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Association of accelerometry-based and self-reported physical activity with cardiovascular risk in South African children

The burden of non-communicable diseases is increasing, with risk factors emerging early in life. Physical activity reduces cardiovascular risk, but limited evidence exists for children from lower-income countries and mostly relies on self-reported methods that might be inaccurate and biased. We aimed to compare self-reported and accelerometer-measured physical activity in relation to cardiovascular risk markers in children from underserved communities in South Africa. We analysed cross-sectional data from 594 children aged 8 to 13. Physical activity was measured via accelerometry and the Physical Activity Questionnaire for Older Children (PAQ-C). Correlation analyses and linear regression models examined the relationship between accelerometer-measured and self-reported physical activity and their association with cardiovascular risk markers (body mass index, blood pressure, blood lipid profile and glycated haemoglobin). Results show a positive but weak correlation between PAQ-C scores and accelerometer-measured moderate-to-vigorous physical activity (MVPA). MVPA was inversely associated with body mass index, whilst sedentary behaviour correlated positively with lipid levels. PAQ-C scores were inversely associated with systolic blood pressure. The comparison of self-reported and accelerometer-measured physical activity in children from Gqeberha, South Africa, revealed inconsistencies in their correlation and association with cardiovascular risk markers. Accelerometry provided a more accurate cardiovascular risk estimation than PAQ-C, although associations were weak. Further, longitudinal studies should investigate the predictive power of both methodologies. These findings inform researchers and public health practitioners in the choice of method for physical activity appraisal beyond practical considerations, especially when combined with cardiovascular risk and in lower-income settings.

Significance:

We explore two widely used methods to assess physical activity levels in children. By comparing both methods, we expose inconsistencies in their correlation and association with cardiovascular risk markers. These data can guide researchers and public health practitioners in the use of one method beyond practical considerations. Whilst this work focuses on children from marginalised areas of South Africa, the issues explored are of relevance to other lower-income settings.

Introduction

Cardiovascular diseases (CVD) are the leading cause of death worldwide,[1] and their burden is increasing in low- and middle-income countries (LMICs).[2] Meanwhile, physical activity (PA) has substantial positive effects on CVD mortality. In fact, beneficial health outcomes begin with very modest amounts of moderate-to-vigorous physical activity (MVPA).[3] Although the positive effects of PA on cardiovascular health have already been observed in childhood, the relationship between PA and cardiovascular risk markers (CRMs) has predominantly been studied in adults.[4] Furthermore, most studies examining PA behaviour have originated from high-income countries (HICs).

Behaviours associated with PA are complex constructs that differ according to socioeconomic status, region and cultural context.[5] Yet, PA health benefits observed in HICs have been broadly extrapolated to LMICs due to the scarcity of evidence from these regions. An umbrella systematic review found that 3.1% of studies concerned with promoting PA in children and adolescents were from LMICs.[6] Of those, only one originated from Africa. This observation was corroborated by Guthold et al., who reported that sub-Saharan Africa had the least available data on PA amongst adolescents worldwide.[7] Moreover, estimates of PA levels in LMICs are heterogeneous, partly due to an unstandardised use of different measurement methods.

With current physical inactivity estimates arising from self-reported methods, a device-based PA data gap exists, especially in LMICs.[7] A systematic review of PA trends in sub-Saharan Africa found that 72.2% of studies relied on self-report methods to assess PA.[8] Self-reporting provides a convenient way to assess activity patterns across large populations in a short time.[9,10] However, self-reports are prone to inaccuracy and bias originating from recall errors, the social desirability effect and difficulties understanding the questions.[11] Wearable devices such as accelerometry are seen as a more accurate alternative,[12] as they can quantify energy expenditure and estimate the intensity, duration and frequency of PA.[13] Nevertheless, accelerometry technology is costly and time consuming, especially on a large scale, whilst it also involves a range of subjective decisions.[14] As a consequence, the lack of consensus on PA assessment instruments and data management limits the comparability of studies.

