Validation of self-reported physical activity by accelerometry in Tanzanian primary school children

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Research

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Abstract

Background: Insufficient physical activity is a serious public health concern. Assessing physical activity accurately in children remains a challenge and valid tools for its assessment in African children are needed. This study compares self-reports versus accelerometry-captured physical activity.

Methods: In this cross-sectional study, 51 primary school children aged 9 – 11 years from four primary schools in Kilimanjaro region were enrolled. Children were asked to complete a self-reported questionnaire on physical activity and wore an accelerometer for seven consecutive days. Accelerometry was used as a reference method to assess for child reporting accuracy.

Results: Spearman correlation between self-reports and accelerometry was moderate ($r=0.41$, $p=0.002$). Children who reported walking to school had higher moderate to vigorous physical activity (MVPA) for both accelerometry and self- reports compared to their counterparts ($p < 0.001$). Intra-class correlation (ICC) showed that 32% of the variations in accelerometry weekly total MVPA was contributed by the differences in activities between children.

Conclusions: Objective measures of physical activity such as accelerometers can be used to accurately measure physical activity in children where feasible. Self-reports have limited validity, and therefore more research is needed to develop better self-reported measures with specific activities which can easily be recalled by children.

Background

Physical activity in children is a key to better health. Active children gain health benefits including cardiorespiratory, muscular fitness and bone health. Physical activity plays an important role in prevention of non-communicable diseases (NCDs) and avoidance of weight gain (1). The World Health Organization (WHO) recommends an average of at least 60 minutes per day of moderate to vigorous activities for 5 – 17 years old, to gain benefits for their later life (2-4). Studies in low and middle-income countries reported low levels of physical activity and high levels of sedentary behaviours in children (5, 6). In Tanzania 82.1% of school-going children are not meeting the recommended physical activity levels (7).

Physical activity is a complex behaviour which includes day-to-day variations of activities which might not be easily remembered by children (8). Tools for measuring physical activity include subjective measures such as self-reports, proxy reports by parents and teachers, activity diaries and recalls. Selection of a suitable assessment questionnaire for physical activity and instruments is based on the target population under study, respondent burden, cost effectiveness and type of information to be collected. In population studies, objective measures may be too expensive to be feasible so self-reports are often used to assess physical activity. However, self-reports are prone to errors due to large day-to-day variations and inaccurate estimation of physical activity levels (9, 10).

Objective measures have been widely used in high-income countries to track physical activity in children; methods include motion sensors such as heart rate monitors, accelerometers and pedometers. Heart rate monitors are cheap to use but they have shown a weak relationship with energy expenditure while pedometers only capture steps taken to provide estimates of activity levels. Over the years, accelerometers have been used increasingly in high-income countries for assessment of physical activity in children (11, 12). Accelerometers provide valid estimates of activity levels by capturing movement in real time and having low technical error of measurement. They are particularly useful for validating self-reports (8, 9).

The purpose of this pilot study was to determine the validity of self-reports to measure physical activity in Tanzanian primary school children, using accelerometry as a reference method. For Tanzania, it is unknown if children can report their physical activity and if physical activity from self-reports is correlated with objective measures.

Methods

Participants and procedures

The study was conducted in two districts purposely selected, Moshi municipal and Moshi rural district, of Kilimanjaro region in the Northern part of Tanzania. Two primary schools (1 private and 1 government) from each district were conveniently selected. The study was approved by the National Institute for Medical Research (NIMR), certificate number: IX/2735 and the Kilimanjaro Christian Medical University College Ethics Committee (KCMUCO) certificate number: 2225. School permission was obtained from the regional medical officer, district education officers and school authorities.

Eighty children were randomly selected, i.e. 20 from each school, and their parents were contacted for a detailed explanation of the study aims and procedures. Thereafter children were sent home with the information sheet and consent form for parents to sign. Data were collected from May to July 2018 from primary school children aged 9 – 11 years.

