Duration and intensity of different types of physical activity among children aged 10–13 years

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Abstract

Objectives To use a predominately objective measurement approach to assess and describe: (1) the amount of time that children aged 10–13 years spend participating in outdoor active play, active travel, curriculum-based physical activity at school, and organized sport; (2) the movement intensity composition of these four types of physical activity (i.e., % of time spent at a sedentary, light, or moderate-to-vigorous intensity); and (3) the proportion of each movement intensity obtained by participating in these four types of physical activity.

Methods Three hundred seventy-seven children aged 10–13 years from Kingston, Canada, were studied. Children wore an accelerometer and GPS watch for 7 days and recorded the start and end times of the school day, recess periods, and organized sport sessions on a log. These data were used to estimate time spent in the four types of physical activity and the movement intensity composition of these activities.

Results Time spent in outdoor active play (36 min/day) and organized sport (40 min/day) was higher than that for active travel (17 min/day) and curriculum-based physical activity (26 min/day). With the exception of organized sport, values were higher for boys than for girls. Older children accumulated less outdoor active play and more active travel than younger children. The greatest proportion of light- and moderate-to-vigorous-intensity movement was attributed to outdoor active play.

Conclusion We used a primarily objective measurement approach to assess and describe the amount of time children aged 10–13 participate in four types of physical activity. These descriptive findings could be used to identify target areas for physical activity interventions and policies.

Résumé

Objectifs Employer une stratégie de mesure principalement objective pour évaluer et décrire : 1) le temps consacré par des enfants de 10 à 13 ans au jeu actif à l'extérieur, au transport actif, à l'activité physique prévue au programme scolaire et au sport organisé, 2) la composition de ces quatre types d'activité physique du point de vue de leur intensité de mouvement (c.-à-d. le pourcentage du temps consacré aux activités sédentaires, légères ou d'intensité modérée à vigoureuse) et 3) la proportion de chaque intensité de mouvement obtenue en participant à ces quatre types d'activité physique.

Méthode En tout, 377 enfants de 10 à 13 ans vivant à Kingston, au Canada, ont été étudiés. Les enfants ont porté un accéléromètre et une montre GPS pendant 7 jours et ont inscrit dans un journal les heures de début et de fin de leur journée scolaire, de leurs récréations et de leurs séances de sport organisé. Ces données ont servi à estimer la durée des quatre types d'activité physique et la composition de ces activités du point de vue de leur intensité de mouvement.

Résultats Le temps consacré au jeu actif à l'extérieur (36 minutes/jour) et au sport organisé (40 minutes/jour) était supérieur au temps consacré au transport actif (17 minutes/jour) et à l'activité physique prévue au programme (26 minutes/jour). Sauf pour le sport

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organisé, les valeurs étaient plus élevées chez les garçons que chez les filles. Les enfants plus vieux ont accumulé moins de minutes de jeu actif à l'extérieur et plus de minutes de transport actif que les plus jeunes. La plus grande proportion de mouvement d'intensité légère et d'intensité modérée à vigoureuse a été imputée au jeu actif à l'extérieur.

Conclusion Nous avons employé une stratégie de mesure principalement objective pour évaluer et décrire le temps consacré par des enfants de 10 à 13 ans à quatre types d'activité physique. Nos constatations descriptives peuvent servir à fixer des cibles pour des interventions et des politiques d'activité physique.

Keywords Play · Transportation · Youth sports · Physical education · Sedentary lifestyle · Child

Mots-clés Jeu · Transports · Sports pour les jeunes · Éducation physique · Mode de vie sédentaire · Enfant

Introduction

The majority of Canadian children do not accumulate the recommended 60 min/day of moderate-to-vigorous physical activity (Colley et al. 2017). A better understanding of how children accumulate their physical activity would inform future interventions and policies designed to improve children's physical activity levels. Recent research examining time-use patterns of physical activity has framed movement based on its intensity (i.e., min/day spent at a sedentary, light, and moderate-to-vigorous intensity) (Chastin et al. 2015; Carson et al. 2016). Physical activity could also be framed based on the type of physical activity being performed. For children, this would reflect time spent participating in outdoor active play, active travel, curriculum-based physical activity at school, and organized sport. While there are considerable data, primarily from self-report, on the prevalence and/or frequency of participation in different types of physical activity (Marques et al. 2016; Gray et al. 2014; Larouche et al. 2014), it is unclear how much time children spend participating in these different types of physical activity. This information could be used to identify target areas for physical activity interventions and policies. For instance, a finding that children spent fivefold greater time participating in organized sport compared with active travel would suggest that more emphasis should be placed on increasing active travel.