Multiple studies have exposed differences and paucity of agreement between self-report methods and device-based assessments. For example, the Scottish Health Survey 2003 found that more than 75% of children reported meeting the recommended 60 minutes of moderate-to-vigorous physical activity (MVPA) per day,[15] whilst other

studies from the United Kingdom using accelerometry reported a prevalence of less than 5%.[16-18] In South Africa, estimates for meeting PA recommendations range between 35.8%[8] and 77%[19] and vary both between and within instruments.[20-22] It is therefore not surprising that previous studies have shown a weak-to-moderate correlation between self-reported and device-based PA assessments.[13,23] Filling the PA data gap with more harmonised, device-based and larger sample studies is necessary to promote best PA practices in LMICs.[7]

Given the scarcity of data on PA behaviour from LMICs and the differences in the use and scope of self-report questionnaires versus accelerometry-based PA measurements, the aim of this study was twofold. First, we compared self-reported and accelerometer-measured PA amongst a large sample of school children from South Africa. Secondly, we examined their association with different CRMs. Based on the existing evidence, we hypothesised that self-reporting and accelerometry would vary in their PA estimates and association with CRMs.

Materials and methods

Study design and setting

This study was part of the KaziBantu project, a school-based intervention programme that attempts to promote sustainable lifestyle changes to achieve better health within disadvantaged communities in Gqeberha, South Africa. The *KaziBantu* programme was designed as a cluster-randomised controlled trial (RCT) and included eight schools that were randomly allocated to an intervention group (four schools) and a control group (four schools).[24] The study was structured such that after the completion of a baseline assessment in January 2019, children from the four intervention schools participated in the *KaziKidz* health promotion intervention for 32 weeks. The trial was registered at ISRCTN on 11 July 2018 under the registration number 18485542.

Participants

Data from 981 children were initially collected during a baseline assessment in early 2019. The children were aged between 8 and 16 years and were attending grades 4–6. Only children between the ages of 8 and 13 were retained in the final study sample, as there was only one child at age 14 and 16, respectively. After excluding children due to lack of consent or dropping out ($n = 14$), reporting an impairment during data collection ($n = 238$), not answering all questions from the PAQ-C ($n = 39$), having no or invalid ActiGraph measurements ($n = 75$), missing information on height and weight ($n = 27$), or being outside the age range ($n = 2$), the final study sample consisted of 586 children (301 boys and 285 girls). The minimal sample size was originally calculated for the cluster RCT, as described in the study protocol.[24] A posteriori power analysis conducted with G*Power 3.1 Software (Heinrich Heine Universität Düsseldorf, Germany) revealed that the sample of 586 participants was sufficiently powered to demonstrate a weak correlation ($r = 0.102$) between self-reported and accelerometry-based PA (assuming an alpha error of 0.05 and a power of 0.80).[25]

Data collection

Accelerometry-based assessment of physical activity

The ActiGraph accelerometry device (ActiGraph wGT3X-BT, Pensacola, Florida, USA) was used to measure PA. Participants were directed to wear the device for seven consecutive days around the hip. They were allowed to remove the ActiGraph for activities that involved water contact (e.g. swimming or showering). Accelerometers were set up at a sampling rate of 30 Hz and ran on the latest firmware version (version 1.9.2). Analysis was carried out with the ActiLife software (version 6.13.4), using data set up at epochs of 10 s.

To be eligible for the data evaluation, the ActiGraph had to be worn for at least four valid weekdays and at least one weekend day. A day was considered valid if the ActiGraph had been worn for at least eight hours during that day.[26] Sleep time was removed and during waking time, non-wear periods, defined and identified based on the Troiano 2007 algorithm, were excluded from the analysis. The different PA intensities were categorised according to the cut-off points from Evenson 2008 for children.[27]

Self-reported physical activity

A simplified version of the Physical Activity Questionnaire for Older Children (PAQ-C) was used to assess children's PA behaviour over the previous week.[28] Specifically, children ranked their personal PA level by answering questions 2–8, whereas question 10 inquired whether children were fit to perform PA. Later, a summary activity score between 1 and 5 (1 = lowest PA level, 5 = highest PA level) was calculated for questions 2–8. Children who reported sickness in question 10 or failed to answer one or more questions were excluded from the study sample ($n = 277$).

Blood pressure

Resting BP was measured after the children were directed to be seated for 5 min. BP was measured three times with a pause of 1 min between each measurement. A calibrated Omron digital blood pressure monitor (Omron M6 AC model; Hoofddorp, The Netherlands) was used by nurses or biokineticists for the measurements. Only the second and third measurements were used to calculate an average for systolic (SBP) and diastolic BP (DBP). Elevated blood pressure in children was defined as above 120/80 mmHg or the 90th percentile according to sex, age and height reference values.[29]

Blood lipid profiles and glycated haemoglobin

A point-of-care instrument (Alere Afinion AS 100 Analyzer, Abbott Technologies; Abbott Park, United States of America) was used to determine the blood lipid profiles (BLP) and glycated haemoglobin (HbA1c) concentrations. A healthcare worker first cleaned the fingertips with an alcohol swab and then pricked it with a safety lancet. Two drops of blood were carefully squeezed out of the finger, but only the second drop was collected for analysis. The device delivered the results within 8 min. All devices used were tested and calibrated before the procedure.[24]

