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ORIGINAL ARTICLE

Development of accelerometer-based light to vigorous physical activity in fitness profiles of school-aged children

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This study examined the developmental trajectories of light (LPA) and moderate-to-vigorous physical activity (MVPA) in fitness profiles derived from motor competence, perceived motor competence, health-related fitness, and MVPA behavior. Locomotor, stability, and object control skills, muscular and cardiovascular fitness, and physical activity were assessed in 510 (girls 285 and boys 225) Finnish school-aged children ($M_{age} = 11.26 \pm 33$ years) over three years. Physical activity was measured using hip-mounted accelerometers. Fitness profiles were identified using latent profile analysis, and the development of physical activity levels across four assessments was analyzed with latent growth curve models. Results showed that (1) three homogeneous profiles were identified: At-risk, Intermediate, and Desirable; (2) the Desirable group was more physically active than the other groups, the Intermediate group was more physical active than the At-risk group; and (3) LPA decreased similarly over time, while MVPA remained stable in all three profiles. Initial more advanced motor competence, perceived motor competence, health-related fitness, and higher MVPA behavior were associated with higher levels of long-term LPA and MVPA. This finding supports the importance of motor competence skills acquisition in the early school years. Attention should also be paid to increasing engagement in light physical activities, especially in inactive or insufficiently active children with low motor competence skills.

KEYWORDS
health-related fitness, latent growth curve model, latent profile analysis, motor competence

1 | INTRODUCTION

A major concern arising from the decline in moderate-to-vigorous physical activity (MVPA) in school-aged children[1] is that a large proportion of children lack adequate proficiency in motor competence.[2] This, in turn, may inhibit their long-term engagement in physical activity and health-related fitness.[1,3,4] While several studies on MVPA patterns exist,[1,5,6] studies incorporating light physical activity (LPA) and its relation to motor competence are lacking. A greater understanding of children's motor competence skills throughout the school years is required to effectively target physical activity programs to the children in most need[7] and encourage them to adopt a physically

active lifestyle.[5,6] This study examined school children's LPA and MVPA trajectories in relation to motor competence, perceived motor competence, health-related fitness, and MVPA engagement over a period of three years.

The Developmental Model proposed by Stodden et al.[2,8] posits that in middle and late childhood (6–12 years of age), motor competence (ie, performance and proficiency in movement skills comprising locomotor, stability, and object control skills) is positively related to physical activity engagement (at least 60 min of MVPA per day). In turn, both motor competence and physical activity are reciprocally associated with perceived motor competence (ie, awareness and beliefs of personal capability to perform gross motor skills), and health-related fitness (ie, muscular strength and endurance and cardiovascular endurance). The dynamic and reciprocal relationships between motor competence, perceived motor competence, health-related fitness, and MVPA are expected to associate with a health-enhancing lifestyle, including higher long-term physical activity engagement, and show negative relationships with lower physical activity levels. A strong empirical evidence for positive associations between MVPA engagement and actual motor competence,[9,10] perceived motor competence,[2,9] and health-related fitness[11–3] from childhood to adolescence has previously been reported.

Despite the large body of research on children's motor competence[3] and MVPA,[7,14] more attention should be paid to increasing their participation in LPA. Currently inactive or insufficiently active children with low motor competence skills should be encouraged to engage in physical activity of any intensity, such as walking to school or participating in activity programs during recess.[15] Increasing LPA levels may provide a feasible gateway to enhancing overall daily physical activity participation, especially in less physically active children.[16] Without additional evidence on the factors promoting LPA engagement, improving children's LPA behavior is challenging, especially as motor competence,[3,4] perceived motor competence,[17] and health-related fitness[18] have been shown to be important antecedents of MVPA.

