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Original Article

Objectively measured 24-h movement behaviours of child-guardian pairs in low-to-middle income households in Nairobi City County, Kenya

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ABSTRACT

Background: The decreasing prevalence of physical activity (PA) among urban children in Sub-Saharan Africa is a growing public health concern. More emphasis should focus on examining the influence of parental PA behaviour on the children's PA patterns. We explored associations of 24 hour (h) accelerometer-measured movement behaviours of guardian-child pairs in Nairobi City County, Kenya.

Methods: This cross-sectional study assessed 80 pairs consisting of children aged 9–14 years and their guardians in one area of low and one area of middle socioeconomic status (SES) (Embakasi Sub-County and Lang'ata Sub-County), in Nairobi City County, Kenya. The study used waist worn Tri-axial Actigraph (GT3X+ and ActiSleep+) accelerometers to quantify PA and sedentary time (SED). Association between guardians' and children's PA was examined using linear regression, adjusting for guardians' educational attainment and household wealth.

Results: Of the children, 42 (52.5%) and 76 (96.2%) of the guardians were women. Children in low SES areas spent more time ($p < 0.001$) in moderate-to-vigorous physical activity compared to children from middle SES area. The guardians in low SES area were younger and spent more time in light PA ($p = 0.036$) while their counterparts had higher daily SED ($p = 0.049$). Guardian's SED associated with higher children's SED ($p = 0.033$) even after adjusting for guardians' educational attainment ($p = 0.032$) and wealth ($p = 0.05$). There was no association between guardians' and children's MVPA.

Conclusion: Considered alongside the extant literature, these results suggest that health promotion strategies should aim to reduce parental SED time while also planning to increase children's PA.

1. Introduction

The widespread problem of physical inactivity and the increasing prevalence of childhood obesity,[1] has made the promotion of regular physical activity (PA) among young people a global public-health priority.[2] Research show that PA is lower in urban residents in low-income countries compared to their rural counterparts.[3–5] Moreover, rapid urbanization and economic growth is associated with sedentary lifestyle[6] which raises concern because of the rapid urbanization and high rates of rural to urban migration in most low-income countries.

Globally, children and youth lug behind in meeting recommended WHO guidelines levels of 60 minute (min) per day of moderate-to-vigorous physical activity (MVPA).[7] Studies have concluded that adolescent girls are significantly affected compared to adolescent boys (84.7% vs 77.6%).[8] A meta-analysis of 23 studies conducted in Africa, show that only a small fraction (20%) of adolescents meets the recommended PA levels[9] and a 30% prevalence rate of sedentary behaviour.[10] The PA guidelines for children and youth include a minimum of 60 min of MVPA per day. However, there is insufficient and inconclusive data on

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Abbreviations

BMI	body mass index
LPA	light physical activity
MPA	moderate physical activity
MVPA	moderate-to-vigorous physical activity
SED	sedentary time
SES	socioeconomic status
SD	standard deviation
VPA	vigorous physical activity
WHO	World Health Organization

the prevalence of PA among children and youth in Sub Saharan Africa, especially with studies using device-measured PA data.[11] Previous studies in Kenya[12,13] have identified children in low-to-middle income families in Nairobi needing further research on 24 h movement behaviours including the socioeconomic characteristics of the area in which they live.

It is estimated that 21.4% of adult inhabitants of sub-Saharan Africa are insufficiently active, with women (24.8%) being less active than men (17.9%).[14] Parents' PA directly influences their child's PA through modelling (being physically active themselves) and social support (e.g. verbal encouragement, paying for participation, transporting to and from venues, purchasing clothing and equipment).[15,16] Previous reviews of studies on the influence of parental modelling assessing the correlation between parent and child PA has presented mixed results.[2,17] These mixed findings might be due to heterogeneity in study designs, geographical location and the methods used to assess PA. For instance, many of the PA assessments used self-report methods which are prone to measurement error,[18] due to, e.g., social desirability, language barrier and recall biases.[19] Accordingly, the use of tri-axial accelerometry, may obtain more valid and precise measurements of PA that might better identify the associations between the PA levels of parents-child pairs. A systematic review summarized the evidence from 39 papers on the relationship between parent and child PA and reported that studies using objective assessment of parental PA showed stronger relationship between parent and child PA compared with studies using self-report. They however concluded that there was no clear evidence for the strength of relationship being dependent on type of PA measure of parent and child (total PA, moderate-to-vigorous PA, steps).[20] To the best of our knowledge, there is no study conducted in Sub-Saharan Africa examining the relationship between parent-child PA and sedentary behaviour (SED).