Questionnaire adaptation process

For this study, questionnaires from the International Study on Childhood Obesity, Lifestyle and Environment (ISCOLE) were adapted and modified (13). The ISCOLE physical activity questions were reviewed to check for the appropriateness of the cultural context and applicability for use with primary school children in Tanzania. These questionnaires had been used in several high-income countries, and only in one African country (Kenya). The focus during modification was to retain those questions which were descriptive enough for children to understand, and that related to durations and participation in different activities. Modifications were made to account for the relevant usual activity types and the structuring of questions. These involved rewording of some questions, and removing questions that were not appropriate for the Tanzania school children, (e.g., the question asking “How much time did you spend outside before school, or before bedtime?” was removed because it did not necessarily imply

physical activity). Questions asking about attitudes and personal reasons for making someone active and sleep information were also removed as they were not under study aim (e.g., “I can ask my parent or other adult to do physically active things with me”, “I find exercise a pleasure activity”).

The modified questionnaire draft was shared with the region’s school health coordinator for review and advice and then piloted with 15 school children to check for comprehension and relevance of questions used. Children were asked to indicate activities during typical days in their lives, stratified by school days and weekend days.

Physical activity measurement from self-reports

The final questionnaire was designed to collect information on multiple dimensions of physical activities including types, frequency and duration. Therefore, in this questionnaire, some questions included the duration of different activities, whilst others asked whether or not a child participated in these activities. Questions involved were walking to school, being physically active for 60 minutes a day, exercise during school breaks, after school activities and sedentary behaviours such as television viewing and playing with electronic games.

Physical activity measurement from accelerometry

Children were instructed how to wear the triaxial accelerometers (ActiGraph, wGT3X-BT Pensacola, FL) for 7 consecutive days. Instructions were also given to teachers and parents in order to assist their children with accelerometer attachment. Accelerometers were attached with an elastic band on children’s right hip. Children were instructed to remove the accelerometers when bathing or swimming. Accelerometers were set to collect data from 06:00 AM to 09:00 PM (bedtime) except for the initiation day when accelerometers were commenced from 09:00 AM. When returned, data from each accelerometer were uploaded to the computer using Actigraph software.

Accelerometer data reduction and scoring

The raw activity data were reduced into 15-s epochs data for analysis, scored then converted to “. agd” files and imported into “CSV” and Excel sheets using Actigraph software. Evenson’s cut points for children were used to categorize sedentary, light, moderate and vigorous activities (14-16). Total moderate and vigorous activity (Total MVPA) was also estimated.

To avoid bias with the children who did not wear the device for the set time and days, we applied filters to define time blocks of activities from the accelerometers to match with the activities from self-reports (Additional file 1). For each block, we allowed two minutes after breaks assuming children will be reorganizing themselves for starting break or next classroom session.

An example of accelerometer captured patterns of activities in three spatial dimensions X, Y and Z and varied by blocks is indicated in Fig. 1. The graph was taken from one child in one day of the week. The period with no bars means the child was either not active or the device was not worn at all.

Statistical analysis

Self-report data were entered into Excel and accelerometer data were exported to Excel; both were then imported into STATA for analysis. Descriptive summaries of the study population were done using frequencies, percentages and plots for demographic characteristics, physical activity from self-reports and accelerometer.

The distributions of data were checked using Shapiro Wilk test. For data that were normally distributed, mean and standard deviation were presented; for skewed data, median and interquartile ranges were presented.

Self-reports: Questions with information on time spent on participating in certain activities were included, and total time calculated. Total weekday MVPA was defined as the sum of minutes for walking to school for five days (since this question had categorical responses, we calculated the midpoint for example: a response of 15 – 30 minutes of walking to school was considered as 22.5 minutes) and reported being physically active for at least 60 minutes for each day (for example: if the child reported being active for 3 days, we multiplied by 60 minutes to get 180 active minutes. The average minutes of MVPA was calculated by dividing the total time of MVPA by the number of days of the week recorded.

Total weekday sedentary time was defined as the sum of minutes spent on leisure activities which were watching television, using a computer or playing video games. The average minutes of sedentary time was estimated by adding all sedentary activities dividing by five days of the week.

