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

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ABSTRACT

Introduction/Purpose: To determine personal, environmental, and participation factors that predict children's physical activity (PA) trajectories from preschool through to school years. **Methods:** 279 children (4.5 ± 0.9 years old, 52% boys) were included in this study. PA was collected via accelerometry at 6 different timepoints over 6.3 ± 0.6 years. Time stable variables were collected at baseline and included child's sex and ethnicity. Time dependent variables were collected at 6 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 modelling 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 modelling, and improving quality of life are also warranted.

Key Words: PHYSICAL ACTIVITY, CHILD, LONGITUDINAL, ACCELEROMETER

INTRODUCTION

Physical activity in childhood has positive implications for an array of physical and mental health factors (1, 2). For preschoolers 3-4 years old, recommendations encourage at least 60 minutes of energetic play and a total of at least 180 minutes in a variety of physical activities per day (3). For children 5 years of age and older, the recommended amount of physical activity includes at least an average of 60 min per day 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 since 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 five years old, with declines occurring into adolescence (9). Therefore, a trajectory of diminished physical activity in childhood could be a contributing factor towards 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 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 to 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). Additionally, 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 six, 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 aged 10.6 ± 0.5 years old (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 non-representative samples and use of subjective outcome measures (19). Additionally, 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 aged two to six years old at baseline found that maternal physical activity was positively associated with child physical activity over five years (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 amongst individuals following similar behaviour 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, aged three to five years old at enrollment, annually for three years (timeframe 2010-2014), while the SKIP study continued the follow-up for an additional three years (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 years of age and older provided assent to participate in the SKIP study. Participants were recruited into the HOPP study from the south-central Ontario region, using a community-based recruitment strategy. This strategy targeted government-funded centres for early childhood development, preschools, daycare centres, 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 behaviours, 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 Caucasian or non-Caucasian. Non-Caucasian 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 IPAQ 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 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 (PedsQL) (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 5-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 hours a day.

Physical activity

Physical activity was measured using an Actigraph accelerometer worn on the right hip during all waking hours for 7 days, 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-sec epochs and analyzed with ActiLife software (Version 6.13.4, Actigraph, Pensacola, FL). Non-wear time, identified by at least 60 minutes 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 [CPM]) and MVPA. CPM 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. MVPA was derived using validated cut-points by Evenson et al. (30): >574 counts / 15-sec and expressed as minutes per day. Inclusion criteria for valid physical activity were a wear time of at least 3 days with a minimum of 10 hours per day; days with less than 10 hours were excluded (31). Predictive validity of the Actigraph accelerometer to estimate metabolic equivalents has been shown to range from 0.79 – 0.80 in children 5-9 years of age (32).

Statistical analysis

All statistical analyses were performed in STATA (version 17.0). Descriptive statistics at timepoints one through six (age, years) 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, years) 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, years) and TPA and timepoint (age, years) were fitted up to a cubic polynomial model for 2, 3 and 4 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/day, 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% CIs for each trajectory were plotted and included for visual representation.

RESULTS

The average total follow-up from baseline (timepoint 1) to timepoint 6 was 6.3 ± 0.6 years, and average duration between timepoints was 1.3 ± 0.1 years, for the 279 participants included in this study. One hundred and thirty-five (48.4%) participants were female and 246 (88.2%) were Caucasian. 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. 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-Caucasian 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 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 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 years, with these children engaging in less than the recommended average of 60 mins of MVPA per day from timepoint 4 (~ 8.5 years) 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 years and engaged in at least 90 mins of MVPA per day on average across all 6 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 behaviours 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 years, more than double the median measurement period of 2.5 years 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 years) 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 years old (19), but extend previous findings by observing an association between parental physical activity and TPA into late childhood (average age 10.7 years old). 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 behaviours, 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 mins/day of total physical activity. This is substantially higher than a sample of Canadian adults (mean age 47 years) that reported an average of 91.4 mins/day 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). Additionally, 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 neighbourhoods have increased rates of participation in organized sport and physical activity compared to children from lower income neighbourhoods (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 behaviour 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 U.S., 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 quality of life 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). Additionally, participants in this study were predominantly Caucasian 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 years old 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-aged 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 modelling 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 to other longitudinal analytical approaches that require more complex interpretation. Notwithstanding these limitations, a 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 years.