In addition to learning more about the time children participate in different types of physical activity, it would be helpful to know more about the movement intensity composition of these types of physical activity. Because higher intensity movement is more strongly associated with health indicators than lower intensity movement (Poitras et al. 2016), children may benefit more from participating in physical activity types that primarily consist of higher intensity movement. Previous studies have examined the movement intensity composition of specific types of physical activities (Carlson et al. 2015; Sacheck et al. 2011; Stone et al. 2012), but they have not made comparisons across types. Furthermore, although previous work has investigated children's physical activity by location using objective methodologies (i.e., accelerometers and global

positioning system [GPS]) (Klinker et al. 2014; Rainham et al. 2012), to our knowledge, no study has combined these methodologies to classify children's physical activity according to type.

Accordingly, the primary objective of this paper was to determine the amount of time that children aged 10–13 years spend participating in outdoor active play, active travel, curriculum-based physical activity at school, and organized sport. The secondary objectives were to determine the movement intensity composition of these four types of physical activity and to determine what proportion of time spent in each movement intensity was obtained through participation in these types of physical activity.

Methods

Study sample

A sample of 458 children aged 10–13 years was recruited from the ~5000 children in this age range who live in Kingston, Ontario, Canada (Statistics Canada 2017). Data collection occurred between January 2015 and December 2016 and was balanced across the four seasons. Season of data collection was defined as spring (Apr–Jun; mean temperature = 11.7 °C), summer (Jul–Aug; mean temperature = 20.2 °C), fall (Sep–Nov; mean temperature = 10.5 °C), or winter (Dec–Mar; mean temperature = –2.8 °C) based on a combination of weather patterns and school calendars. An equal number of boys and girls and of 10-, 11-, 12-, and 13-year-olds were recruited. In addition, participants were recruited to ensure proportional representation from Kingston's 12 electoral districts. Participants were recruited using word of mouth, flyers, posters, and social media. Written informed assent and consent were obtained from child participants and their parents/guardians, respectively. This study was approved by the General Research Ethics Board at Queen's University.

Measurement of physical activity

Participants' physical activity was measured over 7 consecutive days using a measurement approach developed by our research group that was specifically designed to assess the time spent in outdoor active play, active travel, curriculum-based physical activity, and organized sport. Within the context of this measurement approach, outdoor active play captured unstructured and informal physical activities that are freely chosen, typically child-led with little or no adult supervision, and which occur in a variety of outdoor locations (Veitch et al. 2008) (e.g., exploring nature, playing at recess, playing basketball in the driveway). Active travel captured human-powered transportation such as walking or bicycling to all destinations. Curriculum-based physical activity captured physical activity performed during class time at school. This included physical education classes, special movement-oriented school events, and Daily Physical Activity (i.e., an Ontario school policy which stipulates that students should perform 20 min/day of physical activity in class). Organized sport captured physical activities that are scheduled, typically governed by rules and regulations, often competitive in nature, and supervised and managed by adults (e.g., soccer game, gymnastics practice). These four types of physical activity were considered to be mutually exclusive.

A description of the measurement approach used to assess time spent in these different types of physical activity, including measurement devices used, steps used to clean and merge the data collected by these devices, algorithms, and decisions rules used when processing the data, and the validity and reliability of these methods are available elsewhere (Borghese and Janssen 2018). A brief description is provided below.