Accelerometry: Total time spent in moderate and vigorous physical activity (Total MVPA) and total sedentary time were estimated. All children were included in the analysis if they had sufficient and valid accelerometry data with minimum of 3 weekdays and at least 1 weekend day.

To examine validity, we included only school days as we expected the child to be more active in school, as they spend most of their times in school, while for the weekend they might be engaged in unstructured activities which might be difficult to remember. We used scatter plots and Spearman rank test to check for correlation between overall weekly activities (MVPA) from self-reports and accelerometry. Bland Altman plots were used to assess the level of agreement between average weekday self-report MVPA and accelerometry based MVPA.

The mean weekday accelerometry and self-reports MVPA (minutes per week) were calculated. Wald test was used to compare the mean weekday MVPA across sex, age, school location, school type, school location, walking to school, exercise during breaks, after school activities and participation in physical education sessions, taking into account for clustering effect of children within schools. Box plots were constructed to check for variations between self-reported (walking to school, exercise during break/ lunch and after school activities) and accelerometry MVPA for blocks of activities and across days of the week.

For understanding the associations between weekday accelerometry MVPA and different child level variables (sex, age, school type, school location and walking to school) a simple linear regression was

done accounting for repeated measures and the clustering effects. A child was regarded as a cluster due to repeated measurements of accelerometry data on different weekdays. Regression coefficients from the linear regression, 95% confidence intervals (95% CI) and intra-class correlations were presented.

Results

Of the 80 parents contacted for consenting their children's participation in the study, 51 (65%) accepted. Of these 51 children 32 (63%) were girls (Table 1). Overall, children reported spending an average of 60 (IQR: 26, 65) minutes on MVPA physical activities daily, as compared to 98 (IQR: 74, 118 minutes captured by accelerometry. Sedentary times were reported as 90 (IQR: 60, 150) minutes and from accelerometry 74 (IQR: 48, 118).

Table 1 Characteristics and physical activity data for primary school children (N=51)

Characteristic	n (%)
Female	32 (63)
Age (years)	
9	11 (22)
10	17 (33)
11	23 (45)
School type	
Government	27 (53)
Private	24 (47)
School location	
Moshi urban	33 (65)
Moshi rural	18 (35)
Accelerometry data	
Number of days during entire period for which accelerometry data were available	
3 days	1 (2)
4 days	1 (2)
6 days	1 (2)
7 days	48 (94)
Number of weekdays for which accelerometry data were available	
3 days	2 (4)
4 days	1 (2)
5 days	48 (94)
Number of days on weekend for which accelerometry data were available (n=49)	
1 day	3 (6)
2 days	46 (94)

*Daily MVPA (minutes)	98 (74, 118)
*Sedentary bouts (minutes)	74 (48, 118)

Self-reported physical activity data	
Number (%) of children reporting:	
Walking to school	29 (57)
Screen time (games, television)	48 (94)
Exercise during school breaks	41 (80)
After school exercises (house chores, games)	44 (86)
Attend physical education sessions (n=47)	36 (77)
*Daily MVPA (minutes)	60 (26, 65)
*Sedentary bouts (minutes)	90 (60, 150)

Abbreviations: MVPA moderate to vigorous physical activity

*Figures represent median (interquartile range)

The scatter plot shows moderate correlation of r = 0.41 between accelerometry and self-reported MVPA. The Bland Altman plot of average MVPA shows the level of agreement between the mean daily accelerometry MVPA and the daily average MVPA from self-reports ranges from -33 to 101, with a mean difference of 34 (Fig.2).

The average total weekday MVPA was 408 minutes (SD 166) from accelerometry and 261 minutes (SD 179) from self-reports. There is evidence of a consistently higher mean MVPA minutes for both accelerometry and self-reports for children who reported walking to school 480 and 318 (Table 2). Similarly, for weekend data the mean MVPA for accelerometry activities was higher compared to self-reports weekend activities (Additional file 2).