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 behaviours and health outcomes, including sedentary behaviour and cardiovascular health.

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FIGURE LEGENDS

Figure 1. Longitudinal trajectories for changes in MVPA

Figure 2. Longitudinal trajectories for changes in TPA

SUPPLEMENTAL DIGITAL CONTENT

SDC 1: SupplementaryTables_1-4.docx

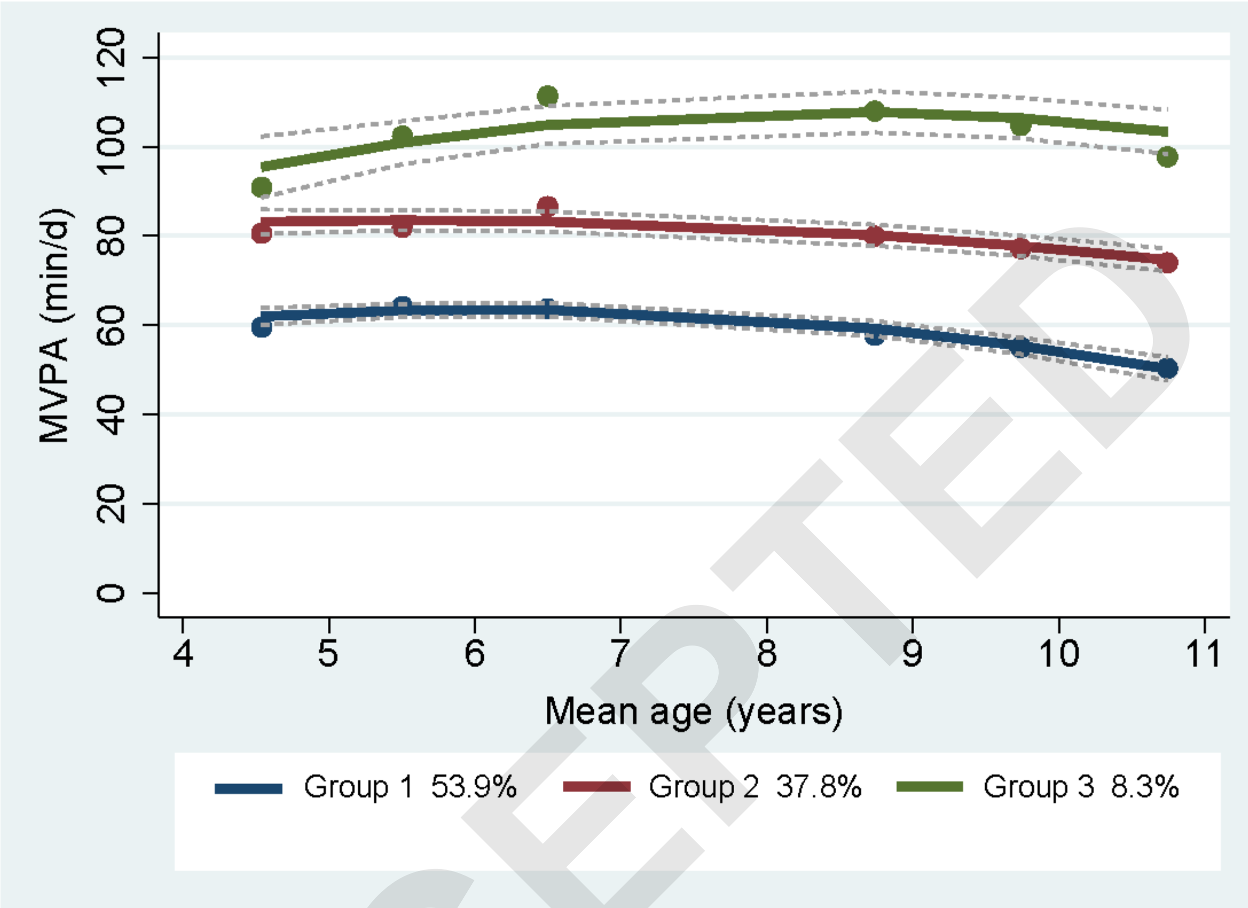
Table S1 - Mean ± SD for MVPA trajectories