A clear shortcoming of previous studies is the lack of data on school-aged children that accurately reflects the time they spend in other movement behaviors besides MVPA[16,19] in relation to motor competence and health-related fitness.[1,5,20] It is largely unknown how motor competence, perceived motor competence, health-related fitness, and MVPA behavior contribute to LPA over time, that is, the antecedents of LPA require more attention. According to the current methodology, longitudinal person-oriented analyses (eg, latent growth modeling) are recommended over traditional variable-centered analyses (eg, analysis of variance), as such methods can capture heterogeneity in developmental trajectories.[21] This is an important methodological extension in the research area, because each participant has a unique developmental trait. To fill these research gaps, research incorporating motor competence, perceived motor competence, health-related fitness, and MVPA behavior on habitual physical activity patterns at different intensity levels is eminently justified.

The aims of this study were to identify homogeneous fitness profiles from data on motor competence, perceived motor competence, health-related fitness, and MVPA behavior[2,8] and to examine the developmental trajectories of LPA and MVPA engagement over time in these profiles. LPA and MVPA levels were expected to decrease over time, especially in the less physically competent children.[1] Based on the reciprocal relationships between actual and perceived motor competence, health-related fitness, and MVPA engagement, more physically competent children were expected to have higher LPA and MVPA levels than the less competent children.[2,4,9-13]

2 | METHODS

2.1 | Participants

Participants were 510 (girls 285 and boys 225) Finnish children with a mean age of 11.26 ±.33 at the beginning of the data collection. Children were recruited from 17 randomly selected public schools in Southern (26% of children) and Central Finland (74%). The participating schools exhibited the characteristics typical of Finnish comprehensive schools, that is, Finnish-speaking, ethnicity mostly Caucasian, approx. 300–500 children, and following the national curriculum. Grade 5 children were invited to participate through direct contact with principals. Children were drawn from 38 classes taught by classroom teachers, who were the same at both T0 and T1. After transferring to the secondary level, children were instructed by specialist physical education teachers at T2 and T3. All the children participated in regular physical education classes (two × 45 min per week). No children with special needs or disabilities participated in the study, although the opportunity was given to all children equally.

2.2 | Procedure

Physical activity data were collected using identical procedures at each timepoint (August to September) in 2017 (T0), 2018 (T1), 2019 (T2), and 2020 (T3). Motor competence and health-related fitness data were collected by the researchers during school physical education lessons at

T0. Children's guardians were informed about the study, and written consent for their participation was obtained. The protocol was approved by the ethics committee of the local university.

2.3 | Measures

2.3.1 | Motor competence

Motor competence was measured using three motor competence skill tests: two-legged side-to-side jump test (stability skills),[22] the throw-catch test (object control skills),[23] and the five-leaps test (locomotor skills).[23] To form a single motor competence score from these test scores, the results were standardized and combined using *Z*-scores. The details of the motor competence tests were recently provided elsewhere [Citation removed for the peer review].

2.3.2 | Perceived motor competence

Perceived motor competence was assessed using the sport competence dimension of the Physical Self-Perception Profile.[24] The item stem was "*What am I like*?" The subscale consisted of five items on a five-point Osgood-scale (1 = *I am good at sport and* 5 = *I am not good at sport)*. The sum score of the five items was used as the measure of perceived physical competence. A Finnish study showed that the reliability of the composite for the factor loadings was.90 and that the construct validity of the scale was supported by confirmatory factor analysis (χ^2 (5) = 22.67, $p < 0.001$, *CFI* = 0.98, *TLI* = 0.97, *RMSEA* = 0.074, *SRMR* = 0.020, *90% CI* [0.05, 0.11]) in a sample of school-aged children.[25]

2.3.3 | Health-related fitness

Health-related fitness was assessed using the 20-m shuttle run test for cardiovascular fitness[26] and the push-up and curl-up tests for muscular fitness.[23] For the analyses, a sum score of health-related fitness was calculated using the standardized *Z*-scores of the cardiovascular fitness, push-up, and curl-up tests. Descriptions of the test protocols were previously provided by [Citation removed for the peer review].