Table 2 Mean and CI of weekday accelerometry and self-reported MVPA in minutes by participants characteristics accounting for schools as clusters (N=51)

Characteristic	n	Accelerometry		Self-report	
		Mean MVPA (95% CI)	p-value	Mean MVPA (95% CI)	p-value
Overall		408 (361- 455)		261 (199 - 323)	
Sex					
Male	19	441 (361-522)	0.28	294 (225 - 362)	0.19
Female	32	388 (328 - 448)		241 (194 - 289)	
Age (years)					
9	11	307 (92 - 523)		257 (173 - 342)	
10	17	457 (296 - 617)	0.06	276 (208 - 343)	0.86
11	23	420 (247 - 592)		252 (193 - 310)	
School type					
Government	27	490 (434 - 547)	<0.001	292 (235 - 349)	0.08
Private	24	315 (255 - 374)		225 (174 - 277)	
School location					
Moshi urban	33	389 (331 - 448)	0.29	260 (205 - 315)	0.96
Moshi rural	18	441 (357 - 526)		262 (214 -310)	
Walking to school					
Yes	29	480 (419 - 541)	<0.001	318 (271 - 365)	<0.001
No	22	313 (258 - 367)		186 (134 - 237)	
Screen time (games, television)					
Yes	47	395 (347 - 444)	0.07	363 (257 - 468)	0.12
No	4	555 (372 -738)		252 (212 - 293)	
Exercise during school breaks					
Yes	41	402 (352 - 453)	0.64	246 (209 - 284)	0.12
No	10	430 (288 - 572)		321 (184 - 458)	
After school exercises					
Yes	44	407 (358 - 456)	0.94	256 (215 - 296)	0.50
No	7	412 (214 - 611)		294 (144 - 444)	

Attend physical education sessions (n=47)					
Yes	36	380 (332 - 428)	0.19	258 (221 - 295)	0.25
No	11	456 (300 - 611)		208 (93 – 322)	

Abbreviations: MVPA moderate to vigorous physical activity, CI confidence interval. Data are shown in mean minutes per weekdays

In the unadjusted analysis, the type of school attended by children (33.6, 95% CI 18.9 – 48.4, $p < 0.001$) and walking to school (33.4, 95% CI 18.5 – 48.3, $p < 0.001$) showed strong evidence of an association with total weekday accelerometry MVPA. The intra-class correlation (ICC) of total weekday accelerometry MVPA between children ranged from 38 – 47%, and the remaining variation is due to differences within the children from day to day activities. In the multivariable model, after accounting for the effect of child level factors, only school type showed evidence of association with the total weekday accelerometry MVPA (23.4, 95% CI 4.0 – 42.8, $p = 0.02$) and 32% of the variation in total weekday accelerometry MVPA was observed between children, (Table 3).

Table 3 Associations between child level factors and total weekday accelerometry MVPA for primary school children (N = 249)

Characteristic	Crude Coefficient (95% CI)	p-value	ICC	Adjusted Coefficient (95% CI)	p-value	ICC
Sex						
Female	1			1		0.32
Male	12.5 (-5.2-30.1)	0.17	0.47	13.2 (-1.0-27.3)	0.07	
Age (years)	7.9 (-2.9-18.8)	0.15	0.47	5.4 (-4.0-14.8)	0.26	
School type						
Private	1			1		
Government	33.6 (18.9-48.4)	<0.001	0.38	23.4 (4.0-42.8)	0.02	
School location						
Moshi urban	1			1		
Moshi rural	11.5 (-6.4-29.3)	0.21	0.47	7.7 (-8.8-24.2)	0.36	
Walking to school						
No	1			1		
Yes	33.4 (18.5-48.3)	<0.001	0.38	13.7 (-6.8-34.3)	0.19	

Abbreviations MVPA moderate to vigorous physical activity, ICC intra class correlation coefficient, CI confidence interval.

Notes: Forty-seven children had a total of 5 days, 4 had either 3 or 4 days) which made a total number of 249 of observations (5 days x 47, 3 days x 2, 4 days x 2).