Table S2 – Mean ± SD for TPA trajectories

Tables S3A, B, C Personal, environmental, and participation factors for MVPA Trajectory Groups 1-3

Table S4A, B, C - Personal, environmental, and participation factors for TPA Trajectory Groups 1-3

Figure 1



MVPA (min/d)
0
20
40
60
80
100
120
4
5
6
7
8
9
10
11
Mean age (years)
Group 1 53.9%
Group 2 37.8%
Group 3 8.3%

Figure 2

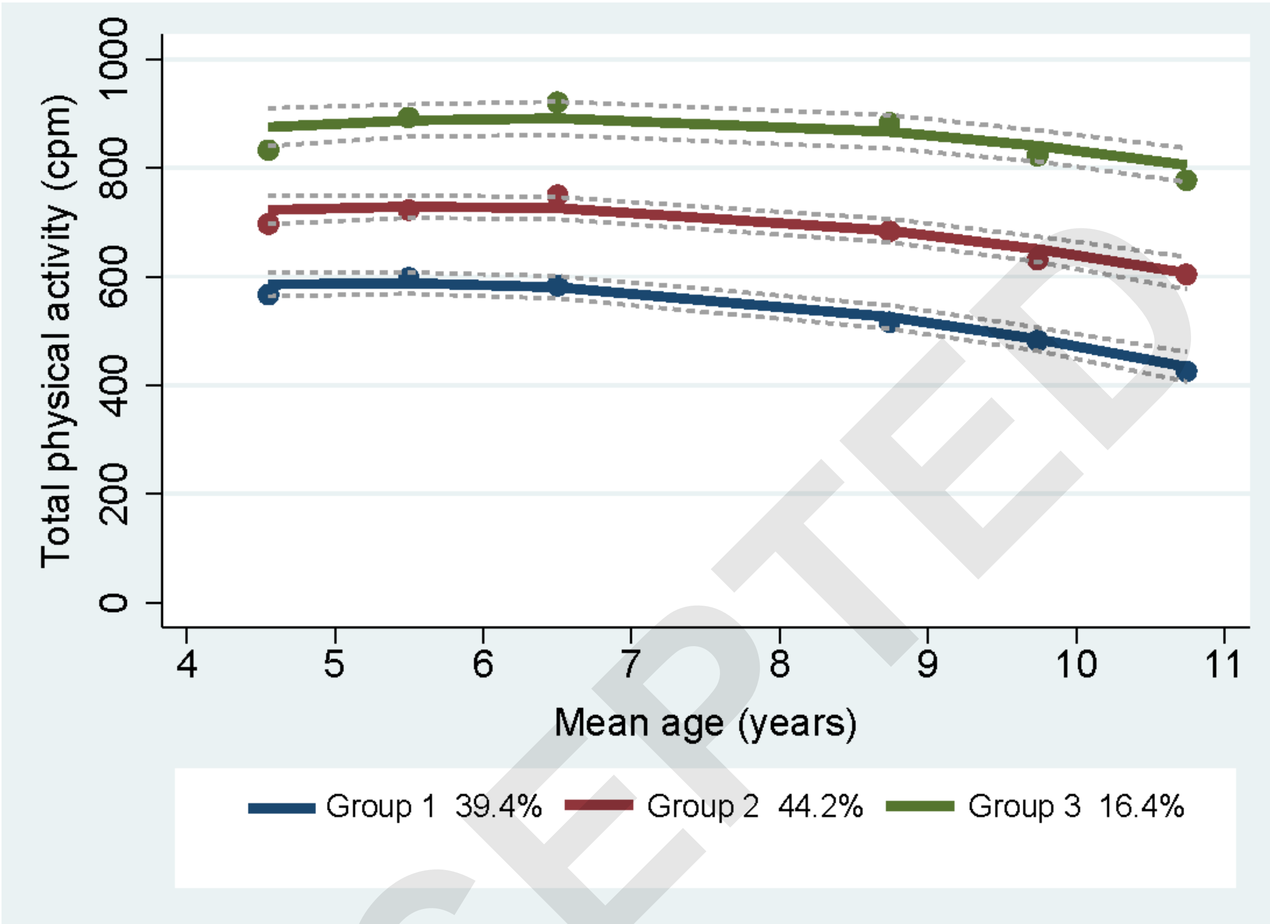

Total physical activity (cpm)
0
200
400
600
800
1000
4
5
6
7
8
9
10
11
Mean age (years)
Group 1 39.4%
Group 2 44.2%
Group 3 16.4%

Table 1. Time dependent variables

Variable	T1	T2	T3	T4	T5	T6
Age, years	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 $45K	22 (8.1%)	18 (6.7%)	15 (5.7%)	9 (3.3%)	14 (5.5%)	9 (3.7%)
$45K - $74999	30 (11.0%)	34 (12.6%)	36 (13.7%)	37 (13.4%)	23 (9.0%)	24 (9.9%)
$75K - $124999	103 (38.0%)	83 (30.7%)	80 (30.4%)	71 (25.6%)	63 (24.7%)	59 (24.3%)
>$125K	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/day	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 / 24hrs	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/day	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/day = parental total physical activity in minutes per day;
QoL = quality of life;
Wknd PA min/day = weekend physical activity (child) in minutes per day

Table 2. Determining number of groups for total participants

	2 groups BIC	3 groups BIC	2 vs. 3* 2ΔBIC	4 groups BIC	3 vs. 4* 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 $2\log_e$

Table 3. Multivariable regression analysis: personal factors

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

Note: Ethnicity = non-caucasian

Table 4. Multivariable regression analysis: environmental factors

MVPA	Group 1 Coefficient estimate	*p* value	Group 2 Coefficient estimate	*p* value	Group 3 Coefficient estimate	*p* value