During the 7-day measurement period, participants wore an Actical accelerometer (Philips Respironics, Bend, OR) on their right hip for 24 h/day (Trost et al. 2000). Data were recorded in 15-second epochs. Participants were instructed to remove the device only for water-based activities. Participants also wore a Garmin Forerunner 220 GPS watch (Garmin, Olathe, KS), which recorded their longitude and latitude positions approximately every 2 s to 2 min depending on satellite signal availability. Participants also maintained a log wherein they recorded their daily bed and wake times, times that either the accelerometer or the GPS watch was not worn, and the start and end times of organized sport sessions. Participants also provided the name of their school, start and end times of the school day, and recess periods. School days were abstracted from schoolboard websites.

Accelerometer and GPS data were imported into the Personal Activity and Location Measurement System (PALMS) software (The Physical Activity and Location Measurement (PALMS) 2017). GPS coordinates were matched to 15-s accelerometer epochs. PALMS identified epochs that

occurred during active trips (i.e., walking or bicycling at speeds < 25 km/h) and vehicle trips (speeds $\geq$ 25 km/h). All trips identified by PALMS were visually inspected and falsely identified trips were deleted (Borghese and Janssen 2018).

Merged accelerometer and GPS data were then combined with geographic information system (GIS) data in ArcMap 10.5 (ESRI, Redlands, CA) to identify whether each epoch occurred while the participant was indoors (i.e., within a building footprint) or outdoors. We then applied an algorithm to correct some of the error in the precision of location estimates which resulted from poor signal quality (Borghese and Janssen 2018).

We used SAS 9.4 (SAS Institute, Cary, NC) to merge the times recorded in the logs with the file that contained the merged accelerometer, GPS, and GIS data. All epochs that occurred during sleep or during non-wear time of either device were removed. Non-wear time included both the times that children identified as having removed either device or 60 consecutive minutes with zero counts/minute (with up to two non-zero minutes) (Colley et al. 2010). There were no biologically implausible count values (> 5000 counts/15-s epoch). A valid measurement day was defined as having ≥ 10 h of both accelerometer and GPS data (Colley et al. 2010); all epochs from invalid measurement days were deleted. Participants had to have at least 4 valid measurement days to be included (Trost et al. 2000). Time spent in each movement intensity was classified according to established intensity cutoffs for the Actical accelerometer: moderate-to-vigorous, ≥ 375 counts/15 s; light, between < 375 and ≥ 25 counts/15 s; and sedentary, < 25 counts/15 s (Colley and Tremblay 2011).

All epochs that occurred during organized sport, as recorded on the logs, were flagged. Likewise, all epochs identified as being part of active travel from PALMS were flagged. Trips with the same start and end destination (e.g., walking around the neighbourhood, going for a run) were excluded because they were considered travel for leisure rather than active travel to a specific destination. Identification of outdoor active play was done using a previously established prediction algorithm that classified epochs as either being part of outdoor active play or not using a combination of accelerometer, GPS, GIS, and self-report data (Borghese and Janssen 2018). Epochs that occurred while sleeping, indoors, or during school curriculum time, organized sport, or active travel were excluded prior to applying the outdoor active play algorithm. Identification of curriculum-based physical activity was done using a previously established prediction algorithm that classified epochs that occur during school curriculum time as being either part of curriculum-based physical activity or not (Borghese and Janssen 2018). Epochs flagged as being part of each type of physical activity were summed and the average minutes/day was calculated. Time spent in light and moderate-to-vigorous physical activity that did not occur while participating in the four types of physical activity described above was categorized

as “other.” Types of physical activity that would have fallen in the “other” category include activities of daily living (e.g., getting dressed, walking around the house), household chores, work, indoor play, and exercise (e.g., going for a run, going to the gym).