The BLP included total cholesterol (TC), low-density lipoprotein (LDL), high-density lipoprotein (HDL), triglycerides (TG), non-high-density lipoprotein (non-HDL) and the ratio between TC and HDL (TC/HDL). Acceptable serum lipid and lipoprotein concentrations for children are <4.4 mmol/L for TC, <2.8 mmol/L for LDL, >1.2 mmol/L for HDL, <1 mmol/L for TG, <3.1 mmol/L for non-HDL and <3.7 for TC/HDL.[30] Levels of HbA1c revealed participants' average plasma glucose level over the past 8–12 weeks and were reported as a percentage of the total haemoglobin (%). Individuals with an HbA1c of 6.5% or higher are diagnosed with diabetes.[31]

Body mass index

The body height of the children was measured by a stadiometer with an accuracy of 0.1 cm. Participants were instructed to keep their backs erect, and their shoulders relaxed. The body weight was measured by standing on a digital weighing scale (Tanita MC-580; Tanita, Tokyo, Japan) with an accuracy of 0.1 kg. For each participant, the BMI was calculated by dividing body weight (kg) by the square of body height (m^2). Based on sex and age references specified by the World Health Organization (WHO), BMI for age was calculated and subsequently classified as "Thin" if it was below −2 standard deviation (SD), "Normal weight" if between −2 and 1 SD, "Overweight" if above 1 SD, or "Obese" if above 2 SD.[32]

Statistical analyses

Statistical analyses were conducted with the SPSS Statistics program (IBM SPSS Statistics for Mac, Version 27). Descriptive statistics were calculated as frequencies (%) for categorical variables and as medians (with interquartile range) for relatively symmetric, as well as skewed continuous variables. To identify differences between boys and girls, Mann–Whitney *U*-tests were conducted for continuous data, and Pearson's chi-squared tests were used for categorical data. Significance was set at $p \leq 0.05$ for all statistical analyses, and all tests were two-sided.

The relationship between PAQ-C scores and accelerometry-derived PA metrics was assessed using Spearman's rank correlation coefficients (ρ). Accelerometer wear time, age and sex were included as control variables. Cohen's correlation guidelines were used to evaluate the effect sizes as follows: $|\rho|$=0.1 small effect size, $|\rho|$=0.3 medium

effect size, $|\rho|=0.5$ large effect size.[33] Linear regression models were used to analyse the associations between PA and sedentary behaviour (SB) with CRMs. All models were adjusted for the influence of height, weight, sex, age and accelerometer wear time except BMI which was controlled only for sex, age and wear time. Unstandardised regression coefficients were used to assess effect size and discuss clinical relevance.

Ethics approval and consent to participate

The procedures of the *KaziBantu* study comply with the Declaration of Helsinki and have received ethical approval from the Nelson Mandela University Ethics Committee (reference #H18-HEA-HMS-001; dated 26 March 2018), Eastern Cape Department of Health (reference #EC_201804_007; dated 5 June 2018), and Eastern Cape Department of Education (dated 9 May 2018). The study was also cleared by the ethical review board of the Ethics Committee Northwest and Central Switzerland (reference #R-2018-00047; dated 1 March 2018). Each possible participant was informed about the study's objectives, procedures, risks and benefits. Participation in this study was voluntary and withdrawing was possible at any time with no further consequences. Oral approval (assent) had to be given by the participating children, whilst written informed consent was given by the corresponding parent or guardian.

Results

Descriptive characteristics

Characteristics of the study participants are presented in Table 1. With a median of 70.6 min of MVPA per day, 64.8% of the children achieved

Table 1: Descriptive characteristics of school-age children from Gqeberha, South Africa, in January 2019