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/day	0.009	0.108	0.003	0.667	0.031	0.204
TPA	Group 1 Coefficient estimate	*p* value	Group 2 Coefficient estimate	*p* value	Group 3 Coefficient estimate	*p* value
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/day	0.082	0.206	0.038	0.549	0.090	0.490

Note: P. Influence = parental influence; Tot. min/day = parental physical activity

Table 5. Multivariable regression analysis: participation factors

MVPA	Group 1 Coefficient estimate	*p* value	Group 2 Coefficient estimate	*p* value	Group 3 Coefficient estimate	*p* value
QoL	0.207	0.006	0.163	0.003	0.608	<0.001
Sleep / 24hrs	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	Group 1 Coefficient estimate	*p* value	Group 2 Coefficient estimate	*p* value	Group 3 Coefficient estimate	*p* value
QoL	1.393	0.005	3.894	<0.001	0.501	0.876
Sleep / 24hrs	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

Note: QoL = child's quality of life; Wknd PA = weekend physical activity

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

MVPA	Group 1		Group 2		Group 3	
	Coefficient estimate	*p* value	Coefficient estimate	*p* value	Coefficient estimate	*p* value
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/day	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 / 24hrs	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	Group 1		Group 2		Group 3	
	Coefficient estimate	*p* value	Coefficient estimate	*p* value	Coefficient estimate	*p* value
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/day	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 / 24hrs	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

Note: Ethnicity = non-caucasian; P. Influence = parental influence; Tot. min/day = parental physical activity; QoL = child's quality of life; Wknd PA = weekend physical activity