The aims of this study were first to describe 24 h accelerometer measured PA (total amount and intensities) and SED among children aged 9–14 years and their guardians residing in low and middle socioeconomic status (SES) areas in Nairobi County, Kenya. Further, and second to examine the strength of associations between parents' and children's SED and MVPA from varying sociodemographic background. We hypothesized that children with more active guardians are more physically active, compared to those with less active guardians. We also hypothesized that the SES of their living area may modify this association.

2. Material and methods

2.1. Ethical approvement

This study was guided by ethical standards and national and international laws. The study protocol was reviewed and approved by the Kenyatta University Ethics Review Committee (PKU/946/11002) and a research permit obtained from the National Commission for Science, Technology and Innovation prior to data collection. All study participants, eligible families (children aged 9–14 years and their guardians), signed informed consent forms (assent forms for children) to indicate their willingness to participate in the study. The study was implemented in accordance with the Declaration of Helsinki.

2.2. Design, participants, and setting

This study was part of a larger research project called "The Kenya-Finland Education and Research Alliance (KENFIN-EDURA)". The project aimed to establish the determinants of risk factors for non-communicable diseases (NCDs) among families (children aged 9–14 years and their guardians) residing in Nairobi County, Kenya, with special focus on a comparison between a low- and a middle-SES area of the groups.[21] This paper focuses on the 24 h PA data from parent-child pairs in different areas of deprivation.

The data was collected from two sub-counties in Nairobi City County namely: Embakasi Central (Kayole ward; Low-SES), and Lang'ata (Nairobi West ward; Middle-SES). When referring to these areas, we use "Embakasi" and "Lang'ata". Prior to the data collection, 223 households were mapped with the support of community health officers and health volunteers from health centres in the study areas. The quantitative part of the larger project was mainly descriptive, and the study had multiple outcome measures. One main outcome was childhood overweight/obesity which was used as the basis for power calculation. According to Broyles et al.,[22] an expected difference in child BMI z-score between Low- and Middle-SES in low-income countries is 0.5. When we use 1.0 as the standard deviation (SD), and $\alpha = 0.05$ and power = 80%, a total 2-group sample size is $n = 126$ ($n = 63$ per group). To allow for non-response, we aimed to invite in total 160 households, i.e., 80 from each for the study area.

For this study, we conducted post-hoc power analysis for F-test, using G*Power software with effect size 0.17, $\alpha = 0.05$, total sample size $n = 80$ and number of predictors 3 (full model for the SED analysis in Table 4). Based on the calculation, our analysis has 86% power.

Households were recruited if they had child residents between the ages 9–14 year who had lived at the home for at least six months and were willing to take part in the study. The recruited guardian was one of the child's parents who resides in the home, was available during the study's home visit, were willing to take part in the study and was responsible for decision making and guidance of the child's day to day lifestyle. The exclusion criteria were the documentation of chronic disease conditions or any significant illnesses preventing physical activity participation. Simple random sampling technique was used to select the households and the final sample of 72 households for Embakasi and 77 households for Lang'ata (149 households - 93% of those invited) was achieved. The participants were assessed in their homes at a pre-arranged appointment.

2.3. Instruments and procedures

During home visits, participants and their guardians were given verbal explanation as well as informed consent letter explaining the purpose of the study, what participation entailed, and the right to refuse to participate in any part of the study. Guardians signed the consent letter while children signed an assent form. The guardians also completed the background information questionnaire which contained items about socio-demographic characteristics (age, gender, area of residence, occupation, wealth indicators, and family size). In the background questionnaire, guardians were asked to indicate their educational attainment using the following 10 categories: No formal education, Adult education only, Completed primary, Not completed primary, Completed secondary education, Not completed secondary, Certificate training, Diploma, Degree, Post Graduate.

Stature and body mass of children and their guardians were measured with minimal clothing and footwear removed, using a digital electronic scale (Seca Robust 813) to the nearest 0.1 kg and a stadiometer (Seca 217) to the nearest 0.1 cm. BMI-for-age z-scores for children were

calculated, using WHO's growth references.[23] For adults, BMI ($kg \cdot m^{-2}$) was calculated by dividing weight for the square of height. PA and SED were monitored using tri-axial Actigraph accelerometers (ActiGraph LLC, Pensacola, FL). The monitors were attached to an elastic waist belt and worn over the right mid-axillary line. The sampling rate was set at a 30 Hz for both children and their guardians to align with the filtering processes and calibration studies.[24] One second epochs were used to offer the greatest flexibility during subsequent filtering and analysis.[25,26] The children used the ActiGraph GT3X+ (ActiGraph LLC, Pensacola, FL) while the adults used the ActiSleep+ (ActiGraph LLC, Pensacola, FL). The GT3X+ and the ActiSleep + both contain the Actigraph micro-electromechanical systems (MEMS) accelerometer with the same specifications and functionality. Specifically, both devices contain a tri-axial accelerometer with 220 mV/g sensitively and ± 6 G dynamic range. The acceleration data is sampled by a 12-bit analog to digital converter at 30 Hz–100 Hz and stored on the flash memory in raw, non-filtered units of gravity (G's).[27]