Discussion

Overall moderate correlation was observed between self-reports and accelerometry assessments of physical activity in primary school children. The Bland Altman plots shows a similar trend of randomness, indicating that accelerometer is measuring what self-report is measuring, and the error observed may be due to over- and under-reporting of the actual MVPA. This reflects the limitations of children's accuracy to report their actual minutes of MVPA as described in other studies (8, 17, 18).

A few studies have evaluated objective measures against self-reports of children's physical activity in different parts of the world and reported low to moderate correlations. For instance, a study for tracking physical activity trends in youth aged 10 -18 years reported a correlation of 0.27 and 0.34 for boys and

girls (19). Similarly, other validation studies using accelerometry as a reference method, reported low correlations and documented that most physical activity questionnaires have low to moderate validity (18, 20-26). Together, these data highlight the challenge of capturing physical activity by self-report among children, and speak to the need for objective measurement.

For the walking to school block, children who reported walking to school daily had higher accelerometer MVPA as compared to those who didn't. We found evidence of an association in mean accelerometer MVPA and self-reports MVPA for children who walked to school. It is possible that this regular activity is easily remembered by school children, as they will be following the same routine every day. Studies in Global matrix report highlighted that walking to school was a reliable indicator for assessing physical activity in children and youth (27).

In the analysis of weekday MVPA captured accelerometers 68% of the daily variation was the day-to-day variability within children and only 32% was due to differences between children. The daily within variation can be explained by differences in daily activities whereby children may not follow the same activity routine every day. Most children who are in government schools walk to school every day while most in private schools use private cars to school, but there may be other activities which contribute to the variation in MVPA from day to day. Some studies reported that variations of activities in children depends on habitual behaviours and thus children differ in activity types, levels depending on the time and opportunities to be involved in activities, and supportive environment (28, 29).

The majority of children reported less time in total MVPA than actually confirmed by accelerometry. Differences in activity levels between self-reports and accelerometer correspond to what is found in the literature, which reflects the difficulties for children to quantify bouts of activities performed (7, 23, 29). Recently researchers in the Active Healthy Kids Global Alliance aimed at promoting physical activity in children and youth around the world pointed out that estimating prevalence of physical activity is a worldwide concern, and thus there is a need for standardized physical assessment surveillance systems in each country (16).

The strengths of this study include the use of accelerometers as a gold standard to collect information on physical activity. This was one of the few studies conducted in resource-restricted countries that aimed to validate reported physical activity by applying an objective method. We achieved a high compliance of wearing accelerometers since most children wore them for 7 days as instructed.

In contrast, limitations of this study need to be acknowledged. Our questionnaire was based on an adapted version of an existing tool that used time spent on television or computer games as a proxy for assessing sedentary behaviours. It therefore missed other sedentary behaviours such as sitting in school, reading, meal times or sitting idle. Therefore, we may have underestimated the amount of true sedentary behaviour. Secondly, the high refusal rate (36%) from parents to allow their children to participate in the study contributed to a potential bias in our results as these children who did not participate may have been systematically different from those who participated.

Conclusions

Assessing physical activity in children is challenging, and the data suggests that self-reported measures of physical activity have limited validity. Given the challenges of self-reports in this population of school children, the use of objective measurements such as accelerometers are needed to accurately measure physical activity in children. Other measures, such as direct observations or physical fitness tests, may be alternatives if accelerometers are not available. Despite these flaws, assessing physical activity using devices is often not possible, especially in low- and middle-income countries due to cost. Secondly, there are no standard protocols for analysis or reporting device-based measurements, which makes the interpretation of physical activity data from devices complex. We therefore recommend more research to develop better self-reported measures including specific types of physical activities that can easily be recalled by children and are in line with a structured event of the day, which can be used as a proxy for assessing physical activity in children.

Abbreviations

MVPA: moderate to vigorous physical activity; CI confidence intervals; ICC: intra-class correlation coefficient.