Supplementary Material

Table 1. Mean ± SD for MVPA trajectories

MVPA	Group 1	Group 2	Group 3
Timepoint 1	59.3 (11.9), n=130	81.0 (15.6), n=95	92.2 (15.6), n=20
Timepoint 2	64.2 (12.7), n=141	82.2 (15.0), n=100	103.7 (13.1), n=19
Timepoint 3	63.6 (13.7), n=142	87.3 (16.1), n=98	112.0 (16.1), n=21
Timepoint 4	57.8 (14.8), n=146	80.1 (14.4), n=99	108.9 (16.5), n=19
Timepoint 5	54.7 (13.0), n=127	77.6 (14.5), n=96	106.1 (17.1), n=20
Timepoint 6	50.5 (13.8), n=131	74.6 (16.2), n=90	95.5 (17.2), n=16

Table 2. Mean ± SD for TPA trajectories

TPA	Group 1	Group 2	Group 3
Timepoint 1	565.9 (103.1), n=101	698.3 (118.7), n=107	838.5 (122.2), n=43
Timepoint 2	594.4 (108.1), n=105	727.7 (107.7), n=116	893.7 (150.1), n=42
Timepoint 3	579.3 (111.1), n=104	755.0 (134.9), n=116	924.5 (188.2), n=43
Timepoint 4	505.8 (118.1), n=107	691.4 (133.6), n=115	888.1 (166.6), n=41
Timepoint 5	478.1 (102.9), n=93	634.2 (121.4), n=108	821.6 (185.3), n=42
Timepoint 6	425.7 (101.6), n=97	606.5 (130.0), n=104	778.9 (161.0), n=35

Table 3A. MVPA Trajectory Group 1 (n=153): Personal, environmental, and participation factors

Variable	T1	T2	T3	T4	T5	T6
Sex (male), n	55 (35.9%)	--	--	--	--	--
Ethnicity (Caucasian), n	133 (86.9%)	--	--	--	--	--
Household Income, n						
Less than $45K	13	11	9	5	9	6
$45K - $74999	18	22	22	24	16	14
$75K - $124999	67	52	53	48	39	35
>$125K	49	63	60	71	69	72
Parental Influence, n						
Encourage child						
Never	1	1	1	2	2	4
Less than once	1	1	1	8	6	7
1-2 times	14	15	15	22	19	15
3-4 times	35	39	35	28	32	32
5-6 times	22	12	22	22	18	17
Daily	78	82	73	69	61	55
Parent Tot. min/day	137.1 (94.6) n=153	148.2 (97.0) n=150	131.0 (88.6) n=148	128.4 (88.3) n=152	147.8 (89.0) n=138	128.6 (87.1) n=131
QoL	87.0 (8.9) n=151	85.8 (9.9) n=151	85.0 (10.2) n=148	82.0 (11.8) n=152	81.9 (11.6) n=138	82.6 (11.4) n=131
Sleep / 24hrs	10.9 (1.1) n=152	10.6 (1.0) n=151	10.2 (0.8) n=149	10.0 (0.9) n=152	9.9 (0.7) n=138	9.6 (0.9) n=131
Wknd PA min/day	82.7 (38.4) n=153	82.0 (38.7) n=151	79.2 (39.4) n=149	82.5 (39.1) n=151	80.5 (38.0) n=138	71.5 (38.4) n=131

Table 3B. MVPA Trajectory Group 2 (n=104): Personal, environmental, and participation factors