The device was worn 24 $h \cdot day^{-1}$ removing only for water-based activities such as swimming and showering. The participants were asked to wear the instruments for at least eight full days (plus an initial familiarization day and the morning of the final day), including two weekend days and instructed to wear the monitor until it was collected by research staff. Eight days was chosen to maximize on the number of participants providing sufficient wear time necessary for analysis. Assessors were present at the participants' home to explain the wearing instructions and ensure that the participants were able to correctly attach the monitor. To increase compliance the guardian and the child were asked to remind each other to wear their monitors all the time and correctly.

2.4. Children's accelerometer data processing

The downloaded GT3x files were aggregated to 60-second (s) epochs for the removal of nocturnal sleep time. The detection of nocturnal sleep episodes was performed in SAS (version 9.3; SAS Institute Inc., Cary, NC) using an automated algorithm developed for use in 24 h waist worn accelerometer protocols. The algorithm produces estimates of a nocturnal sleep, labelling each minute as: sleep, wake or non-wear based on the tilt of the accelerometer, counts of the y-axis and the time of day.[28]

After the removal of nocturnal sleep episodes, data were aggregated to 5 s epochs for the assessment of PA and SED[29] using KineSoft software (KineSoft, Saskatchewan, Canada). Participants providing at least four days, including at least one weekend day of valid data ($\geq$ 10 $h \cdot day^{-1}$ of waking wear time) were included in the analysis.[30] Non-wear periods were defined as any sequence of at least 20 consecutive minutes of zero activity counts.[31,32] The cut points of Evenson et al.[33] were used to define SED, light physical activity (LPA), moderate physical activity (MPA) and vigorous physical activity (VPA).[33] MPA and VPA were summed to obtain MVPA.

2.5. Guardian (adult) accelerometer data processing

Sleep time was determined using a fully automated algorithm developed for use in 24 h waist worn accelerometer protocols[28] and recently validated in adults.[34] After the removal of nocturnal sleep episodes participants providing at least four days, including at least one weekend day, of valid data ($\geq$ 10 $h \cdot day^{-1}$ of waking wear time) were included in the analysis.[30] Non-wear was classified as 60 min of consecutive zeros with the allowance of interruptions up to 2 min as has been used in large population studies[25] and shown to minimise the misclassification of SED as non-wear while also retaining data.[35] Troiano cut-points were used to determine time ($min \cdot day^{-1}$) spent at different intensity categories and the MPA and VPA data were summed to obtain MVPA.[25]

2.6. Data analysis

Statistical analyses were conducted using SPSS Statistics 25 (IBM, US) and R statistical software.[36] Participants' socio-demographic characteristics, PA volumes and intensities by study area have been described with means and standard deviations (continuous variables) or frequencies and percentages (categorical variables). Household's SES was described by creating a wealth index, according to the World Food Program's guidelines.[37] The study's protocol[21] provides more details on the calculation of the wealth index. Ten original categories of educational attainment were coerced into five categories for the statistical analyses: No education or incomplete primary, Complete Primary, Complete secondary, Certificate, diploma or adult education, Tertiary education.

To explore the association between living area and guardians' and children's PA intensities we used linear regression for all continuous variables (PA as $min \cdot day^{-1}$ for different intensity levels) and logistic regression model for categorical variable (not reaching recommended total MVPA). Also, the association between guardian's and children's PA and SED was analysed using linear regression. Normality of the main exposure and outcome variables were visualised using histograms and normality plots prior to the regression analysis. Prior to the analyses we examined several potential confounders, mediators and moderators using graphical illustrations and their correlations with the main exposures (guardians' SED and MVPA) and outcomes (children's SED and MVPA). Finally, we created four linear regression models: (i) first we adjusted for guardian age and gender (model 1), second we adjusted either for guardian's educational attainment (model 2), wealth index (model 3), with the final full model adjusting for both guardian's educational attainment and wealth index (model 4). The moderating effect of living area was assessed by introducing an interaction term between area and main exposure to the full model and comparing it with the model without the interaction term, using a likelihood ratio test.

3. Results

3.1. Household's and participants' characteristics

From the 149 recruited households, 104 children (69.8%) and 89 guardians (60.1%) returned the accelerometers with sufficient wear time and were included in the analysis. Participant characteristic of households with and without sufficient accelerometer data (from both guardian and child) are presented in Supplement Table 1. Households with sufficient accelerometer data ($n = 80$) did not significantly differ from those without accelerometer data ($n = 36$) across all socio-demographic characteristics, except that guardians with accelerometer data were older ($p = 0.002$) and had higher wealth index ($p = 0.021$) compared to those without accelerometer data.

