Physical Activity Trajectories in Early Childhood: Investigating Personal, Environmental, and Participation Factors

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ABSTRACT

MCPHEE, P. G., N. A. DI CRISTOFARO, H. A. T. CALDWELL, N. A. PROUDFOOT, S. KING-DOWLING, M. J. MACDONALD, J. CAIRNEY, S. R. BRAY, and B. W. TIMMONS. Physical Activity Trajectories in Early Childhood: Investigating Personal, Environmental, and Participation Factors. *Med. Sci. Sports Exerc.*, Vol. 55, No. 7, pp. 1232–1240, 2023. **Introduction/Purpose:** To determine personal, environmental, and participation factors that predict children's physical activity (PA) trajectories from preschool through to school years. **Methods:** Two hundred seventy-nine children (4.5 ± 0.9 yr, 52% boys) were included in this study. Physical activity was collected via accelerometry at six different timepoints over 6.3 ± 0.6 yr. Time-stable variables were collected at baseline and included child's sex and ethnicity. Time-dependent variables were collected at six timepoints (age, years) and included household income (CAD), parental total PA, parental influence on PA, and parent-reported child's quality of life, child's sleep, and child's amount of weekend outdoor PA. Group-based trajectory modeling was applied to identify trajectories of moderate-to-vigorous PA (MVPA) and total PA (TPA). Multivariable regression analysis identified personal, environmental, and participation factors associated with trajectory membership. **Results:** Three trajectories were identified for each of MVPA and TPA. Group 3 in MVPA and TPA expressed the most PA over time, with increased activity from timepoints 1 to 3, and then declining from timepoints 4 to 6. For the group 3 MVPA trajectory, male sex (β estimate, 3.437; $P = 0.001$) and quality of life (β estimate, 0.513; $P < 0.001$) were the only significant correlates for group membership. For the group 3 TPA trajectory, male sex (β estimate, 1.970; $P = 0.035$), greater household income (β estimate, 94.615; $P < 0.001$), and greater parental total PA (β estimate, 0.574; $P = 0.023$) increased the probability of belonging to this trajectory group. **Conclusions:** These findings suggest a need for interventions and public health campaigns to increase opportunities for PA engagement in girls starting in the early years. Policies and programs to address financial inequities, positive parental modeling, and improving quality of life are also warranted. **Key Words:** PHYSICAL ACTIVITY, CHILD, LONGITUDINAL, ACCELEROMETER

Physical activity in childhood has positive implications for an array of physical and mental health factors (1,2). For preschoolers 3 to 4 yr old, recommendations encourage at least 60 min of energetic play and a total of at least 180 min in a variety of physical activities per day (3). For children 5 yr and older, the recommended amount of physical activity includes at least an average of 60 min·d^{-1} at moderate-to-vigorous intensity to incur health benefits (4). Likewise, evidence suggests that greater total physical activity might improve cardiovascular fitness in childhood (5). Despite empirical evidence to support the positive associations between physical activity and health, many children do not engage in the recommended amount of physical activity to incur health benefits (6,7). This is concerning, particularly because physical activity habits that develop in childhood often carry throughout adolescence and into adulthood (8). Recent research showed an increase in moderate-to-vigorous physical activity (MVPA) up to 5 yr old, with declines occurring into adolescence (9). Therefore, a trajectory of diminished physical activity in childhood could be a contributing factor toward the development of cardiovascular disease, poor mental health, and other conditions later in life (10). On the other hand, some children are able to maintain relatively high levels of physical activity throughout childhood (11). Consistent engagement in physical activity leads to sustained health benefits (12), but an understanding

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of factors that predict inclusion in distinct trajectories of childhood physical activity is lacking.

Childhood encompasses a dynamic time of growth and development, which is influenced by personal factors (e.g., biological [sex]) and factors external to the child (13). Indeed, boys engage in more physical activity than girls, and research has attributed this difference to boys participating in more extracurricular sports, having greater cardiorespiratory fitness, and greater competence in physical education compared with girls (14). Likewise, physical activity can be influenced by participation factors and opportunities. Not surprisingly, involvement in community physical activity was shown to be positively associated with MVPA in children (15). In addition, a positive association exists between quality of life (QoL) and MVPA in childhood (16), and longer sleep duration has been shown to positively correlate with higher levels of physical activity (17). Lastly, opportunities to engage in physical activity can be shaped by society and other environmental factors. Parental attitudes toward physical activity and parental physical activity levels were positively associated with the child's physical activity (18). Longitudinal research has reported similar associations between environmental factors and physical activity in childhood. In a systematic review of children up to age 6 yr, parent's awareness of the child's physical activity and maternal role modeling were positively associated with change in physical activity (19). Similarly, parental support for children's physical activity and parents' self-reported physical activity were positively associated with changes in physical activity over time in children age 10.6 ± 0.5 yr (20). It is therefore likely that a combination of these factors predicts the trajectory of childhood physical activity. We have previously shown that group-based modeling can identify distinct trajectories of physical activity over time and that membership in these trajectories is relevant for future physical literacy (21).