Statistical analysis

Data were analyzed using SAS 9.4. Statistical significance was set at $p < 0.05$. Estimates of time spent in different movement intensities and different types of physical activity are presented as mean and 95% confidence intervals (95% CI). Estimates of mean time spent in each type of physical activity were determined using a two-part modeling strategy (Diehr et al. 1999). This modeling strategy was used because a substantial proportion of participants accrued 0 min/day for one or more types of physical activity (outdoor active play = 1%, active travel = 8%, curriculum-based physical activity = 19%, organized sport = 29%) and these variables could not be transformed to follow a normal distribution. In the first part of the two-part model, we used logistic regression to model the probability of the presence of any minutes (i.e., non-zero value) of physical activity. In the second part of the two-part model, we used a generalized linear model (PROC GENMOD, using a logit link function and gamma distribution) to estimate mean time spent in physical activity in those participants who engaged in > 0 min of physical activity. We then multiplied the estimates derived from part one and part two of the model together to derive an overall mean. We used ANOVA with Bonferroni post hoc tests to compare time spent in different movement intensities and time spent in each type of physical activity by sex, age, and season.

Estimates of the movement intensity composition within each type of physical activity, as well as the proportion of overall movement intensity derived from each type of physical activity, are presented as mean (95% CI). We compared means using linear mixed models including participant as a random effect. Comparisons using the full sample are presented; similar results were observed when analyses were conducted separately by sex, age, and season. Other comparisons were made using one-way ANOVA.

Results

A total of 377 out of 458 (82%) participants had ≥ 4 days with ≥ 10 h of combined accelerometer and GPS data and were included in the analyses. These participants provided data for 5.9 days on average and the mean combined accelerometer and GPS wear time was 13.1 h/day. Socio-demographic characteristics of the sample are in Table 1. By comparison to the sample included in the final analysis, a higher proportion of those with insufficient wear time participated during the

Table 1 Participant characteristics ($n = 377$)

Characteristic	Number	Percent
Sex		
Boys	191	50.7
Girls	186	49.3
Age		
10	90	23.9
11	95	25.2
12	100	26.5
13	92	24.4
Season		
Winter (Dec–Mar)	133	35.3
Spring (Apr–Jun)	86	22.8
Summer (Jul–Aug)	43	11.4
Fall (Sep–Nov)	115	30.5
Race		
White	328	87.0
Other	49	13.0
Family income (\$CDN per year)		
$\leq \$50,000$	50	13.3
$\$50,001–\$100,000$	110	29.2
$\geq \$100,000$	173	45.9
No response	44	11.7
Parental education		
High school or less	29	7.7
2 years college	114	30.2
4 years college/university	234	62.1

summer months (31% vs. 23%, $p < 0.001$) and were in the lowest income (27% vs. 13%, $p = 0.02$) and parental education (15% vs. 8%, $p = 0.04$) categories.

A description of time spent in different movement intensities is presented in Table 2. Mean daily moderate-to-vigorous-intensity movement was ≥ 60 min/day in 36% (134 of 377) of participants. Moderate-to-vigorous movement was higher for boys than for girls, highest for children participating in the spring, and lowest for children participating in the summer. Children aged 12–13 years accumulated less time in light-intensity movement, but more sedentary time, compared to children aged 10–11 years. Light-intensity movement was lowest for children participating during the summer.

Time spent in each type of physical activity is presented in Table 3. Children spent more time participating in outdoor active play (36 min/day) and organized sport (40 min/day) than they did participating in active travel (17 min/day) and curriculum-based physical activity (26 min/day) (all $p < 0.001$). Boys spent more time in outdoor active play, active travel, and curriculum-based physical activity than girls; however, girls spent more time in organized sport ($p < 0.05$). Thirteen-year-olds

Table 2 Time spent in different movement intensities by sex, age, and season

	Moderate-to-vigorous-intensity movement (min/day)	Light-intensity movement (min/day)	Sedentary time (min/day)
Total	56 (53, 58)	160 (157, 163)	570 (564, 577)
Sex			
Boys	62 (59, 66)	162 (157, 166)	558 (549, 568)
Girls	49 (46, 52)*	158 (153, 162)	583 (575, 591)*
Age			
10	58 (53, 63)	170 (164, 177)	549 (538, 560)
11	58 (54, 62)	165 (159, 171)	553 (540, 566)
12	52 (48, 56)	154 (148, 160) [†]	583 (572, 594) ^{†,‡}
13	55 (50, 60)	151 (144, 157) ^{†,‡}	596 (584, 609) ^{†,‡}
Season			
Winter	51 (47, 54)	160 (155, 166)	579 (569, 589)
Spring	69 (63, 75) [§]	166 (160, 172)	560 (546, 574)
Summer	39 (34, 44) ^{§,}	146 (135, 158) ^{§,}	575 (556, 594)
Fall	58 (54, 62) ^{§, ,¶}	160 (155, 165)	567 (555, 579)