2.3.4 | LPA and MVPA

LPA and MVPA were measured using Actigraph GT3X+ accelerometers. Children were asked to wear the hip-mounted monitor for seven consecutive days during waking hours (6am–11pm), except when swimming and engaged in other water-based activities. Only days with ≥500 min of valid wear time were included in the analyses.[27] Data were collected using a 30-Hz frequency and divided into 15-s epochs. Non-wear time was defined as 30 minutes of consecutive zeros. The cut-points proposed by Evenson et al.[28] were used to calculate LPA (104–2295 cpm) and MVPA (≥2296 cpm).

2.4 | Statistical analyses

First, normality of the distribution, outliers, and missing values were examined. Next, correlations, means, and standard deviations were analyzed. Confirmatory factor analysis was implemented to test the construct validity of the perceived motor competence scale. To answer the research questions, latent profile analysis was conducted to identify homogeneous groups of children with respect to perceived motor competence, motor competence, health-related fitness, and MVPA at time point T0. Based on the profiles identified, a parallel latent growth curve model including LPA and MVPA from T0 to T3 was implemented. To examine differences in the latent LPA and MVPA means and variances between the fitness profiles, group membership was added into the model as a covariate. Equality of means and variables between fitness profiles were tested using Wald's test of parameter equality. Preliminary analyses were performed using SPSS 26.0 and main analyses using Mplus 8.4.

3 | RESULTS

3.1 | Preliminary analyses

The graphical display showed that the observed variables were normally distributed and standardized values (±3.0), indicating no significant outliers. The percentage of missing values for the variables used in the latent profile analysis was 5.2% (345 out of 6 617 values). The missing completely at random (MCAR) test[29] (χ^2 = 221.19, *df* = 209, p = 0.269) showed that the data with and without missing values were similar. The proportion of children with incomplete accelerometer data decreased across the measurements, because some participants did not wear accelerometer for a valid measurement period (Table 1). However, missing scores did not represent any particular school or group. Missing values were estimated using the full information maximum likelihood method.[30]

TABLE 1 Test specific number of participants, correlations, means, and standard deviations of the study variables

	n	1	2	3	Mean	SD	α
1 Perceived motor competence T0	487				3.49	0.84	0.88
2 Motor competence T0		0.39***					
Throw-catch T0	494				10.90	5.13	
Side-to-side jump T0	496				37.60	6.55	
5-jump T0	493				7.73	0.90	
3 Health-related fitness T0		0.33***	0.68***				
Push-up T0	483				22.94	12.38	
Sit-up T0	489				39.57	22.81	
Cardiovascular fitness T0	476				36.16	18.01	
4 Physical activity							
MVPA T0	453	0.25***	0.39***	0.38***	58.81	22.94	
MVPA T1	285	0.17**	0.32***	0.33***	55.05	20.81	
MVPA T2	208	0.22**	0.28***	0.27***	52.94	21.78	
MVPA T3	129	0.22*	0.24**	0.33***	57.19	25.68	
LPA T0	453	0.08	0.09	0.08	218.47	39.69	
LPA T1	285	0.11	0.15*	0.17**	216.23	43.61	
LPA T2	208	0.14	0.13	0.15*	202.51	44.33	
LPA T3	129	0.25**	0.20*	0.20*	180.06	47.01	

***$p < 0.001$, **$p < .01$, *$p < 0.05$. α, Cronbach alpha.

TABLE 2 The parameter estimates for the latent cluster solutions within one to six groups at T0

Groups	Parameters	AIC	BIC	ABIC	LT5%	LT1%	pLMR	Entropy
1-solution	8	6964	6998	6972	–	–	–	–
2-solution	13	6605	6660	6619	–	–	.000	.73
3-solution	**18**	**6532**	**6608**	**6551**	–	–	**0.003**	**0.68**
4-solution	23	6485	6583	6510	1	–	.000	.75
5-solution	28	6463	6582	6493	1	–	.023	.75
6-solution	33	6447	6586	6482	2	–	.154	.76

Notes: Bold indicates the most reasonable solution.

Abbreviations: AIC, Akaike Information Criterion; BIC, Bayesian Information Criterion; ABIC, Adjusted Bayesian Information Criterion; LT, less than; pLMR, p-value for Adjusted Lo-Mendell-Rubin Ratio Test.