Table 1 presents the characteristic of children and their guardians who had sufficient accelerometer data by study area (54%). More households (58.8%) from the Low-SES area (Embakasi) provided sufficient accelerometer data compared to those from Middle-SES area (Lang'ata). Proportion of boys and girls were similar, but vast majority of participating guardians were women (which was the case for the whole study cohort as well). Most of the guardians had 10 000–30 999 Kenyan shillings (77–239 USD) monthly income, 77.5% were married, and 62.0% of the guardians and 17.9% of the children were overweight. There were differences in income, guardians' educational attainment, and occupational status by the two areas, as expected per study design.

3.2. Average, weekday and weekend PA intensity levels for children and their guardians

Table 2 shows time (minutes) spent on each PA intensity level on average, on weekdays and on weekends for children and their guardians. On average, children spent more time in MVPA compared to guardians, who in turn had higher LPA. Further, children spent more time in

Table 1
Participants' characteristics for those who provided sufficient accelerometer data ($n = 80$) in Embakasi and Lang'ata, Nairobi County, Kenya.

Variables	All		Low-SES (Embakasi)		Middle-SES (Lang'ata)	
	Mean/ *n*	*SD*/%	Mean/ *n*	*SD*/ %	Mean/ *n*	*SD*/ %
Number of households	80	100.0	47	58.8	33	41.3
Child sex						
Boys	38	47.5	22	46.8	16	48.5
Girls	42	52.5	25	53.2	17	51.5
Age of children	11	1.4	11	1.3	11	1.6
Child BMI *z*-score	−0.06	1.45	−0.4	1.4	0.4	1.5
Child overweight, (BMI *z*-score > 1.0)	14	17.9	3	6.4	11	35.5
Guardian gender						
Men	3	3.8	0	0	3	9.4
Women	76	96.2	47	100.0	29	90.6
Age of guardians	37.8	9.9	34.4	6.7	42.6	11.7
Guardian BMI	28.3	6.8	28.0	6.2	28.8	7.6
Guardian overweight (BMI > 24.9 kg·m^{-2})	49	62.0	30	63.4	19	59.4
Household sociodemographic characteristics						
Household size	5.0	1.4	5.0	1.2	4.9	1.7
Income						
10 000 Ksh	16	20.0	16	34.0	0	0
10 000–30 999 Ksh	33	41.2	26	55.3	7	21.2
31 000–50 999 Ksh	7	8.8	1	2.1	6	18.2
≥ 51 000 Ksh	21	26.2	2	4.3	19	57.6
Income not reported	3	3.8	2	4.3	1	3.0
Guardian's educational attainment						
None	12	15.0	9	19.2	3	9.1
Primary	18	22.5	16	34.0	2	6.1
Secondary	29	36.2	20	42.6	9	27.3
Certificate	13	16.2	2	4.3	11	33.3
Tertiary	8	10.0	0	0	8	24.2
Employment status						
Unemployed	23	28.7	13	27.7	10	30.3
Employed	23	28.7	12	25.5	11	33.3
Casual	13	16.2	11	23.4	2	6.1
Entrepreneur	15	18.8	7	14.9	8	24.2
Status not reported	6	7.5	4	8.5	2	6.1
Marital status						
Married or cohabiting	62	77.5	39	83.0	23	77.5
Single	9	11.2	2	4.3	7	11.3
Divorced or separated	5	6.2	4	8.5	1	6.3
Widow	4	5.0	2	4.3	2	5.0
Wealth Index	0.29	0.88	−0.8	0.6	0.8	0.8

BMI, body mass index; Ksh, Kenyan shillings; *n*, frequency; *SD*, standard deviation; SES, socioeconomic status.

sedentary behaviours than their guardians. These differences seemed similar between weekdays and weekends.

3.3. Physical activity intensities by area of residence (Low-SES vs. Middle-SES)

The study sought to determine whether there were association between the study area and time spent in each of the PA level category weekdays, during weekend days and on average among the children and guardians. Results (Table 3) indicate that children residing in Low-SES area (Embakasi) spent more time in MVPA daily, on weekdays and over the weekend than their counterparts residing in Middle-SES area. They also spent more time in MPA and LPA than the children in Middle-SES area. Only 12 (21.1%) children in Low-SES area did not accumulate the recommended < 60 min·day^{-1} of MVPA compared to 20 (42.6%) children in Middle-SES area. However, none of these associations were statistically significant after further adjustments with wealth and guardian's educational attainment (data not shown).

Table 2
Average, weekday and weekend minutes spent on each physical activity intensity level for children aged 9–14 years and their guardians in Nairobi County, Kenya.