Declarations

Ethics approval and consent to participate

We certify that all ethical procedures concerning human participants were followed. Ethics approval was obtained from the National Institute for Medical Research (NIMR), Tanzania certificate number: IX/2735 on 27/03/2018 and the Kilimanjaro Christian Medical University College Ethics Committee (KCMUCO) certificate number: 2225 on 21/09/2017. School permission was obtained from the regional medical officer, district education officers and school authorities. All parents of participating children signed a written informed consent for their children to participate. Children were asked to sign a brief written assent to participate in the study.

Consent for publication

Not applicable.

Availability of data and materials

The dataset used for this study will be available from the corresponding author upon request.

Competing interests

All authors declared no competing interests.

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Authors' contribution

MVM, SF, HG and SM were involved in the study design. SF supervised data analysis, critically revising the manuscript and writing. EK, PA and JT involved in data analysis. All authors read and approved the final manuscript.

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Figures

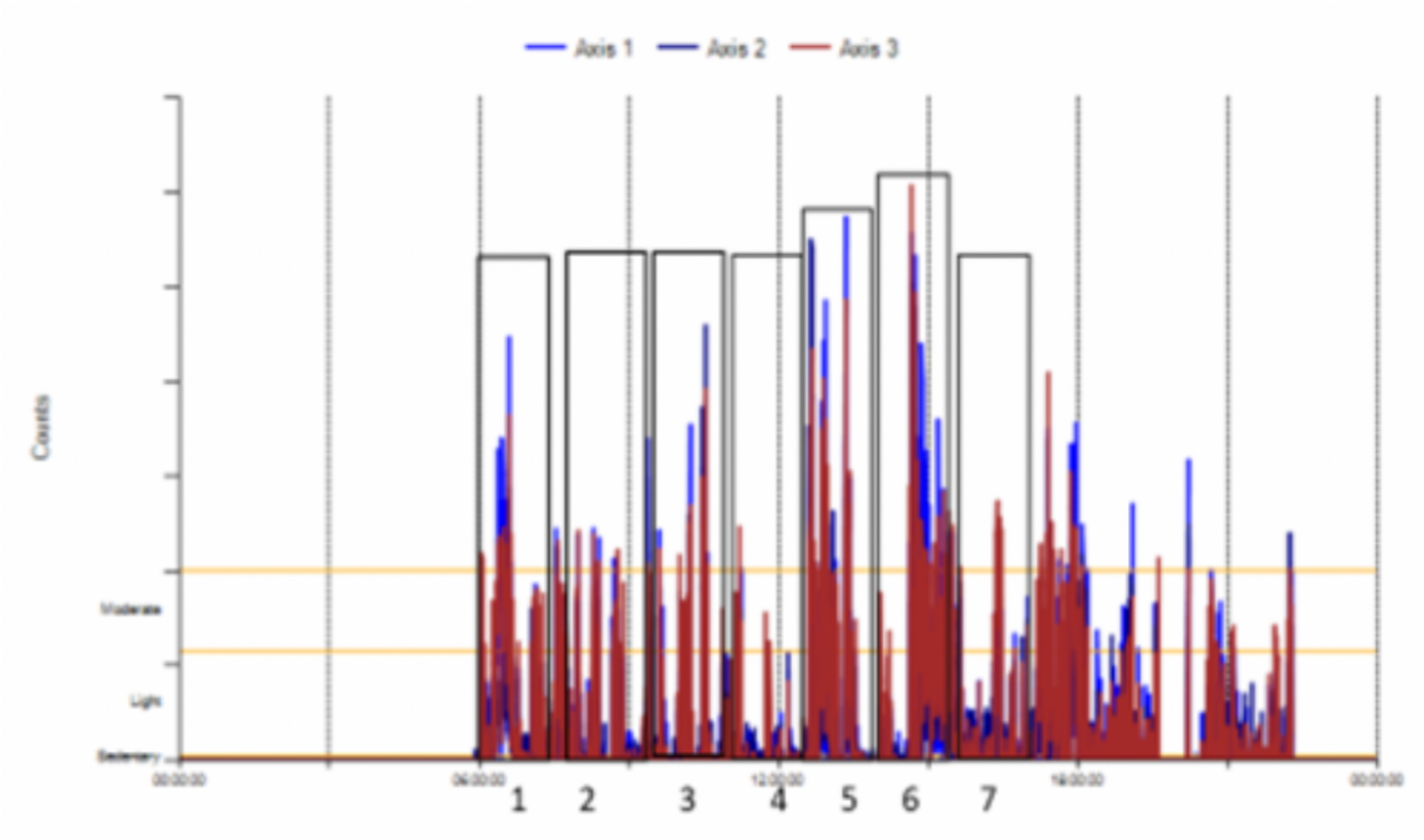

Figure 1

Accelerometry graph output showing seven blocks of activities: 1 Morning block, 2 Morning sitting in class, 3 Breaktime, 4 After break class sitting, 5 Lunch time, 6 After lunch sitting, 7 After school activities

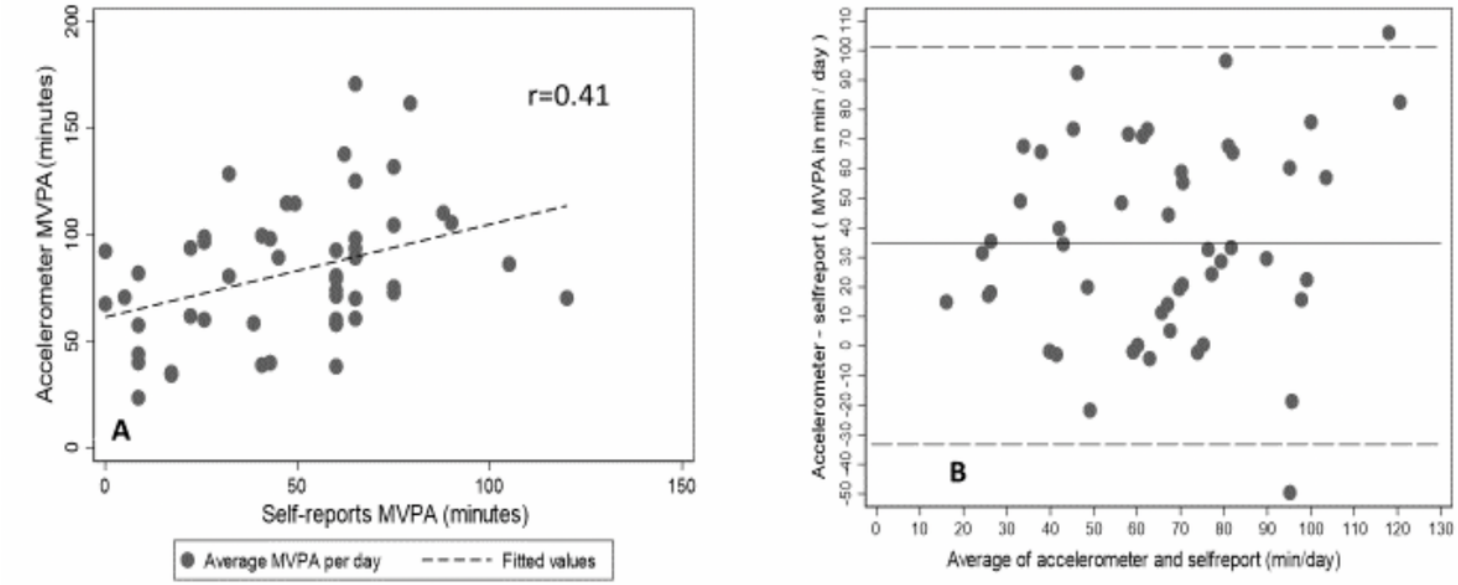

Figure 2

Scatter plot (A) of average MVPA per day for self-reports and accelerometry and Bland Altman (B) plot of accelerometry and self-reports MVPA