Despite a growing body of longitudinal evidence documenting multiple predictors of physical activity in childhood, knowledge gaps in our understanding of physical activity trajectories include limited points of data collection (e.g., often only two or three timepoints) (9,20) and low to medium quality evidence of prospective cohort studies due to nonrepresentative samples and use of subjective outcome measures (19). In addition, these studies have included few predictors of physical activity over time, potentially missing important modifiable factors that can impact physical activity during childhood. Recent longitudinal evidence in children age 2 to 6 yr at baseline found that maternal physical activity was positively associated with child physical activity over 5 yr (22). However, attrition in this study was a limitation and participation-related factors, such as QoL and sleep, were not available to discern associations with physical activity over time (22). Given the documented declines in physical activity throughout childhood and into adolescence (23), it is imperative to understand the factors that influence physical activity trajectories in childhood to inform appropriate interventions to help children achieve the health benefits of regular physical activity. Group-based trajectory modeling is a statistical method used to estimate group membership among individuals following similar behavior patterns over time (24). This method provides an opportunity to identify predictors of distinct trajectories of physical activity in early childhood, and to leverage these findings to encourage positive predictors of physical activity. To the best of our knowledge, no one has previously investigated the influence of personal, environmental, and participation factors on childhood physical activity trajectories over time. Identifying factors that are associated with physical activity trajectories using group-based trajectory modeling could inform interventions and public health policies and programs to improve physical activity throughout childhood, leading to positive impacts on health outcomes.

The purpose of this study was to investigate personal, environmental, and/or participation factors predicting children's physical activity trajectories from preschool through to the school years. Specifically, using data collected from children participating in a prospective cohort study, we assessed the influence of personal (sex, ethnicity), environmental (household income, parental total physical activity, and parental influence on physical activity), and participation (QoL, sleep, and amount of weekend outdoor physical activity) factors on trajectories of MVPA and total physical activity (TPA).

METHODS

This longitudinal observational analysis included participants that enrolled in the Health Outcomes and Physical activity in Preschoolers (HOPP) study (2010–2014) and continued into its follow-up study, the school-age kids health from early Investment in Physical activity (SKIP) study (2015–2019). The HOPP study followed a cohort of children, age 3 to 5 yr at enrollment, annually for 3 yr (timeframe 2010–2014), whereas the SKIP study continued the follow-up for an additional 3 yr (timeframe 2015–2019) (i.e., 6 timepoints total). Both studies were conducted at McMaster University, Hamilton, Ontario, Canada. The Hamilton integrated Research Ethics Board provided approval for the conduct of both studies. Parent or guardian informed consent was obtained for their child to participate in the studies. Children 7 yr and older provided assent to participate in the SKIP study. Participants were recruited into the HOPP study from the Southcentral Ontario region, using a community-based recruitment strategy. This strategy targeted government-funded centers for early childhood development, preschools, daycare centers, and local school boards. Children with a physical disability or diagnosed medical condition were ineligible for the study. Specific details pertaining to the rationale and design of the original HOPP study are reported elsewhere (25).

There were 418 children that enrolled in the HOPP study, and 279 (66.7%) of these children also enrolled in the SKIP study. Both studies collected parent-reported basic information on demographics, as well as information pertaining to physical activity and other health indicators (25). For the purpose of this analysis, variables pertaining to personal, environmental, and participation factors that were collected at baseline (time-stable) or available at all six timepoints (time-dependent) were included from 279 participants enrolled in both the HOPP and SKIP studies.

The World Health Organization's International Classification of Functioning, Disability and Health (ICF) framework is a unified and standard language for the description and understanding of health and health-related states (26). The ICF consists of categories that can measure health, which include: body functions and structures, activities and participation, environmental factors, and personal factors. Chapters within each category specify behaviors, traits, and/or factors at both the individual and population level. For the purpose of this study, the ICF framework was utilized to define personal, environmental, and participation factors that were associated with childhood physical activity.