Variables	Children ($n = 104$)		Guardians ($n = 89$)	
	Mean	*SD*	Mean	*SD*
Average LPA	215.2	46.3	382.7	92.3
Average MPA	45.6	16.1	42.1	32.0
Average MVPA	73.2	29.4	42.3	32.0
Average SED	605.5	81.1	512.4	112.5
Average VPA	27.6	15.6	0.2	0.7
Weekday LPA	179.7	48.0	322.8	100.5
Weekday MPA	44.1	16.4	43.9	34.4
Weekday MVPA	71.1	29.9	44.1	34.4
Weekday SED	518.4	89.7	422.0	112.0
Weekday VPA	26.9	16.0	0.2	0.8
Weekend LPA	221.4	56.2	364.6	98.1
Weekend MPA	51.4	20.9	37.0	36.5
Weekend MVPA	81.5	36.8	37.2	36.8
Weekend SED	542.9	104.1	525.7	128.4
Weekend VPA	30.2	18.5	0.2	1.3

LPA, light physical activity; MPA, moderate physical activity; MVPA, moderate-to-vigorous physical activity; *n*, frequency; SED, sedentary time; *SD*, standard deviation; VPA, vigorous physical activity.

The guardians in Low-SES area were much younger and spent significantly more time in LPA daily and on weekdays compared to their Middle-SES counterparts. The guardians residing in Middle-SES area had a higher SED per day than the guardians residing in Low-SES area. Similar to the children's results, none of these associations were statistically significant after further adjustments with wealth and guardian's educational attainment (data not shown).

3.4. Association between guardian's and children's PA and SED

The linear regression analyses revealed that higher average guardian SED was associated with higher average child SED in the crude model (Table 4) and after adjusting for guardian's educational attainment and wealth. However, the variance in child average SED explained by parental SED was low, indicating that other factors explain children's average SED time.

While there was no association between guardians' and children's average MVPA, both guardian's educational attainment and wealth were negatively associated with children's average MVPA in model 1 (data not shown). In the full model, guardian's educational attainment remained the strongest determinant for child average MVPA. Even though also modest, the explanatory level of the full model was better for average MVPA than for average SED ($R^2 = 0.10$). On the other hand, associations between guardians' and children's average SED and average MVPA were not moderated by living area (Low-SES area or Middle-SES area) (data not shown). The full model explained 10% of the variance in MVPA.

The results were similar when weekday and weekend average SED and MVPA were examined separately (Table 4). However, in contrast to the total and weekday MVPA, guardian's wealth appeared as the strongest determinant for child average MVPA instead of educational attainment.

4. Discussion

The aims of this study were first to describe 24 h PA and SED among children and their guardians and second to establish associations between parents and children's SED and MVPA residing in low and mid socioeconomic status in Kenya. Children from Low-SES area had higher LPA and MVPA and were also more likely to reach the 60 min daily recommendation for MVPA compared to children from Middle-SES area. Among guardians, similar association was found only for LPA, but not for other intensities or reaching the recommendation for PA. Guardians' SED

Table 3
Children's and guardian's PA dimensions by area of residence (Low-SES area vs. Middle-SES area) in Nairobi County, Kenya.

Variables	Children aged 9–14 years					Guardians				
	Low-SES ($n = 57$)		Middle-SES ($n = 47$)		p[a]	Low-SES ($n = 48$)		Middle-SES ($n = 41$)		p[a]
	Mean/n	SD/%	Mean/n	SD/%		Mean/n	SD/%	Mean/n	SD/%	
Total										
SED, min/day	601.00	76.12	615.86	81.34	0.34	497.23	94.70	525.35	124.20	**0.049**
LPA, min/day	224.00	42.50	199.62	45.37	**0.006**	397.57	77.79	350.94	105.25	**0.036**
MPA, min/day	50.60	15.42	37.33	11.47	**< 0.001**	43.66	31.20	39.04	33.07	0.221
VPA, min/day	29.14	17.06	23.84	10.55	0.065	0.16	0.53	0.27	0.75	0.737
MVPA, min/day	79.74	30.31	61.17	20.07	**< 0.001**	43.83	31.27	39.32	33.22	0.219
Weekdays										
SED, min/day	529.21	96.26	510.85	84.60	0.319	411.51	101.39	433.82	118.09	0.163
LPA, min/day	188.97	48.64	161.42	38.19	**0.002**	337.48	89.64	294.16	107.94	**0.044**
MPA, min/day	48.20	16.34	36.38	11.87	**< 0.001**	45.69	34.91	40.91	33.96	0.262
VPA, min/day	27.30	17.69	23.54	10.15	0.201	0.13	0.40	0.29	1.00	0.748
MVPA, min/day	75.50	31.64	59.91	19.87	**0.004**	45.82	35.00	41.20	34.03	0.26
Weekends										
SED, min/day	535.17	94.80	559.10	108.49	0.259	528.58	111.57	507.55	140.37	0.924
LPA, min/day	231.06	50.63	205.08	58.51	**0.026**	366.13	94.25	353.07	108.46	0.747
MPA, min/day	56.44	18.51	42.77	19.04	**0.001**	36.28	28.18	36.07	44.11	0.367
VPA, min/day	33.22	18.40	26.23	18.27	0.095	0.25	1.62	0.24	0.69	0.835
MVPA, min/day	89.66	34.20	69.00	35.15	**0.007**	36.53	28.41	36.30	44.49	0.367
Not reaching recommended MVPA[b]	12	21.05	20	42.55	**0.019**	11	22.92	14	35	0.16