Variable	All ($N = 586$)	Boys ($n = 301$)	Girls ($n = 285$)	p-value[a]	η^2 or Cramer's V[b]
Anthropometric					
Age	10.0 (10.0–11.0)	11.0 (10.0–11.0)	10.0 (9.0–11.0)	**0.002**	0.02
Height (cm)	139.5 (133.5–146.0)	138.6 (132.9–144.3)	140.8 (134.5–146.9)	**0.013**	0.01
Weight (kg)	33.3 (28.9–39.6)	32.1 (28.3–37.2)	35.4 (30.0–41.9)	**<0.001**	0.03
BMI[c] (kg/m^2)	17.1 (15.6–19.2)	16.7 (15.4–18.2)	17.8 (15.8–20.3)	**<0.001**	0.03
Blood pressure					
SBP[d] (mmHg)	107.8 (99.0–116.3)	106.5 (98.0–115.5)	109.0 (99.5–117.0)	**0.032**	0.01
DBP[e] (mmHg)	65.5 (60.5–71.5)	64.5 (59.5–69.8)	66.5 (61.5–72.5)	**0.019**	0.01
Blood lipid profile					
TG[f] (mmol/L)	0.8 (0.6–1.0)	0.7 (0.6–0.9)	0.9 (0.7–1.2)	**<0.001**	0.07
TC[g] (mmol/L)	3.7 (3.3–4.2)	3.6 (3.2–4.1)	3.8 (3.4–4.3)	**0.010**	0.01
LDL[h] (mmol/L)	2.0 (1.7–2.4)	1.9 (1.6–2.4)	2.0 (1.7–2.4)	0.063	0.01
HDL[i] (mmol/L)	1.3 (1.1–1.5)	1.3 (1.1–1.5)	1.3 (1.1–1.5)	0.168	<0.01
Non-HDL[j] (mmol/L)	2.4 (2.0–2.8)	2.3 (2.0–2.8)	2.5 (2.1–2.9)	**<0.001**	0.03
TC/HDL[k] (ratio)	2.9 (2.5–3.3)	2.8 (2.4–3.2)	3.0 (2.7–3.5)	**<0.001**	0.03
Blood sugar					
HbA1c[l] (%)	5.4 (5.3–5.6)	5.4 (5.3–5.6)	5.4 (5.3–5.6)	0.383	<0.01
PAQ-C[m]					
Median score (1–5)	2.9 (2.4–3.4)	3.0 (2.4–3.6)	2.7 (2.3–3.2)	**<0.001**	0.02
ActiGraph					
Sedentary time (%)	64.2 (60.3–67.9)	62.4 (58.7–66.5)	65.6 (61.9–69.0)	**<0.001**	0.06
Light activity time (%)	28.9 (26.0–31.6)	29.2 (26.0–31.8)	28.6 (26.0–31.1)	0.154	<0.01
Moderate activity time (%)	4.8 (3.8–6.1)	5.5 (4.4–6.7)	4.1 (3.3–5.1)	**<0.001**	0.16
Vigorous activity time (%)	2.0 (1.3–2.9)	2.5 (1.8–3.6)	1.6 (1.1–2.1)	**<0.001**	0.18
MVPA[n] (min/day)	70.6 (52.6–89.4)	83.8 (64.4–104.1)	57.7 (45.5–75.2)	**<0.001**	0.21
Wear time (min/day)	1034.0 (1002.1–1053.4)	1040.6 (1008.7–1059.6)	1028.5 (997.2–1049.3)	**<0.001**	0.03
Meets physical activity guidelines[o] (Yes/No; %)	64.8/35.2	81.7/18.3	47.0/53.0	**<0.001**	0.37

Note: Values in bold indicate statistically significant results. Data are median (IQR) or percentage.

[a]Between-sex differences assessed by Mann-Whitney-U-Test or Pearson's chi-square test. [b]Effect size indicated by η^2 for continuous data and Cramer's V for categorical data. [c]Body mass index; [d]Systolic blood pressure, [e]Diastolic blood pressure, [f]Triglycerides, [g]Total cholesterol, [h]Low-density lipoprotein, [i]High-density lipoprotein, [j]Difference between TC and HDL, [k]Ratio between TC and HDL, [l]Glycated haemoglobin, [m]Physical Activity Questionnaire for Older Children, [n]Moderate- to vigorous-intensity physical activity, [o]More than or equal to (Yes), or less than (No) 60 minutes of MVPA per day.

the recommended minimum of 60 min of MVPA per day. Overall, study participants spent 64.2% of their daily time in SB, 28.9% in light PA, 4.8% in moderate PA, and 2.0% in vigorous PA. The median wear time of the ActiGraph accelerometer was 17.2 h per day. The median PAQ-C score was 2.9, which lies slightly above half the possible value between 1 (lowest) and 5 (highest).