Personal factors. Personal factors included the participant's biological sex (parent reported; male or female) and ethnicity. Due to lack of ethnic diversity in the sample, ethnicity was dichotomized into White or non-White. Non-White included Chinese, Aboriginal, African Canadian, Japanese, Arab, Korean, Latin American, South Asian, Southeast Asian, West Asian, and other ethnicities (including mixed ethnicities) self-identified by the parent or guardian. Both sex and ethnicity were considered time-stable variables as they were collected at a single timepoint only (baseline).

Environmental factors. Household income (CAD), parental total physical activity, and parental influence on physical activity were considered environmental factors. Parental physical activity was collected using the International Physical Activity Questionnaire (short-form) (27). Specific questions included number of days, and hours and minutes each day in a typical week spent in vigorous activities, moderate activities, walking, and sitting. Parent total activity was derived by adding the values for time spent in vigorous and moderate activities, and time spent walking, and reported as average minutes per day of activity (27). The International Physical Activity Questionnaire has been reported to have strong test-retest reliability (Spearman's rho 0.8) (28). Parental influence was quantified by asking parents the following question: "In a typical week, how often do you encourage your child to do energetic play?" Response options included never = 0; less than once = 1; 1–2 times = 2; 3–4 times = 3; 5–6 times = 4; and daily = 5. Environmental factors were considered time-dependent variables and collected at all six timepoints.

Participation factors. Participation factors included QoL, sleep, and amount of weekend outdoor physical activity. These variables were considered time-dependent and collected at all six timepoints. Parent-reported QoL was assessed using the Pediatric Quality of Life Inventory (29); this validated instrument includes a 23-item self-report questionnaire with four sub-scales (physical, emotional, social and school functioning). Each response item was measured on a five-point Likert scale with responses ranging from 0 to 4. Items were totaled, reverse-scored (where appropriate) and transformed to a 0 to 100 scale with higher scores indicating higher child QoL.

Total scale score for parent proxy report has been demonstrated to achieve a Cronbach alpha reliability coefficient of 0.90, and in the present study was found to be 0.89, making the total scale score appropriate for individual participant analysis and group comparisons (29). Sleep was derived as parent-reported average hours per night that the child spent sleeping on weekdays and weekends. Weekend outdoor physical activity was quantified by asking the parent/guardian: "On a typical weekend day, how much time does your child spend actively playing outdoors?" A single response option was reported that ranged from no outdoor activity on a weekend to more than 2 $h \cdot d^{-1}$.

Physical activity. Physical activity was measured using an Actigraph accelerometer worn on the right hip during all waking hours for 7 d, except for water activities. Parents or children recorded when the accelerometer was put on and removed in a logbook. Accelerometer data were downloaded in 3-s epochs and analyzed with ActiLife software (Version 6.13.4, Actigraph, Pensacola, FL). Non–wear time, identified by at least 60 min of consecutive 0 counts or as indicated in the logbook, were removed. For the purpose of this study, physical activity was quantified as TPA (counts per minute) and MVPA. Counts per minute combined all movement from the vertical axis (y axis) while the device was worn and was a function of total counts divided by wear time. Moderate-to-vigorous physical activity was derived using validated cut-points by Evenson et al. (30): >574 counts per 15 s and expressed as minutes per day. Inclusion criteria for valid physical activity were a wear time of at least 3 d with a minimum of 10 $h \cdot d^{-1}$; days with less than 10 h were excluded (31). Predictive validity of the Actigraph accelerometer to estimate metabolic equivalents has been shown to range from 0.79 to 0.80 in children 5 to 9 yr of age (32).

Statistical analysis. All statistical analyses were performed in STATA (version 17.0). Descriptive statistics at timepoints one through six (age, yr) were calculated and presented as means and standard deviations for continuous variables, and as frequencies (i.e., percentages) for dichotomous and categorical variables. Group-based trajectory modeling was performed to determine relationships between personal, environmental, and participation factors and constructs of physical activity, using the TRAJ package in STATA (24). Firstly, to identify patterns of trajectories of MVPA and TPA, trajectories were estimated using the CNORM distribution for continuous data. Group-based trajectory modeling assumes there is a finite number of discrete groups in the population that each has their own prevalence, intercept and slope (33); in this instance, trajectory shape of MVPA and TPA. Each participant's MVPA and TPA at six timepoints (age, yr) were grouped within a pattern of conditional probabilities based on maximum likelihood statistics that assumes individuals differ as members of latent subgroups. The probability of belonging to each group was calculated for each individual and was estimated from model parameters, referred to as posterior probabilities (34). Individuals were assigned to the group to which they had the highest probability of belonging. The first step required determining the most appropriate number of groups and the shape of their trajectories. The relationships between MVPA and timepoint (age, yr) and TPA and

TABLE 1. Time-dependent variables.