LPA, light physical activity; MPA, moderate physical activity; MVPA, moderate-to-vigorous physical activity; n, frequency; SED, sedentary time; SES, socioeconomic status; SD, standard deviation; VPA, vigorous physical activity.
[a] p-value from linear regression for continuous variables and from logistic regression for categorical variables; adjusted for sex.
[b] MVPA recommendation is $\geq$ 60 min/day for children, and $>$ 150 min/week for adults.

Table 4
Association between guardian's and children's PA and SED for households who provided sufficient accelerometer data ($n = 80$) in Nairobi County, Kenya.

Models	Total average				Weekday average				Weekend average			
	β	SE	p	R^2	β	SE	p	R^2	β	SE	p	R^2
Crude model for SED				0.04				0.15				0.03
Guardian average SED, min/day	0.17	0.08	0.033		0.33	0.09	< 0.001		0.06	0.03	0.07	
Adjusted for wealth and guardian's educational attainment				0.04				0.18				0.18
Guardian average SED, min/day	0.17	0.08	0.038		0.34	0.09	< 0.001		0.07	0.03	0.05	
Wealth index	6.91	10.79	0.52		−14.63	11.25	0.198		−13.23	4.54	0.005	
Guardian's educational attainment (ref. no education)												
Complete primary	46.17	29.95	0.13		71.99	30.52	0.021		−0.22	13.07	0.99	
Secondary	4.31	27.39	0.88		31.83	27.78	0.256		−7.94	11.67	0.50	
Certificate	21.26	33.89	0.53		47.8	34.78	0.174		−18.28	15.36	0.24	
Tertiary	26.66	40.9	0.51		55.79	42.72	0.196		5.73	19.96	0.78	
Crude model for MVPA				−0.01				−0.01				0.07
Guardian average MVPA, min/day	0.04	0.10	0.73		0.03	0.04	0.52		0.15	0.06	0.016	
Adjusted for wealth and guardian's educational attainment				0.10				0.06				0.19
Guardian average MVPA, min/day	−0.01	0.10	0.94		< 0.01	0.04	0.98		0.1	0.06	0.09	
Wealth index	−5.84	3.77	0.13		−0.01	0.06	0.88		−0.18	0.06	0.006	
Guardian's educational attainment (ref. no education)												
Complete primary	−15.83	10.42	0.13		−0.31	0.16	0.05		−0.17	0.17	0.31	
Secondary	−19.57	9.55	0.044		−0.28	0.14	0.05		−0.16	0.16	0.30	
Certificate	−30.32	11.84	0.012		−0.43	0.18	0.02		−0.31	0.20	0.12	
Tertiary	−22.77	14.29	0.12		−0.55	0.22	0.014		0.15	0.26	0.57	

MVPA, moderate-to-vigorous physical activity; SE, standard error; SED, sedentary time; p, probability value; PA, physical activity; R^2, coefficient of determination.

was associated with children's SED regardless of household's wealth and guardian's educational attainment. Guardian's educational attainment was the strongest determinant of their MVPA.

The present study reached balanced representation of boys and girls although most guardians were mothers (96%). Considering that recruitment was conducted in the households during daytime, mothers were more likely to be present at home during recruitment for data collection than fathers, who may have been away at work. For this reason, we did not analyse the sex differences in PA intensities in this study. There is therefore need for additional research to investigate both parents' involvement and to verify influences of specifically mothers or fathers with their sons or daughters. With regards to age, previous research has shown that PA parenting practices are associated with greater accelerometer assessed PA among children and adolescents.[38–42] In contrast, our analyses revealed that age difference was not associated with PA levels of parent-child pairs and therefore they were not adjusted for in the analyses. Jago and associates[43] suggest that the weak relationship may be a function of children's age in that children who are older have greater independence and are less influenced by guardians' PA behaviours compared to younger children.