Significant differences were found between girls and boys. BMI, SBP, DBP, TG, TC, non-HDL, and TC/HDL were higher in girls than in boys (BMI: 17.8 vs. 16.7, $p < 0.001$; SBP: 109.0 mmHg vs. 106.5 mmHg, $p = 0.032$; DBP: 66.5 mmHg vs. 64.5 mmHg, $p = 0.019$; TG: 0.9 mmol/L vs. 0.7 mmol/L, $p < 0.001$; TC: 3.8 mmol/L vs. 3.6 mmol/L, $p = 0.010$; non-HDL: 2.5 mmol/L vs. 2.3 mmol/L, $p < 0.001$; TC/HDL: 3.0 vs. 2.8, $p < 0.001$). Boys were significantly more active than girls, as indicated by both the questionnaire (3.0 vs. 2.7, $p < 0.001$) and accelerometry (MVPA min/day 83.8 vs. 57.7, $p < 0.001$), and spent less time engaging in SB than girls (62.4% vs. 65.6%, $p < 0.001$, respectively). The WHO recommendations for PA were achieved by 81.7% of boys compared with only 47.0% of girls.

Correlation analysis between PAQ-C and wGT3X-BT ActiGraphy

We found significant but weak associations between PAQ-C scores and PA metrics measured by the ActiGraph accelerometry (Table 2). The PAQ-C scores were positively associated with average MVPA minutes per day (ρ=0.10, $p = 0.015$). The PAQ-C scores also correlated with the percentage of time spent engaging in moderate- or vigorous-intensity activities (ρ=0.09, $p = 0.035$; ρ=0.10, $p = 0.013$, respectively). However, we found little evidence for an association between PAQ-C scores and the time spent in SB ($p = 0.72$) or light PA ($p = 0.31$). Association patterns are depicted in Figure 1.

Associations between physical activity and sedentary behaviour with cardiovascular risk markers

Significant associations were observed between selected CRMs and PA metrics measured by PAQ-C and ActiGraph (Table 3). The ActiGraph MVPA was significantly and inversely associated with BMI (MVPA: beta=−0.031; CI = −0.043, −0.020; $p < 0.001$). The PAQ-C scores were inversely associated with SBP (beta=−1.563; CI = −2.926, −0.200; $p = 0.025$). Time spent in SB was positively associated with TC, LDL and non-HDL (TC: beta=0.001, CI = 0.000, 0.002, $p = 0.018$; LDL: beta=0.001, CI = 0.001, 0.002, $p = 0.002$; non-HDL: beta=0.001, CI = 0.000, 0.002, $p = 0.008$). Figure 2 provides a graphical representation of significant association patterns. We found little evidence for an association of DBP, HDL, TG, TC/HDL and HbA1c with self-reported PA levels or with accelerometer-measured MVPA and SB.

Discussion

This study compared self-reported (PAQ-C) and accelerometry-based (ActiGraphy) PA and their association with selected CRMs in a population of school-aged children from underserved communities in South Africa. It was found that PAQ-C scores were weakly associated with ActiGraph-measured MVPA and that the two PA assessment methods were inconsistent in detecting relationships with CRMs.

PAQ-C scores correlated positively with ActiGraph-measured MVPA levels. Thus, children who rated themselves as being more physically active according to their PAQ-C scores achieved higher levels of MVPA as measured via accelerometry. However, the strength of the relationship between the two methods was weak. These findings agree with the results from other studies questioning the convergent validity of the PAQ-C.[34-36] A recent meta-analysis by Marasso and colleagues identified a moderate pooled correlation coefficient between the PAQ-C

Table 2: Spearman rank correlations between PAQ-C scores and ActiGraph measurements of physical activity ($N = 586$)

Self-reported physical activity	Accelerometer-measured physical activity				
	Average MVPA[a] (min/day)	***Sedentary time (%)***	***Light activity time (%)***	***Moderate activity time (%)***	***Vigorous activity time (%)***
PAQ-C[b] score (1–5)	**0.101 ($p = 0.015$)**	−0.015 ($p = 0.719$)	−0.042 ($p = 0.309$)	**0.087 ($p = 0.035$)**	**0.103 ($p = 0.013$)**

Note: Values in bold indicate statistically significant results; models are adjusted for sex, age and accelerometer wear time.