	T1	T2	T3	T4	T5	T6
Variables						
Age, yr	4.5 (0.9) *n* = 279	5.5 (0.9) *n* = 279	6.5 (0.9) *n* = 276	8.7 (1.1) *n* = 278	9.8 (1.1) *n* = 256	10.7 (1.1) *n* = 249
Household income (CAD)						
Less than $45,000	22 (8.1%)	18 (6.7%)	15 (5.7%)	9 (3.3%)	14 (5.5%)	9 (3.7%)
$45,000–$74,999	30 (11.0%)	34 (12.6%)	36 (13.7%)	37 (13.4%)	23 (9.0%)	24 (9.9%)
$75,000–$124,999	103 (38.0%)	83 (30.7%)	80 (30.4%)	71 (25.6%)	63 (24.7%)	59 (24.3%)
>$125,000	116 (42.7%)	134 (49.8%)	132 (50.2%)	155 (56.8%)	151 (59.2%)	147 (60.5%)
Parental influence						
Encourage child						
Never	2 (0.7%)	1 (0.4%)	1 (0.4%)	3 (1.1%)	6 (2.3%)	4 (1.6%)
Less than once	3 (1.1%)	2 (0.7%)	4 (1.5%)	9 (3.3%)	8 (3.1%)	11 (4.5%)
1–2 times	19 (7.0%)	26 (9.6%)	24 (8.9%)	30 (11.0%)	27 (10.6%)	28 (11.5%)
3–4 times	54 (19.9%)	62 (22.9%)	52 (19.2%)	54 (19.8%)	48 (18.8%)	45 (18.4%)
5–6 times	41 (15.1%)	33 (12.2%)	43 (15.9%)	36 (13.2%)	38 (14.8%)	31 (12.7%)
Daily	153 (56.2%)	147 (54.2%)	145 (53.5%)	141 (51.7%)	129 (50.4%)	121 (49.6%)
Parent Tot. min·d^{-1}	140.4 (93.8) *n* = 273	145.2 (94.6) *n* = 268	140.7 (89.1) *n* = 269	141.2 (91.8) *n* = 277	152.5 (94.9) *n* = 258	139.7 (85.2) *n* = 245
QoL	87.6 (8.7) *n* = 274	86.9 (9.2) *n* = 275	85.8 (10.0) *n* = 271	82.9 (11.1) *n* = 277	83.3 (11.2) *n* = 256	83.2 (11.4) *n* = 245
Sleep/24 h	10.9 (1.1) *n* = 274	10.6 (0.9) *n* = 275	10.3 (0.8) *n* = 272	11.3 (24.1) *n* = 277	9.8 (0.7) *n* = 256	9.6 (0.9) *n* = 245
Wknd PA min·d^{-1}	85.4 (37.7) *n* = 276	86.7 (37.9) *n* = 275	83.9 (39.0) *n* = 272	91.0 (36.5) *n* = 276	88.8 (35.8) *n* = 255	81.7 (38.2) *n* = 245

Parent Tot. min·d^{-1}, parental total physical activity in minutes per day; QoL, quality of life; Wknd PA min·d^{-1}, weekend outdoor physical activity (child) in minutes per day.

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timepoint (age, yr) were fitted up to a cubic polynomial model for two, three, and four groups. The final number of groups was determined by comparing Bayesian Information Criteria (BIC) when two times the change in the BIC was equal to or greater than previously established criteria (-2ΔBIC). Additionally, posterior probabilities and odds of correct classification (OCC) were calculated to confirm the number of groups chosen. Posterior probabilities >0.7 and an OCC >5 suggested the trajectory included participants with similar patterns of change (34). Participants with incomplete data were included provided they had MVPA or TPA from at least two of the six timepoints.