Variable	T1	T2	T3	T4	T5	T6
Sex (male), n	69 (66.3%)	--	--	--	--	--
Ethnicity (Caucasian), n	95 (91.3%)	--	--	--	--	--
Household Income, n						
Less than $45K	7	6	5	4	5	2
$45K - $74999	12	11	13	11	6	10
$75K - $124999	30	22	22	20	20	21
>$125K	54	61	57	67	66	61
Parental Influence, n						
Encourage child						
Never	1	0	0	0	2	0
Less than once	1	1	1	0	1	2
1-2 times	5	8	6	7	6	11
3-4 times	16	21	16	23	13	11
5-6 times	17	17	19	11	17	11
Daily	59	53	58	59	58	57
Parent Tot. min/day	149.6 (98.1) n=98	140.3 (94.4) n=98	153.3 (90.1) n=99	159.4 (100.0) n=103	163.7 (108.4) n=99	159.1 (82.2) n=95
QoL	87.8 (8.8) n=101	87.9 (8.3) n=102	86.0 (10.1) n=101	83.6 (10.3) n=103	84.5 (10.5) n=97	83.4 (11.6) n=95
Sleep / 24hrs	10.9 (1.0) n=100	10.6 (0.8) n=102	10.3 (0.7) n=101	9.7 (0.8) n=103	9.8 (0.7) n=97	9.6 (1.0) n=95
Wknd PA min/day	90.0 (36.9) n=101	91.5 (36.0) n=102	90.2 (37.9) n=101	100.6 (29.9) n=103	96.0 (31.5) n=96	92.5 (33.8) n=95

Table 3C. MVPA Trajectory Group 3 (n=22): Personal, environmental, and participation factors

Variable	T1	T2	T3	T4	T5	T6
Sex (male), n	20 (90.9%)	--	--	--	--	--
Ethnicity (Caucasian), n	19 (86.4%)	--	--	--	--	--
Household Income, n						
Less than $45K	2	1	1	0	0	1
$45K - $74999	0	1	1	2	1	0
$75K - $124999	6	9	5	3	4	3
>$125K	13	10	15	17	16	14
Parental Influence, n						
Encourage child						
Never	0	0	0	1	2	0
Less than once	1	0	2	1	1	2
1-2 times	0	3	3	1	2	2
3-4 times	3	2	1	3	3	2
5-6 times	2	4	2	3	3	3
Daily	16	12	14	13	10	9
Parent Tot. min/day	122.3 (62.6) n=22	146.3 (80.0) n=20	149.1 (83.5) n=22	144.8 (58.1) n=22	130.2 (49.7) n=21	119.5 (70.4) n=19
QoL	91.3 (5.3) n=22	89.1 (7.1) n=22	90.1 (7.0) n=22	85.9 (9.2) n=22	87.2 (10.8) n=21	85.8 (10.5) n=19
Sleep / 24hrs	10.7 (0.9) n=22	10.4 (0.7) n=22	10.1 (0.8) n=22	9.6 (0.8) n=22	9.5 (0.7) n=21	9.4 (0.6) n=19
Wknd PA min/day	82.7 (36.2) n=22	96.8 (38.1) n=22	87.3 (39.2) n=22	104.5 (31.6) n=22	110.7 (21.5) n=21	98.4 (38.3) n=19

Table 4A. TPA Trajectory Group 1 (n=112): Personal, environmental, and participation factors

Variable	T1	T2	T3	T4	T5	T6
Sex (male), n	42 (37.5%)	--	--	--	--	--
Ethnicity (Caucasian), n	92 (82.1%)	--	--	--	--	--
Household Income, n						
Less than $45K	13	10	9	4	7	4
$45K - $74999	16	14	14	18	11	11
$75K - $124999	47	41	40	34	29	26
>$125K	31	44	41	52	49	51
Parental Influence, n						
Encourage child						
Never	1	1	1	1	1	3
Less than once	1	1	1	7	6	6
1-2 times	12	11	16	19	18	13
3-4 times	27	31	28	23	23	25
5-6 times	17	7	15	16	11	13
Daily	52	58	47	45	41	34
Parent Tot. min/day	126.7 (94.2) n=112	141.7 (99.4) n=111	120.6 (89.4) n=109	124.1 (92.8) n=112	140.6 (94.1) n=101	133.1 (91.8) n=95
QoL	86.2 (9.4) n=110	84.8 (10.7) n=110	84.2 (11.3) n=108	81.1 (12.7) n=112	81.6 (11.6) n=100	82.0 (11.8) n=95
Sleep / 24hrs	10.9 (1.1) n=111	10.5 (1.0) n=111	10.2 (0.8) n=109	9.9 (0.9) n=112	9.8 (0.7) n=100	9.5 (0.9) n=95
Wknd PA min/day	77.6 (38.1) n=112	75.4 (38.2) n=111	75.5 (40.0) n=109	77.2 (40.9) n=111	74.6 (38.7) n=100	68.1 (38.2) n=95