[a]Moderate- to vigorous-intensity physical activity, [b]Physical Activity Questionnaire for Older Children

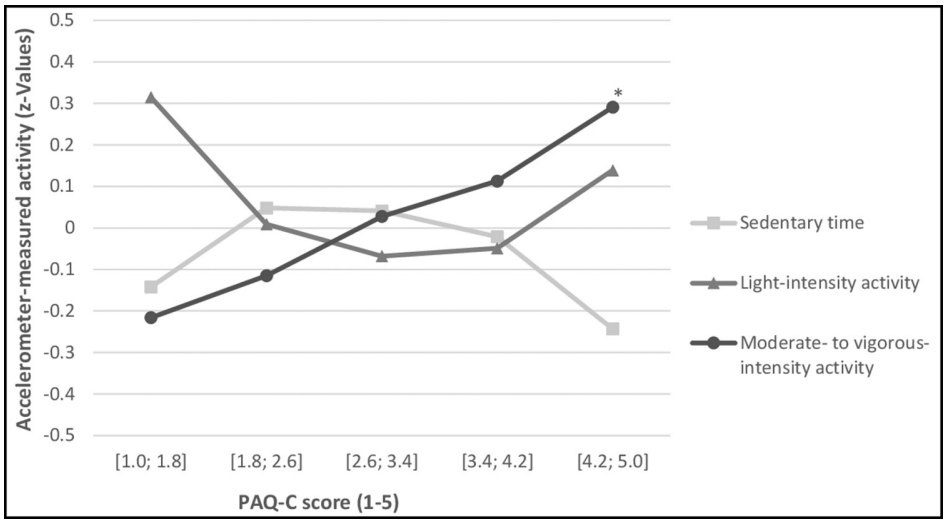

Figure 1: Correlation between accelerometry-based and self-reported physical activity. Moderate-to-vigorous physical activity showed a significant positive correlation with Physical Activity Questionnaire for Older Children (PAQ-C) scores (*$p = 0.015$) in school-aged children from Gqeberha, South Africa.

Table 3: Associations between cardiovascular risk markers with physical activity and sedentary behaviour

Dependent variable		PAQ-C[a] score (1–5)			ActiGraph MVPA[b] (min/day)			Sedentary time (min/day)		
	N	*beta*	95% CI	*p*-value	*beta*	95% CI	*p*-value	*beta*	95% CI	*p*-value
BMI[c,d] (kg/m²)	586	–0.383	–0.773, 0.006	0.054	**–0.031**	**–0.043, –0.020**	**<0.001**	<0.001	–0.005, 0.005	0.989
SBP[e] (mmHg)	577	**–1.563**	**–2.926, –0.200**	**0.025**	0.012	–0.031, 0.055	0.584	–0.002	–0.021, 0.017	0.814
DBP[f] (mmHg)	577	–0.911	–2.077, 0.255	0.125	0.006	–0.030, 0.043	0.729	–0.002	–0.018, 0.015	0.852
TC[g] (mmol/L)	492	0.068	–0.008, 0.143	0.079	<0.001	–0.002, 0.003	0.834	**0.001**	**0.000, 0.002**	**0.018**
LDL[h] (mmol/L)	486	0.033	–0.029, 0.095	0.294	<0.001	–0.002, 0.002	0.894	**0.001**	**0.001, 0.002**	**0.002**
HDL[i] (mmol/L)	492	0.020	–0.015, 0.054	0.260	<0.001	–0.001, 0.001	0.627	<0.001	0.000, 0.001	0.817
TG[j] (mmol/L)	492	0.062	–0.004, 0.129	0.067	<0.001	–0.002, 0.002	0.912	–0.001	–0.001, 0.000	0.254
Non-HDL[k] (mmol/L)	492	0.048	–0.017, 0.112	0.146	<0.001	–0.002, 0.002	0.988	**0.001**	**0.000, 0.002**	**0.008**
TC/HDL[l] (ratio)	492	0.015	–0.057, 0.087	0.685	<0.001	–0.002, 0.002	0.937	0.001	0.000, 0.002	0.155
HbA1c[m] (%)	500	0.008	–0.019, 0.035	0.548	<0.001	–0.001, 0.001	0.569	<0.001	0.000, 0.000	0.629

Note: Values in bold indicate statistically significant results. Unstandardised coefficients (beta) from linear regression models were adjusted for sex, age, height, weight and accelerometer wear time. The number of children included in models (N) varies due to missing data for some cardiovascular risk markers.