Upon estimating trajectory groups for MVPA and TPA, the next step was to investigate the independent contributions of each of the measured personal, environmental, and participation factors to the trajectories. Time-stable explanatory variables were correlated to the trajectories via a generalized logit function, which were interpreted as the odds of being in a certain trajectory group relative to the reference group (34). Time-dependent explanatory variables were correlated with a change in MVPA or TPA of children in a particular trajectory group over time. Model building was performed in two steps. The first step required separate models for personal, environmental, and participation factors: 1) a model was estimated for time-stable variables separately (i.e., personal factors (sex and ethnicity); 2) a model was estimated for time-dependent environmental factors (i.e., household income, parental total activity min·d^{-1}, and parental influence); and 3) a model was estimated for time-dependent participation factors (i.e., QoL, sleep, and amount of weekend outdoor physical activity). The second step combined the three models together to investigate significant independent covariates. In these multivariable models, all analyses considered time-dependent and time-stable explanatory variables simultaneously. An alpha criterion of 0.05 was used to indicate statistical significance. Trajectories and 95% CI for each trajectory were plotted and included for visual representation.

TABLE 2. Determining number of groups for total participants.

	2 Groups	3 Groups	2 vs 3*	4 Groups	3 vs 4*
	BIC	BIC	2ΔBIC	BIC	2ΔBIC
MVPA	−6401.42	−6350.49	101.86	−6337.45	26.08
TPA	−9720.53	−9679.15	82.76	−9681.83	5.36

BIC, Bayesian information criterion.
*Comparison between groups; interpretation of 2ΔBIC = estimate of $2\log_e$.

RESULTS

The average total follow-up from baseline (timepoint 1) to timepoint 6 was 6.3 ± 0.6 yr, and average duration between timepoints was 1.3 ± 0.1 yr, for the 279 participants included in this study. One hundred thirty-five (48.4%) participants were female and 246 (88.2%) were White. Time-dependent participant variables for each of the six timepoints are presented in Table 1. According to the BIC tests, the 3-group model best fit both the MVPA and TPA data (Table 2).

The longitudinal trajectories for changes in MVPA are shown in Figure 1. Three distinct trajectories were identified.

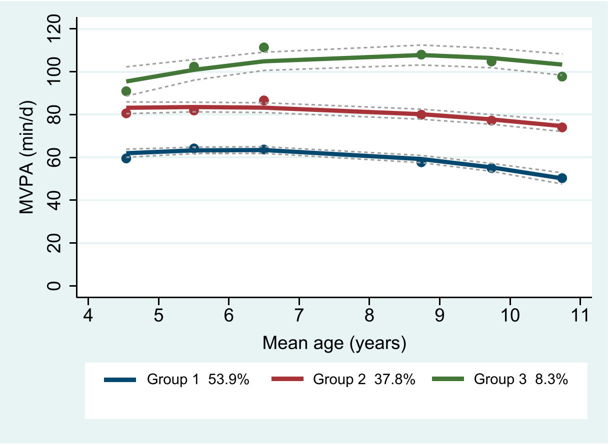

FIGURE 1—Longitudinal trajectories for changes in MVPA.

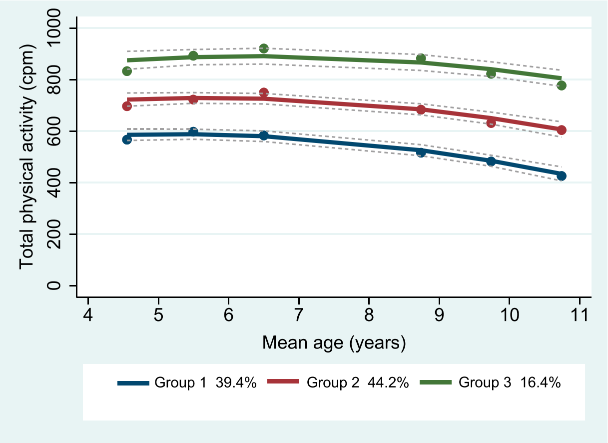

FIGURE 2—Longitudinal trajectories for changes in TPA.

Group 1 was comprised of 98 (64.1%) girls and 55 (35.9%) boys, where MVPA remained relatively consistent from timepoints (ages) 1 (4.5) to 3 (6.5), and then declined from timepoints (ages) 3 (6.5) to 6 (10.7). Group 2 consisted of 35 (33.7%) girls and 69 (66.3%) boys, and followed a similar trajectory as group 1, but with higher levels of MVPA at each timepoint (age) in comparison to group 1. Group 3 engaged in the most MVPA, and this trajectory increased from timepoints 1 (4.5) to 3 (6.5) but like other groups, declined from timepoint 4 (8.7) to 6 (10.7); this group comprised only 2 (9.1%) girls and 20 (90.9%) boys. Descriptive information describing MVPA trajectory groups is presented in Supplemental Table 1 (see Supplemental Digital Content, Mean ± SD for MVPA trajectories, http://links.lww.com/MSS/C810).