Table 4B. TPA Trajectory Group 2 (n=122): Personal, environmental, and participation factors

Variable	T1	T2	T3	T4	T5	T6
Sex (male), n	70 (57.3%)	--	--	--	--	--
Ethnicity (Caucasian), n	115 (94.3%)	--	--	--	--	--
Household Income, n						
Less than $45K	6	6	3	4	6	4
$45K - $74999	13	17	21	16	10	10
$75K - $124999	42	29	32	32	27	28
>$125K	60	64	62	68	71	65
Parental Influence, n						
Encourage child						
Never	0	0	0	1	3	1
Less than once	1	0	0	1	0	2
1-2 times	7	11	4	9	6	9
3-4 times	19	25	21	22	15	16
5-6 times	19	15	19	15	22	12
Daily	73	67	74	71	69	68
Parent Tot. min/day	156.8 (96.8) n=118	147.6 (94.3) n=115	159.1 (90.2) n=117	153.8 (95.1) n=121	166.5 (102.2) n=115	145.6 (81.0) n=109
QoL	87.5 (8.1) n=120	87.6 (8.0) n=120	85.9 (9.1) n=120	83.2 (9.9) n=121	83.4 (11.0) n=115	82.7 (11.5) n=109
Sleep / 24hrs	10.9 (1.0) n=119	10.7 (0.9) n=119	10.3 (0.8) n=120	9.8 (0.7) n=121	9.8 (0.7) n=115	9.6 (1.0) n=109
Wknd PA min/day	91.7 (36.9) n=120	92.4 (36.0) n=119	88.5 (37.4) n=120	99.5 (29.3) n=121	96.2 (30.5) n=115	89.4 (34.4) n=109

Table 4C. TPA Trajectory Group 3 (n=45): Personal, environmental, and participation factors

Variable	T1	T2	T3	T4	T5	T6
Sex (male), n	20 (71.1%)	--	--	--	--	--
Ethnicity (Caucasian), n	40 (88.9%)	--	--	--	--	--
Household Income, n						
Less than $45K	3	2	3	1	1	1
$45K - $74999	1	3	1	3	2	3
$75K - $124999	14	13	8	5	7	5
>$125K	25	26	29	35	31	31
Parental Influence, n						
Encourage child						
Never	1	0	0	1	2	0
Less than once	1	1	3	1	2	3
1-2 times	0	4	4	2	3	6
3-4 times	8	6	3	9	10	4
5-6 times	5	11	9	5	5	6
Daily	28	22	24	25	19	19
Parent Tot. min/day	131.2 (77.8) n=43	147.7 (83.7) n=42	141.7 (75.0) n=43	150.3 (72.8) n=44	142.5 (69.2) n=42	139.6 (80.8) n=41
QoL	91.5 (6.8) n=44	90.0 (6.9) n=45	89.5 (7.8) n=43	86.7 (8.7) n=44	87.2 (10.1) n=41	87.0 (9.1) n=41
Sleep / 24hrs	11.0 (0.9) n=44	10.5 (0.7) n=45	10.3 (0.8) n=43	9.8 (0.9) n=44	9.7 (0.8) n=41	9.7 (0.8) n=41
Wknd PA min/day	88.1 (35.9) n=44	99.4 (35.4) n=45	92.6 (37.8) n=43	102.7 (31.2) n=44	103.4 (30.8) n=40	93.0 (39.3) n=41