Estimates are presented as mean (95% CI). ANOVA with Bonferroni post hoc tests was used to compare values by age, sex, and season with each variable adjusted for the other two variables (e.g., comparisons between age groups were adjusted for sex and season)

*Significantly different from boys ($p < 0.05$)

[†] Significantly different from 10-year-olds ($p < 0.05$)

[‡] Significantly different from 11-year-olds ($p < 0.05$)

[§] Significantly different from winter ($p < 0.05$)

^{||} Significantly different from spring ($p < 0.05$)

[¶] Significantly different from summer ($p < 0.05$)

Table 3 Time spent in each type of physical activity by sex, age, and season

	Outdoor active play (min/day)	Active travel (min/day)	Curriculum-based physical activity (min/day)	Organized sport (min/day)
Total	36 (29, 45)	17 (13, 22)	26 (22, 31)	40 (29, 57)
Sex				
Boys	43 (35, 54)	19 (15, 26)	28 (24, 34)	34 (25, 48)
Girls	29 (23, 36)*	14 (11, 19)*	24 (20, 29)*	46 (33, 66)*
Age				
10	46 (37, 57)	13 (9, 17)	26 (21, 31)	30 (21, 42)
11	44 (36, 54)	15 (11, 20)	26 (21, 31)	42 (31, 57)
12	31 (25, 39) [†]	15 (11, 20)	26 (22, 31)	44 (31, 64)
13	24 (19, 30) ^{†,‡}	25 (19, 32) ^{†,‡,§}	26 (22, 32)	45 (33, 63)
Season				
Winter	27 (22, 33)	12 (9, 15)	23 (19, 28)	44 (33, 59)
Spring	54 (45, 66)	22 (17, 30)	30 (25, 36)	47 (35, 62)
Summer	31 (21, 44) [¶]	16 (11, 22)	—	38 (19, 77)
Fall	35 (28, 44) ^{,¶}	19 (15, 25)	26 (22, 32)	32 (23, 43)

Estimates were derived using a two-part model and are presented as mean (95% CI). ANOVA with Bonferroni post hoc tests was used to compare values by age, sex, and season with each variable adjusted for the other two variables (e.g., comparisons between age groups were adjusted for sex and season)

*Significantly different from boys ($p < 0.05$)

[†] Significantly different from 10-year-olds ($p < 0.05$)

[‡] Significantly different from 11-year-olds ($p < 0.05$)

[§] Significantly different from 12-year-olds ($p < 0.05$)

^{||} Significantly different from winter ($p < 0.05$)

[¶] Significantly different from spring ($p < 0.05$)

Fig. 1 The movement behaviour composition of outdoor active play, active travel, curriculum-based physical activity, and organized sport. Values reflect the proportion of the total time in each type of physical activity spent at different movement intensities. Linear mixed models with Bonferroni post hoc tests were used to compare proportions across the different types of physical activity

spent less time in outdoor active play but more time in active travel than 10- and 11-year-olds ($p < 0.05$). Time spent in outdoor active play was highest for children who participated in the spring, while time spent in both outdoor active play and active travel was lowest for children who participated in the winter ($p < 0.05$).

The movement intensity composition of the four types of physical activity is presented in Fig. 1. Means and 95% confidence intervals are in Supplementary Table 1. The proportion of time spent at a moderate-to-vigorous intensity was highest during active travel (59%). The proportion of time spent at a light intensity was highest during outdoor active play (46%). The proportion of time spent at a sedentary intensity was highest during organized sport (44%).