The longitudinal trajectories for changes in TPA are shown in Figure 2. Three distinct trajectories were identified. Group 1 was comprised of 70 (62.5%) girls and 42 (37.5%) boys and increased from timepoint 1 to 2 and declined from timepoint 2 to 6. Group 2 consisted of 52 (42.6%) girls and 70 (57.4%) boys with activity levels above group 1, that increased from timepoints (ages) 1 (4.5) to 3 (6.5), and declined from timepoints (ages) 3 (6.5) to 6 (10.7). Group 3 was the most active of the three groups, with an increase in TPA from timepoint 1 to 3 and then a decline from timepoints 3 (6.5) to 6 (10.7), comprised of 13 (28.9%) girls and 32 (71.1%) boys. Descriptive information describing TPA trajectory groups is presented in Supplemental Table 2 (see Supplemental Digital Content, Mean ± SD for TPA trajectories, http://links.lww.com/MSS/C810).

Descriptive characteristics for all factors and all years for MVPA (Supplemental Tables 3A, 3B, 3C; see Supplemental Digital Content, Personal, environmental, and participation factors for MVPA Trajectory Groups, http://links.lww.com/MSS/C810) and TPA (Supplemental Tables 4A, 4B, 4C; Supplemental Digital Content, Personal, environmental, and participation factors for TPA Trajectory Groups, http://links.lww.com/MSS/C810) are summarized in Supplemental Material. Multivariable analyses examining associations between personal, environmental, and participation factors are reported in Tables 3, 4, and 5, respectively. Notably, for both MVPA and TPA male sex significantly increased the probability of membership in group 2 (log-odds estimate: 1.519, $P < 0.001$ MVPA; log-odds estimate: 1.214, $P < 0.001$ TPA) and group 3 (log-odds estimate: 3.086, $P < 0.001$ MVPA; log-odds estimate: 1.796, $P < 0.001$ TPA) (Table 3). Being non-White decreased the probability of membership in group 2 trajectory for TPA (log-odds estimate: −0.013, $P = 0.031$). Regarding environmental time-dependent covariates, higher income increased the probability of membership in group 3 for MVPA (β estimate, 4.148; $P = 0.049$), independent of parental influence on physical activity and parental physical activity (Table 4). For TPA, more parental influence increased the probability of membership in group 2 (β estimate: 15.346, $P = 0.008$), independent of income and parental physical activity (Table 4). Regarding participation time-dependent covariates, higher QoL (group 1 β estimate: 0.207, $P = 0.006$; group 2 β estimate: 0.163, $P = 0.003$; group 3 β estimate: 0.608, $P < 0.001$) and more weekend outdoor physical activity (group 1 β estimate: 0.058, $P = 0.024$; group 2 B estimate: 0.064, $P < 0.001$; group 3 β estimate: 0.112, $P = 0.005$) increased the probability of membership in all three groups for MVPA, independent of sleep (Table 5). Likewise, similar associations were observed for membership in groups 1 and 2 for TPA (QoL: group 1 β estimate: 1.393, $P = 0.005$; group 2 β estimate: 3.894, $P < 0.001$; weekend outdoor physical activity: group 1 β estimate: 0.721, $P < 0.001$; group 2 β estimate: 0.452, $P = 0.010$), independent of sleep. However, only more weekend outdoor physical activity increased the probability of group 3 membership (β estimate 2.016, $P = 0.007$), independent of sleep and QoL (Table 5).

When combining the three models for MVPA and TPA, QoL and weekend outdoor physical activity both increased the probability of group 1 membership in MVPA and TPA trajectories, independent of other environmental and participation factors (Table 6). For group 2 membership in both MVPA

TABLE 3. Multivariable regression analysis: personal factors.

	Group 1		Group 2		Group 3	
	Coefficient Estimate	***P***	**Coefficient Estimate**	***P***	**Coefficient Estimate**	***P***
MVPA						
Sex (male)	Constant		1.519	<0.001	3.086	<0.001
Ethnicity	Constant		−0.080	0.156	0.033	0.605
TPA						
Sex (male)	Constant		1.214	<0.001	1.796	<0.001
Ethnicity	Constant		−0.0130	0.031	−0.063	0.291

Note: Ethnicity, non-White.