[a]Physical Activity Questionnaire for Older Children; [b]Moderate-to-vigorous physical activity; [c]Body mass index; [d]Model adjusted only for sex, age and wear time; [e]Systolic blood pressure, [f]Diastolic blood pressure, [g]Total cholesterol, [h]Low-density lipoprotein, [i]High-density lipoprotein, [j]Triglycerides, [k]Difference between TC and HDL, [l]Ratio between TC and HDL, [m]Glycated haemoglobin

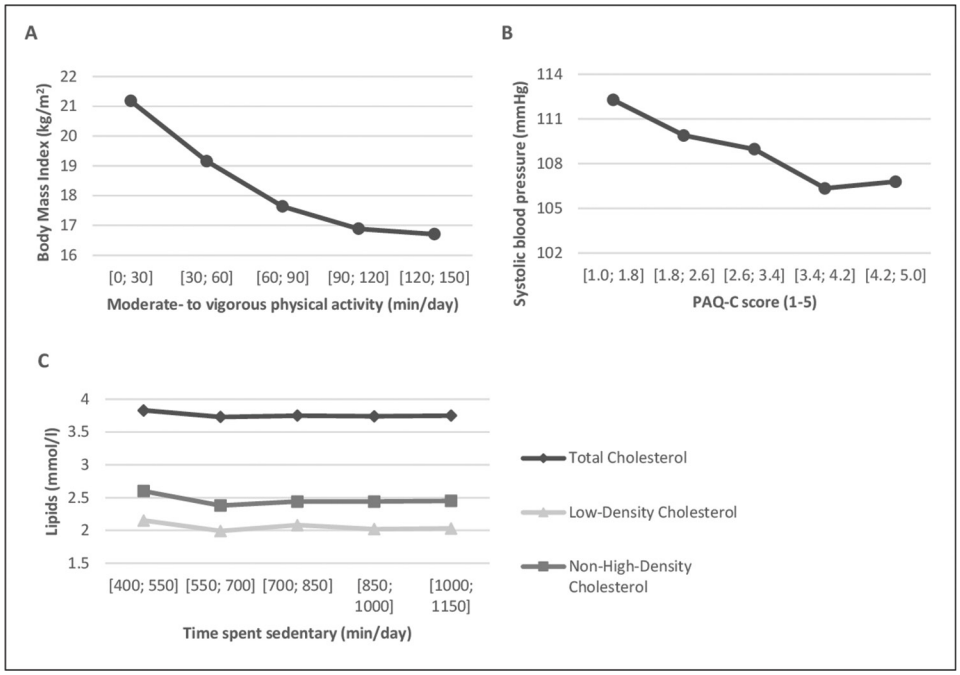

Figure 2: Significant associations between physical activity and cardiovascular risk markers. A significant inverse association between (A) accelerometer-measured MVPA and BMI and (B) PAQ-C scores and SBP. (C) A positive association between SB and lipids can be observed for school-aged children from Gqeberha, South Africa.

and accelerometry measurements, whilst also reporting wide correlation variability in the studies included. The low correlation coefficient and the weak explanatory power observed in this study contribute to the notion that PAQ-C and accelerometry have an inconsistent agreement for measuring MVPA. Furthermore, the PAQ-C would not fulfil the standards of a PA questionnaire proposed by Terwee et al., whereby correlation coefficients with accelerometer-measured MVPA must be at least moderate.[37] Because we only included valid accelerometry data in our analyses to ensure a representative mean wear time (17.23 out of a maximum of 18 h), we deem the presented accelerometry-based assessments as accurate. Therefore, we argue that attempting to derive children's objective MVPA levels from their PAQ-C scores, and vice versa, is linked to a high level of uncertainty.

Differences between self-reported and accelerometer-measured PA can be interpreted as children's difficulties in assessing their own PA habits. It has been observed that memory errors play an important role, particularly when dealing with children.[38] Another factor potentially contributing to discrepancies is the social desirability bias, where study participants report higher PA levels to be viewed favourably by others. Moreover, differences might stem from the ActiGraph not being able to accurately measure activities with little upper body movement such as cycling. During cycling, the upper body is not accelerated in any direction as happens when, for example playing soccer, a popular activity amongst children in South Africa.[39] Previous studies have also pointed out that the PAQ-C and accelerometry do not actually measure the same construct.[40] Accelerometry measures the exact duration, frequency and intensity of body movement, whilst the PAQ-C provides information about self-reported PA behaviour, activity types and settings in which PA is performed. Hence, the simultaneous use of PAQ-C and accelerometry could allow for a more comprehensive study of the relationship between self-perceived and actual PA and customised PA recommendations.