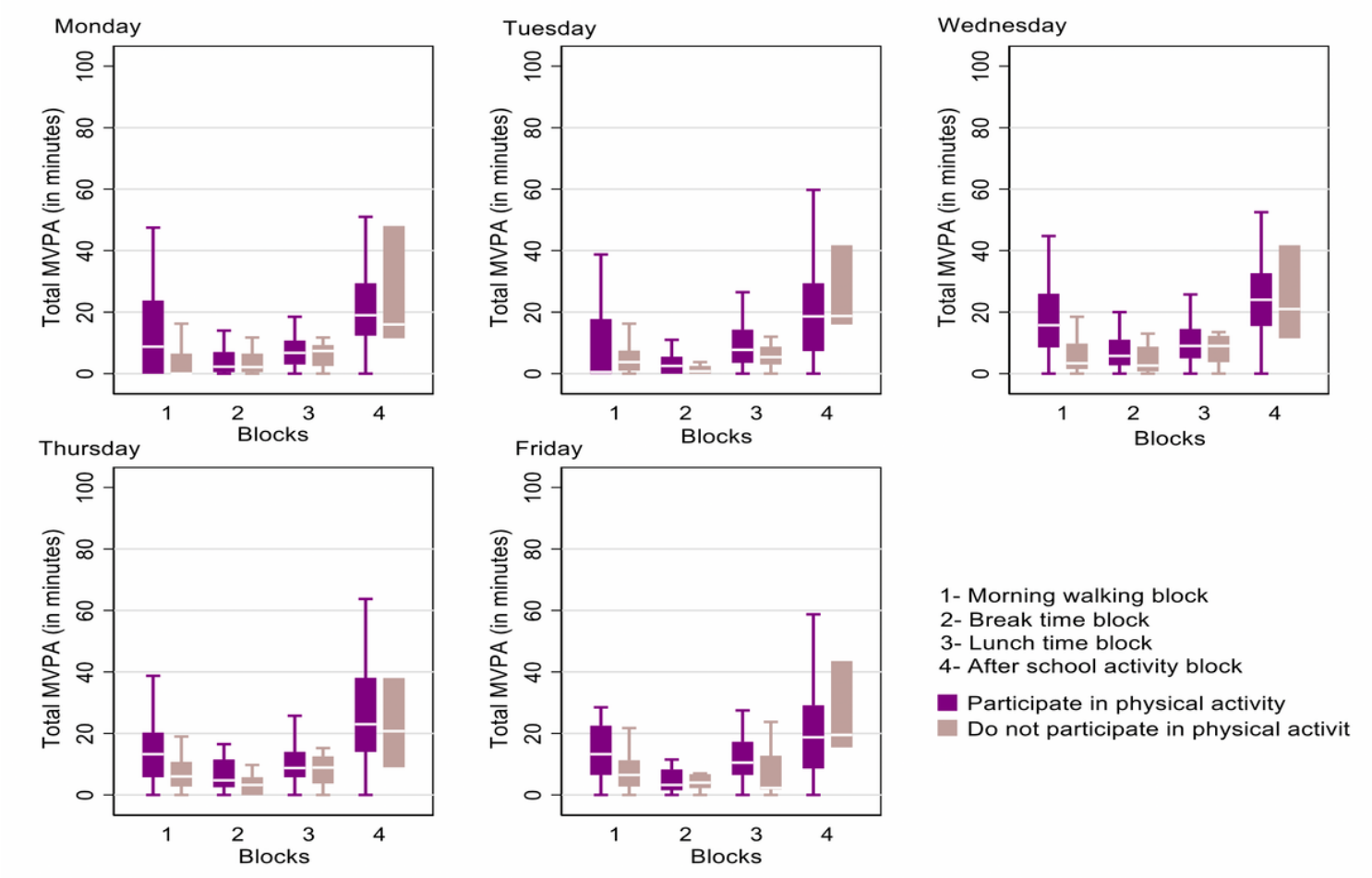

Figure 3

Median and 95% confidence interval of total weekday MVPA in minutes by self-reported activities per blocks of activities

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Additionalfile1.docx
- Additionalfile2.docx