In lower middle-income economies, lifestyle transition shows that previously reported dominance of higher SES in non-communicable

diseases and related behaviour start to disappear presenting a notable increase among lower SES groups[44] hence our focus in the two SES areas in urban Nairobi. The residential areas selected for the study differed significantly from a SES viewpoint making it possible to test the research questions. They also represent many other suburbs that house the largest population groups in urban Nairobi. For instance, low SES areas in Kenyan cities like Nairobi are characterised by densely populated environment with high-rise buildings, shanties and slums infiltrate infrastructural layouts of low standard housing units with shared or non-shared amenities with a high crime rate. On the other hand, middle SES areas comprise gated communities with spacious individual housing units, well maintained streets and availability of community recreation spaces with a lower crime rate. Results show that both children and guardians residing in the Middle-SES area were less active and more sedentary throughout the week than their counterparts from the low SES area. This is perhaps due to access to opportunities in higher income households where more affluent lifestyle characterised by mechanization, motorisation and digitalization of day to day living. Active chores and transportation are more common in low SES areas yet overdependence on screen-based sedentary activities has been witnessed with the rapid urbanization in Sub-Saharan Africa.[45] However, the present study did not find any evidence that participants' living area (Low-SES area or Middle-SES area) would modify associations regarding SED or MVPA among the child-guardian pairs.

Further, our study found that children (in both areas) spend more time sedentary compared to their guardians (predominantly mothers) and these differences were similar between weekdays and weekends. This is probably due to the significant increased exposure to screen-based behavior[46] where influx of electronic media and child focused programming has dramatically increased screen-based sedentary activity.[46] Unfortunately, adolescents are the most sedentary of pediatric populations. Evidence shows that they may spend 57% of afterschool period in sedentary activity.[47] Studies of adults[48] and children[49–51] all suggest that there is less activity during weekends than on weekdays and that sedentary behavior increases on weekends. We also found that guardians from the Middle-SES area spent more time sedentary compared to guardians from Low-SES area. This could be explained by the affluent lifestyle characterised by reduced physical effort brought about by presence of domestic servants and noted increased use of mechanized, motorized, and digitized appliances, chores and transportation.

In our attempt to provide a practical indication of the potential impact of guardians' activity on their children's activity, we explored the association in child-guardian pairs SED. Our initial analysis revealed that higher guardian SED was associated with higher child SED and the association remained after adjusting for guardian's educational attainment and household wealth. Cameron and colleagues[52] using accelerometry in children and surveys of mothers found that some mothers modeled sedentary behaviour for their children; however, they were unable to identify any modeling relationships for higher levels of PA.[52] This may be so for our study, whereby mothers modeled behaviours. Associations between guardians' and children's accelerometer-measured SED has previously been found to vary,[43,53] but guardians' and children's reported screen-based behaviours (playing video games, watching television, using a computer) are more consistently associated.[43,53–55]

We compared MVPA of household's child-guardian pairs and we did not find any association. Previous studies have examined the relationship between parents' and their children's objectively measured steps per day,[56–60] accelerometer-measured counts[43,61–63] light PA,[64] and/or MVPA.[43,63,65] Several of these studies have yielded mixed results with some reporting positive association between parents' and children's MVPA,[53,66–72] while others observed a weak or no association.[43,73–76] The mixed evidence could be linked to the presence of other intervening factors (such as differences in occupation, transportation, SED, socio-cultural influences) in the studied populations that may influence PA behaviours of the household further reducing any distinctive effects and associations. Interestingly, Filanowski et al.[77] found that 6–12 years children engaged in high levels of MVPA when walking with their parents, while parents achieved higher step counts when walking alone but enjoyed walking with their children more. Although the parents PA seemed to increase without the child's company, their positive influence on the child's PA patterns and volumes when co-participating is commendable. Researchers[43] also suggested that older children such as adolescents have greater independence and are less influenced by parents' behaviours. It has also been suggested that parental modeling of PA alone is insufficient to influence child PA,[76] but parental support may mediate any parent–child PA associations which may not necessarily require their immediate presence at the time of the behavior.[78] Such parental support for increasing PA may include encouraging more outdoor play with peers in the neighborhood and in recreation spaces, signing up for opportunities to participate in organized sports, availing equipment for PA such as bicycles and involving the child in more physically demanding household chores and active transportation.

We found that although there were no associations between guardians' and children's MVPA, educational attainment and wealth were related to MVPA. Fewer studies have investigated the relationship between parental educational attainment and child PA; however, evidence points to a negative association between parental education and child PA in lower income countries,[79,80] and a positive relationship between these factors in higher income countries.[81] From these studies, it was noted that negative influence of higher maternal education on child physical activity was stronger than higher paternal education level in lower economic status countries. They speculated that this was due to mothers with higher education in lower economic status countries, having greater access to less labor intensive mechanized equipment and motorized transport as a consequence of greater SES, and being primarily responsible for influencing the child's lifestyle and less active transportation.