TABLE 4. Multivariable regression analysis: environmental factors.

	Group 1		Group 2		Group 3	
	Coefficient Estimate	*P*	Coefficient Estimate	*P*	Coefficient Estimate	*P*
MVPA						
Income	0.001	0.985	0.060	0.638	4.148	0.049
P. influence	0.009	0.949	0.041	0.780	−0.121	0.460
Tot. min·d^{-1}	0.009	0.108	0.003	0.667	0.031	0.204
TPA						
Income	0.414	0.429	0.262	0.764	23.811	0.059
P. influence	0.166	0.898	15.346	0.008	0.124	0.900
Tot. min·d^{-1}	0.082	0.206	0.038	0.549	0.090	0.490

P. Influence, parental influence; Tot. min·d^{-1}, parental physical activity.

and TPA trajectories, male sex, QoL, and weekend outdoor physical activity increased the probability of belonging to this group, independent of other personal, environmental, and participation factors (Table 6). For group 3 membership in MVPA trajectories, male sex and QoL were the only significant correlates. For TPA group 3 membership, male sex, greater household income, and parental total physical activity increased the probability of belonging to this group (Table 6).

DISCUSSION

This longitudinal analysis investigated personal, environmental, and participation factors associated with trajectories of physical activity in children across the early and school-age years. We observed that nearly 54% of children in this sample followed a trajectory where MVPA began to steadily decline after ~ age 5 yr, with these children engaging in less than the recommended average of 60 min of MVPA per day from timepoint 4 (~ 8.5 yr) onward. Children in this trajectory (group 1) were more likely to be female. Only 8% of children followed the highest trajectory (group 3) of MVPA and these children increased their MVPA until ~ age 8.5 yr and engaged in at least 90 min of MVPA per day on average across all six timepoints. Children in this trajectory were more likely to be male and have higher QoL scores, independent of other personal, environmental, and participation factors. Likewise, 16% of children were in the highest trajectory for TPA, and these children were also more likely to be male, from families with greater household income, and with parents/guardians who engaged in more physical activity. These findings underscore the importance of children's QoL and parental behaviors on achieving physical activity recommendations throughout childhood, and highlight a need to place greater emphasis on physical activity promotions for girls starting in the early years and families with lower household income (35).

This study presents the first empirical evidence of personal, environmental, and participation factors associated with group-based physical activity trajectories throughout the childhood years. Our dataset and trajectories include physical activity and time-dependent variables collected at 6 different timepoints over 6.3 yr, more than double the median measurement period of 2.5 yr reported in a previous systematic review (19). Thus, affording an opportunity to investigate important variables associated with physical activity during a range of average childhood years (~ 4.5–10.7 yr) that could be targeted in future interventions.

Regarding environmental factors, our findings complement previous research that found maternal role modeling to be positively associated with changes in physical activity in children up to age 6 yr (19), but extend previous findings by observing an association between parental physical activity and TPA into late childhood (average age, 10.7 yr). This could be particularly important during the COVID-19 pandemic, when access to organized sport and other community activities for children have been limited or sporadic. Recent research found that parental engagement in physical activity was positively associated with healthy movement behaviors, including physical activity, in children and youth during the COVID-19 pandemic (36). Participants in this study had parents who engaged in an average of at least 140 min·d^{-1} of total physical activity. This is substantially higher than a sample of Canadian adults (mean age, 47 yr) that reported an average of 91.4 min·d^{-1} of total activity (37). Nonetheless, our findings identify the importance of parental physical activity on children's TPA independent of parental encouragement for physical activity, supporting the importance of positive parental role modeling on physical activity (20). In addition, higher household income was associated with belonging to the highest TPA trajectory in our study. This aligns with previous research from Cairney and colleagues, who found that children in high-income

TABLE 5. Multivariable regression analysis: participation factors.

	Group 1		Group 2		Group 3	
	Coefficient Estimate	*P*	Coefficient Estimate	*P*	Coefficient Estimate	*P*
MVPA						
QoL	0.207	0.006	0.163	0.003	0.608	<0.001
Sleep/24 h	0.722	0.439	0.212	0.741	3.305	0.120
Wknd PA	0.058	0.024	0.064	<0.001	0.112	0.005
TPA						
QoL	1.393	0.005	3.894	<0.001	0.501	0.876
Sleep/24 h	5.339	0.356	9.491	0.210	53.055	0.223
Wknd PA	0.721	<0.001	0.452	0.010	2.016	0.007

TABLE 6. Multivariable regression analysis: personal, environmental, and participation factors.