Fig. 2 Proportion of the total time spent in each movement intensity accumulated while participating in outdoor active play, active travel, curriculum-based physical activity, organized sport, and other pursuits. Linear mixed models with Bonferroni post hoc tests were used to compare proportions across movement intensities. Labels are not shown for values that contributed to < 3% of the total

The contribution that each type of physical activity made to the total daily time spent in each movement intensity is presented in Fig. 2. Means and 95% confidence intervals can be found in Supplementary Table 2. Approximately half (51%) of children's moderate-to-vigorous-intensity movement, 23% of their light-intensity movement, and 5% of their sedentary time were accumulated while participating in the four types of physical activity measured in this study. A greater proportion of moderate-to-vigorous- and light-intensity movement was accumulated by participating in outdoor active play by comparison to the other three types of physical activity ($p < 0.05$). A greater proportion of light-intensity movement and sedentary time were accumulated during curriculum-based physical activity and organized sport by comparison to active travel ($p < 0.05$).

Discussion

This paper provides descriptive estimates of the time that children spend participating in different types of physical activity, the movement intensity composition of these different types of physical activity, and the extent to which these types of physical activity contribute to children's overall movement. We studied a heterogeneous group of children aged 10–13 years from Kingston, ON, Canada. We found that children spent ≈ 2 h/day participating in the four types of physical activity assessed here; however, only a small proportion ($\approx 29\%$, based on a weighted average) of that 2 h was spent at a moderate-to-vigorous intensity. Furthermore, $\approx 49\%$ of moderate-to-vigorous-intensity movement accumulated throughout the day was obtained from other sources of physical activity. Children devoted more time to outdoor active play and organized sport compared to active travel and curriculum-based physical activity.

A novel aspect of our paper was the (mostly) objective means used to assess time spent in different types of physical activity. Previous physical activity time-use studies have largely relied on self- or proxy-reported measures (Hofferth 2009; Synovate 2017). Several previous studies have combined data from accelerometers and GPS devices to classify children's physical activity according to location (Klinker et al. 2014; Rainham et al. 2012). However, to our knowledge, our study is the first to classify children's physical activity according to type using this methodology. This distinction is important because different types of physical activity can occur at the same location. For instance, physical activity that takes place in a park could reflect any of the four types of physical activity described herein (e.g., children playing in a park, active travel trip that crosses through a park, physical education class in a park, soccer game on a park field).

This paper is the first to present estimates of total daily time spent in outdoor active play in children using a measurement

approach that relies on objective methodologies. Overall, children accumulated 36 min/day of outdoor active play. This is lower than self-reported estimates. For instance, 37% of Canadian children in grades 6–10 who participated in the 2013–2014 Health Behaviour in School-aged Children study reported that they played outdoors for ≥ 2 h/day (ParticipACTION 2016). This 2 h/day threshold was based on the active play target in Canada's Report Card on Physical Activity for Children and Youth (ParticipACTION 2016). In the current study, only 1% (4 of 377) of children accumulated ≥ 2 h/day of outdoor active play on average. Despite this finding, children spent more time in outdoor active play compared to active travel and curriculum-based physical activity, and of the four types of physical activity assessed, it made the largest contribution to their overall moderate-to-vigorous (18%)- and light (10%)-intensity movement. Although children are doing less outdoor active play than we might have previously thought, and far less than previous generations of children (Tremblay et al. 2015), this type of physical activity still makes a substantive contribution to a child's total movement behaviour profile.

The majority of research on children's active travel has focused on the proportion of children who report usually engaging in active travel (Gray et al. 2014; Larouche et al. 2014), and has frequently only considered trips between home and school. The total time that children spend engaged in active travel throughout the day, rather than the frequency of trips to specific destinations, is a more comprehensive marker of their active travel levels. In the current study, children averaged 17 min/day in objectively measured active travel. Previous estimates using similar objective methods from geographically diverse samples range from ≈ 5 to 22 min/day (Carlson et al. 2015; Klinker et al. 2014). In the current study, children spent less time in active travel than in the other three types of physical activity. However, the proportion of time spent at a moderate-to-vigorous intensity was the highest for active travel, as similarly found in previous work (Carlson et al. 2015). Therefore, active travel still contributed to a meaningful proportion (13%) of overall moderate-to-vigorous-intensity movement. Given the highly favourable movement intensity composition of active travel, public health efforts should continue to promote active travel as an efficient way to improve physical activity levels. These efforts should consider all travel destinations and not just school.