Regarding cardiometabolic risk, ActiGraph-measured MVPA was inversely related to BMI. Increasing MVPA by 15 min per day was associated with a BMI reduction of approximately −0.47 points. The significant association between accelerometer-measured MVPA and BMI demonstrates that PA, particularly MVPA, can be a crucial contributor to weight control at a young age.[41] Especially girls should be encouraged to increase their time spent in MVPA, as they spent substantially less time in MVPA and showed higher BMI values compared to boys (57.7 vs. 83.8 min/day and 17.8 vs. 16.7 kg/m^2, respectively). In contrast, children's self-reported PA levels were not significantly associated with BMI. Thus, children who considered themselves as more physically active did not exhibit lower BMI values. More consistent associations with BMI for device-based PA than for self-reported PA have previously been reported and were attributed to self-report bias.[42]

Diverging results were also obtained for the association between PA and SBP. In this study, SBP was weakly and inversely associated with self-reported PA but not with ActiGraph MVPA levels. Research has not shown that self-reported PA estimates are more likely to identify a significant association with BP compared with device-based PA measurements. In contrast, some studies have observed a significant inverse association between PA and BP using device-based methods,[43-45] although this relationship has not always been established.[46-48] The inconsistency of findings on the relationship between PA and BP amongst children and adolescents may be explained by varying durations of PA measurement, a lack of consistency in methodology, the influence of childhood adiposity, and wide ranges of age groups included in the studies.[49]

The activity assessment by accelerometry also provides estimates of the time children spend in SB, which allowed for the analysis of the association between CRMs and physical inactivity. Higher levels of SB were related to small increases in TC, LDL and non-HDL concentrations, whilst neither self-reported nor accelerometer-measured PA was associated with any BLP parameter. Increasing daily SB by 15 min was associated with a predicted increase of +0.015 mmol/L in TC, LDL and non-HDL. Because girls showed higher levels of SB compared to boys (65.6 vs. 62.4% per day, respectively) and higher concentrations in TC (3.8 vs. 3.6 mmol/L, respectively) and non-HDL (2.5 vs. 2.3 mmol/L, respectively), they should particularly be encouraged to reduce time spent in SB. It has been hypothesised that PA and SB have independent effects on lipoprotein metabolism, with PA more strongly affecting HDL and TG, and SB being rather related to the 'bad' cholesterol (LDL and non-HDL).[50] Consistent with the findings of this study, it has been claimed that PA does not lower LDL and TC.[51] However, the significant effect of MVPA on HDL and TG that has been previously observed was not found in this study.[52] Our results conform to those of the European Youth Heart Study that revealed non-significant relationships between MVPA and BLP.[53]

The results of this work must be interpreted considering the following limitations. First, this study has a cross-sectional design, which means that causality cannot be inferred because temporality is not known. Second, 8.0% of children with ActiGraph data were excluded from the analyses due to not meeting our wear time requirements. Third, PA was assessed over the period of 1 week, but since PA is highly variable in children, the measure comprised 1 week may not fully reflect children's true PA levels. Fourth, the limitations of the assessment methods must be considered. PAQ-C is prone to recall errors, social desirability effect and difficulties understanding the questions. Also, more than 25% of study participants reported that an impairment had prevented them from engaging in their usual PA and were therefore not included in the analysis. Limitations of the ActiGraph accelerometry include its inability to accurately measure activities with little upper body movement such as cycling or weight training when worn around the hip. Lastly, the impact of children's dietary habits was not accounted for in the associations between PA and SB with CRMs.

Conclusion

We found a weak relationship between self-reported (PAQ-C) and accelerometer-measured (ActiGraph) MVPA levels in a paediatric population from low-income areas in South Africa. Thus, we advise caution when comparing studies that are based on diverse methodologies for assessing PA. As PA measured via accelerometry and SB showed stronger associations with CRMs, the wearable device ActiGraph allowed for a more accurate CVD risk estimation compared to the PAQ-C questionnaire. However, our results point towards a weak association between PA and CRMs. Therefore, it is of interest to further investigate the association between different PA measurement methods in longitudinal studies, especially under researched paediatric populations from LMICs.

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Competing interests

We have no competing interest to declare.

Authors' contributions

P.A.: Conceptualisation, writing – the initial draft, data compilation, data curation, interpretation of results, student supervision. F.G.: Conceptualisation, writing – the initial draft, data compilation, statistical analyses, interpretation of results. D.I.: Statistical input, writing – revisions. M.G.: Writing – revisions. L.A.: Data collection, writing – revisions. D.D.: Data collection, writing – revisions. N.J.: Data collection, writing – revisions. M.N.: Data collection, writing – revisions. S.N.: Data collection, writing – revisions. R.d.R.: Writing – revisions. P.S.: Writing – revisions. J.U.: Writing – revisions. C.W.: Writing – revisions. U.P.: Writing – revisions. I.M.: Conceptualisation, data collection, writing – revisions.

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