	Group 1		Group 2		Group 3	
	Coefficient Estimate	*P*	Coefficient Estimate	*P*	Coefficient Estimate	*P*
MVPA						
Sex (male)	Constant		1.464	<0.001	3.437	0.001
Ethnicity	Constant		−0.060	0.300	0.053	0.408
Income	0.023	0.647	0.103	0.390	3.351	0.124
P. Influence	−0.041	0.771	0.050	0.727	−0.126	0.442
Tot. min·d^{-1}	0.004	0.545	0.005	0.542	0.044	0.086
QoL	0.142	0.017	0.193	0.015	0.513	<0.001
Sleep/24 h	0.308	0.649	0.962	0.298	2.040	0.358
Wknd PA	0.062	<0.001	0.070	0.005	0.082	0.067
TPA						
Sex (male)	Constant		1.166	<0.001	1.970	0.035
Ethnicity	Constant		−0.072	0.144	−0.042	0.692
Income	0.235	0.577	1.052	0.315	94.615	<0.001
P. Influence	−0.253	0.841	0.283	0.766	23.654	0.189
Tot. min·d^{-1}	0.029	0.580	−0.028	0.680	0.574	0.023
QoL	1.352	0.006	4.302	<0.001	−0.416	0.867
Sleep/24 h	3.775	0.506	4.040	0.598	54.828	0.077
Wknd PA	0.717	<0.001	0.408	0.023	0.457	0.445

neighborhoods have increased rates of participation in organized sport and physical activity compared with children from lower income neighborhoods (38). Together, these findings support the need for interventions to address inequities in opportunities for physical activity in childhood.

Consistent with previous research (14), we observed a disparity between boys and girls for physical activity. Male sex was a significant positive correlate of membership in the highest trajectories for both MVPA and TPA, independent of other personal, environmental, and participation factors. This suggests a need for targeted interventions, programs and policies directed at girls to improve physical activity behavior throughout the childhood years. Interestingly, parent-reported QoL was a strong positive predictor of group membership in the highest physical activity trajectories. Our findings support those from a systematic review suggesting that higher levels of physical activity were associated with higher health-related QoL scores (39), but extend this association across a range of childhood years. As parent-reported QoL is multidimensional, including physical, emotional, social, and school functioning, school- and community-based programs and interventions to increase physical activity and QoL in and throughout childhood are warranted. In Canada and the United States, national programs have been implemented in communities and schools to increase physical activity engagement (40,41). The findings from this study should complement such programs, with a focus on promoting QoL in parallel to physical activity.

Limitations. This study has notable limitations. Environmental and participation factors included parental-reported responses, which may be susceptible to response bias (42). In addition, participants in this study were predominantly White and the majority were from affluent households (i.e., household income >$125,000 CAD per year) with physically active parents. Accelerometry cut-points developed for children ages 5 to 15 yr were used across the entire sample to quantify MVPA (43); this was to ensure consistency rather than applying different cut-points for preschool and school-age children (43). Unfortunately, due to limited sample size and power, we were unable to develop and predict separate trajectories for males and females. Finally, group-based trajectory modeling utilizes latent- or estimated-methods to assign group membership. It is not definitive that all children will follow the same trajectory groups that were estimated in our analysis (34). Finally, the high physical activity groups (both MVPA and TPA) were relatively small proportions of the study sample; thus future research with a larger sample size is desired. However, the clinical utility and interpretability of reporting distinct (group) physical activity trajectories, and factors that identify belonging to these trajectories, should be considered as strengths of this approach, compared with other longitudinal analytical approaches that require more complex interpretation. Notwithstanding these limitations, the strength of this study was the ability to associate different personal, environmental, and participation factors, grounded in the ICF framework, with objective measures of physical activity across 6 yr.

CONCLUSIONS

In conclusion, we found that male sex and higher QoL scores, and male sex, greater household income (CAD), and parents/guardians who in engaged in more physical activity, were associated with consistently high MVPA and TPA, respectively, across early and middle childhood. This is the first study to investigate how different personal, environmental, and participation factors were predictive of physical activity trajectories in early to middle childhood. These findings suggest a need for interventions to address inequities in physical activity engagement in childhood, while also targeting disparities in girls. Future work should understand how trajectory membership is associated with other behaviors and health outcomes, including sedentary behavior and cardiovascular health.

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