4.1. Strengths and weaknesses

A major strength of this study is the accelerometer-based PA data from both children and their guardians. Successfully obtaining objective measures of PA in this population is a major strength considering the complexity of recruitment and executing monitoring exercise which is often met with suspicion due to cultural restrictions and less exposure or unfamiliarity of the use of wearable devices for research. This study is also unique in that it targeted children aged 9–14 years of age, a group on which there is limited information on objectively-measured PA behaviour. Also, the two sub-counties in Nairobi representing Low- and Middle-SES areas enabled us to compare parent-child relationships in MVPA and SED in different socio-economically settings. This comparison is novel in African context, and provides a unique insight into active lifestyle in relation to urban residential areas with varying SES.

The study is limited by being a cross-sectional type of study where the observed associations do not confirm causality. In addition, there are other factors that may help explain the relationship between guardians and children's MVPA and SED that cannot be addressed simply by comparing their PA levels. For instance, the current study did not provide information about parental modeling of activity or the extent to which guardians facilitate activity for their children. Also, the absence of sufficient paternal data hindered the much-needed detailed examination of fathers' MVPA with that of their children. The lack of adequate father PA data is therefore a key limitation of this study. Considering that recruitment was conducted in the households during daytime targeting the parent available at the time, fathers were more likely to be away at work as compelled by African societal gender roles.

One other study weakness was with accelerometry where poor compliance of wearing the accelerometer device for the required number of days was observed. This was highest among the guardians especially for the night session which resulted with fewer participants achieving the required wear time. This resulted in a much smaller final sample for analysis than anticipated. The poor compliance may have been fuelled by cultural aspects and suspicions especially on wearing gadgets at night.

Future studies targeting household accelerometer assessment in similar settings should employ rigorous initiatives and incentives in reminding and encouraging participants to keep the monitors on at all times to ensure maximum adherence in expected device-wear behaviour. Consequently, a weakness in this study was a limited number of sampled households, although we met the initial power calculation for the expected difference of key analyses. The post-hoc power analysis showed that our analysis had 86% power with the sample size that we had for the main analysis of this study ($n = 80$). The total number of assessments done with each household was large: the whole study protocol took at least two visits of about 4–5 h per household. Still, households providing sufficient PA data were similar for their sociodemographic characteristics when comparing to those without PA data, giving confidence that our conclusions are valid even for the sub-county level with this sample size. Regardless, these data serve as important information for researchers and practitioners as well as families.

5. Conclusion

The study findings reveal a positive association in SED for the child-guardian pairs and yet no associations with MVPA. On the other hand both guardian's educational attainment and household wealth were negatively associated with children's MVPA. There was also no proof that the type of living area (Low-SES area or Middle-SES area) would modify associations regarding SED or MVPA among the child-guardian pairs. We conclude that more attention and interventions are needed to generally increase MVPA and reduce SED for both children and their parents regardless of the period of the week, SES of the residential area or age, with health promotion strategies targeted at reducing parental SED time as a key factor. This approach is crucial for both children and their parents in improving their 24 h movement behaviour which is vital for better health. Interventions should also consider education and wealth status of parents in addition to their PA behaviour when addressing children's PA. These should be emphasized in future research to establish them as evidence-based key influencers of PA behaviour in the existing field of knowledge for this population. Further research is needed in this population among the fathers and on moderating and mediating factors to illuminate potential mechanisms underlying successful family-based interventions designed to help parents increase their own PA as well as that of their children.

CRediT authorship contribution statement

Lucy-Joy Wachira: Writing – review & editing, Writing – original draft, Visualization, Project administration, Methodology, Investigation, Conceptualization. **Nils Swindell:** Writing – review & editing, Visualization, Software, Methodology, Formal analysis, Data curation. **Noora Kanerva:** Writing – review & editing, Visualization, Software, Methodology, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Muhoro Munuhe:** Writing – review & editing, Project administration, Methodology, Investigation. **Timo Vuorimaa:** Writing – review & editing, Methodology, Funding acquisition, Conceptualization. **Tiina Laiho:** Writing – review & editing, Methodology, Funding acquisition, Conceptualization. **Sophie Ochola:** Writing – review & editing, Methodology, Investigation, Conceptualization. **Maijaliisa Erkkola:** Writing – review & editing, Methodology, Investigation, Conceptualization. **George Owino:** Writing – review & editing, Methodology, Investigation. **Gareth Stratton:** Writing – review & editing, Software, Resources, Methodology. **Mikael Fogelholm:** Writing – review & editing, Resources, Methodology, Investigation, Funding acquisition, Conceptualization. **Vincent Onywera:** Writing – review & editing, Methodology, Investigation, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare no conflict of interest.

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Appendix A. Supplementary data

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