The Ontario Ministry of Education mandates that children participate in at least 150 min/week of curriculum-based physical activity (Physical and Health Education Canada 2015), including at least 20 min/day of Daily Physical Activity and at least 50 min/week of physical education. Children in the current study accumulated less than this mandated amount. During the school year, our participants accumulated ≈ 130 min/week of curriculum-based physical activity; only 27% of this time was spent in

moderate-to-vigorous-intensity movement. These results are in line with previous research in Ontario, which suggests that few children typically engage in Daily Physical Activity on a daily basis (Stone et al. 2012) and that when they do participate, they accumulate very little moderate-to-vigorous-intensity movement (Stone et al. 2012).

Descriptive data on organized sport are typically based on participation rates and frequency rather than time (Clark 2008; Guèvremont et al. 2008). In Canada, approximately 3 in 4 children engage in organized sport regularly (Guèvremont et al. 2008) and those who participate do so 2.6 times/week on average (Clark 2008). Similarly, in our study, 71% of children participated in organized sport at least once during the 7-day measurement period and these children participated 2.8 times/week on average. Data from our study suggest that children aged 10–13 spend an average of 40 min/day (280 min/week) participating in organized sport. Unfortunately, our findings suggest that 44% of organized sport time was spent at a sedentary intensity, which is consistent with previous research (range 27–49%) (Sacheck et al. 2011). This finding warrants emphasis because parents may believe that organized sport is a primary means through which children accumulate their physical activity (Neely and Holt 2014), which may not be true. However, our finding that time spent in organized sport was higher for girls than for boys was unexpected. This was explained by the tendency for girls to engage in longer sessions of organized sport than boys, but with no difference in frequency of participation.

This study is not void of limitations. First, while recruitment was balanced for sex, age, season, and electoral districts within the city of Kingston, participation was voluntary and we cannot claim that this was a representative sample. Nonetheless, the average minutes/day of moderate-to-vigorous-intensity movement (56 min/day) and the proportion meeting physical activity guidelines (36%) in our sample are almost identical to nationally representative estimates (55 min/day and 36%, respectively) (Colley et al. 2017; Roberts et al. 2017). Moreover, the observed trends in overall movement behaviours across sex, age, and season are consistent with the literature for pre-adolescent children (Colley et al. 2013). However, our exclusion of some participants for insufficient accelerometer and/or GPS wear time resulted in some imbalance in the analytical sample. Second, we did not distinguish between subtypes of curriculum-based physical activity (i.e., physical education class vs. Daily Physical Activity). In the future, researchers may consider gathering this information from children using self-report or through other means. Finally, $\approx 49\%$ of children's moderate-to-vigorous-intensity movement was not classified into the four types of physical activity assessed in the current study. This reflects other types of movement, including activities of daily living (e.g., getting dressed, walking around the house), chores or work, and playing indoors. This also included recreational travel/exercise (e.g., going for a run with same start and end point), which we considered a form of leisure-time exercise rather than active travel to a specific destination.

In conclusion, time-use patterns attributable to physical activity can be framed based on the type of physical activity that children do. We present estimates of time use for four types of physical activity in children. This descriptive examination will contribute to the surveillance of children's physical activity and could inform policy and intervention development aimed at improving children's physical activity levels. Future interventions and policies should consider increasing children's time in outdoor active play and active travel because participation is low (relative to established benchmarks) (ParticipACTION 2016) and because the composition of movement intensity within these types of physical activity is favourable.

Compliance with ethical standards

Written informed assent and consent were obtained from child participants and their parents/guardians, respectively. This study was approved by the General Research Ethics Board at Queen's University.

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