, & Salazar, 2012). Therefore, it may be pertinent to focus investments on out-of-school PA programs for providing opportunities in disadvantaged neighborhoods (Cortinez-O’Ryan et al., 2017), especially when considering that inactive children during weekdays are very likely to remain inactive on weekend days.

On an average day, higher step accumulation per hour was observed in boys than girls during the morning (8:00 – 10:00) and lunch time (13:00 – 15:00). These differences were also observed between weekdays and weekend days in the total sample, being active transportation to school and active play after lunch in weekdays (e.g. football in boys) possibly major contributors of this disparity. Studies in other countries have reported similar PA patterns to those observed in our study (Beltrán Carrillo et al., 2017; Goodman, Page, Cooper, & International Children’s Accelerometry Database, 2014; Vander Ploeg et al., 2012). For example, a study conducted in China reported that boys were more active before school than girls, but no differences were observed at lunch time as in our study (Gao et al., 2015). More comparable findings were reported by Beltrán-Carrillo et al (2017) in a sample of Spanish adolescents showing that boys were more active than girls before and during school hours. The step accumulation patterns described in this study provide relevant information for both reinforcing existing behaviors and creating new strategies to enhance these «more active» periods (e.g. safe routes, active breaks) (DiMaggio, Frangos, & Li, 2016; Hyndman, Benson, Ullah, & Telford, 2014). At the same time, these patterns clearly showed certain temporary spaces not only within a day but also in particular days where low PA levels were observed. These temporary spaces (i.e. lunch break) may be used for providing more opportunities for being more physically active at school or homes.

Chile, as it is located at the south of the Americas, meets special features related to the long hours of exposure to sunlight in spring and

summer periods. The number of accumulated steps per hour in late hours (after 7 pm) was similar to those observed in other countries that have implemented daylight saving (Goodman et al., 2014) and different to those reported in countries located closer to the Ecuador (Tucker & Gilliland, 2007). In line with these findings, Goodman et al. suggested that daylight saving could be evaluated as a public health strategy, due to its impact on the increment of PA levels in children from countries that implement compared to those who do not implement daylight saving (Goodman et al., 2014).

Strengths and limitations

There are other studies in Chile that have measured PA with pedometers, but to our knowledge, this is the first where the sample was obtained from low-income neighborhoods and then randomly selected to participate in the measurement. Pedometers were worn in the participants’ wrists, offering excellent compliance. Additionally, as these devices did not display the step count, it seems unlikely that PA behaviors may have been influenced by their use. The pedometer used in this study had memory, thus, it was not necessary to request children registering daily step count and reset the device every day, reducing sources of bias (i.e. participant’s memory, acceptability). Despite the strengths, our study was not exempt of limitations. The sample size was relatively small, but comparable to other exploratory studies (Deforche et al., 2009; Dorsey, Herrin, & Krumholz, 2011; Godard et al., 2012). PA patterns were measured on a single time frame during spring; therefore, we were not able to measure seasonal changes or trends within a same season. Despite this aspect was not part of our main goal, this may be considered in further studies, especially in countries with marked seasonal changes in terms of temperature, rain fall and sunlight exposure.

Conclusion

Only a third of the participants met the pedometer-determined PA recommendation on an average day, reinforcing the need for effective strategies to improve these figures. Children who met the PA recommendations in weekdays were more likely to meet the guidelines in weekend days than those inactive in weekdays, suggesting that physical behaviours tend to be stable in this age group. Hourly patterns showed that accumulated steps during early hours of the morning and lunchtime in school days play a key role in increasing PA during these days. In addition, boys accumulated more steps than girls during those periods that may reflect in some extent gender disparities in terms of active transportation, and use of playgrounds for engaging active play in activities such as football. This information may be used for designing equitable strategies for increasing the chances for meeting PA recommendations in both girls and boys.

Acknowledgments

Our team is particularly grateful to the children and their families who gave their time and support uninterestedly. The authors would like to thank the research assistance of Cristian Arias, Gerson Avendaño, Aldo Reyes, Daniel Chabur and Javier Nieto. We thank the Municipalidad de Peñalolén and CicloRecreoVía for their support during the execution of the fieldwork.

This research was funded by the Chilean National Fund for Research and Development in Health, FONIS. Grant number: EVS-13I0052. DCP, CUL and NAF were supported by CONICYT FONDECYT 11160720 and the Direccion de Investigacion, Universidad de La Frontera.

Conflict of interest: none

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