3.2 | Correlations, means, and standard deviations

Correlation coefficients, means, and standard deviations were examined (Table 1). The correlations between the latent variables ranged from weak to moderate. The strongest positive correlations were found between motor competence and perceived motor competence and between motor competence and health-related fitness. The strongest association between the latent and outcome variables was between motor competence and MVPA at T0, whereas the correlations between the latent variables and LPA were relatively weak.

3.3 | Confirmatory factor analysis

The factor structure of the perceived motor competence scale at T0 was tested using confirmatory factor analysis. The construct validity of the scale ($\chi^2(4) = 17.528$, $p = 0.002$, $CFI = 0.99$, $TLI = 0.97$, $RMSEA = 0.082$, $SRMR = 0.019$) including the residual correlation between the items with similar wording ("*I am among the best when it comes to joining sport activities"* and "*I am among the first to join in sport activities"*) was confirmed. Correlated residuals among items using similar wording are possible and acceptable in some models, although they should be used cautiously.[31] The Cronbach alpha for the scale was

acceptable (Table 1), and hence, the scale provided reliable results for the ensuing latent profile analysis.

3.4 | Latent profile analysis

Latent group memberships based on perceived motor competence, motor competence, health-related fitness, and MVPA at T0 were identified (Table 2). With the increasing number of groups after the three-group solution, the AIC, BIC, and ABIC indices decreased, but only marginally. Compared to the three-group solution, the four-group solution contained one cluster that included less than 5% of the participants. After considering all the indices, a three-group solution was deemed the most justifiable.

Group 1 was labeled the "*At-risk Fitness Profile*." The children in this group had the lowest perceived motor competence, motor competence, health-related fitness, and MVPA scores compared to the other clusters, and therefore, having a higher risk of developing physically inactive lifestyle. This cluster comprised about one-fourth of the total sample. Group 2 was named the "*Intermediate Fitness Profile*" and included nearly half of the total sample. These children had moderate perceived motor competence, motor competence, health-related fitness, and MVPA scores compared to the other two groups. Group 3, accounting for one-fourth of the total sample, was labeled the "*Desirable Fitness Profile*" and contained the children with highest perceived motor competence, motor competence, health-related fitness, and MVPA scores. Means and standard deviations of the study variables for each group are presented in Table 3.

3.5 | Latent growth curve modeling

A parallel latent growth curve model of LPA and MVPA, including the covariate effects of cluster membership, was estimated to examine reciprocal relationships between levels and changes from T0 to T3. The intraclass correlations indicated that MVPA had a multilevel structure (Appendix 1), and therefore, the growth curve model using the complex model option to adjust parameters for sampling weights was implemented.[32] The theorized model showed poor model fit to the data ($\chi^2(26) = 77.30$, $p < 0.001$, $CFI = 0.91$, $TLI = 0.88$, $RMSEA = 0.062$, *90% CI* [0.05, 0.08], $SRMR = 0.063$). Based on the modification indices, the residuals of LPA at T0 and MVPA at T0

TABLE 3 Means and standard deviations (in the parentheses) of the study variables by groups

	Group 1 At-risk *N* = 139 (27%) 88 girls, 51 boys	**Group 2 Intermediate *N* = 245 (48%) 130 girls, 115 boys**	**Group 3 Desirable *N* = 126 (25%) 67 girls, 59 boys**
Profile variables			
Perceived motor competence T0	3.16 (.81)	3.48 (.74)	3.84 (.93)
Motor competence T0			
Throw-catch T0	8.30 (5.23)	11.09 (4.77)	13.48 (4.21)
Side-to-side jump T0	33.97 (5.73)	37.64 (5.89)	41.55 (6.32)
5-jump T0	7.22 (.85)	7.77 (.73)	8.24 (.93)
Health-related fitness T0			
Push-up T0	18.04 (10.96)	22.23 (11.14)	29.58 (13.25)
Sit-up T0	28.31 (18.29)	38.34 (21.20)	54.20 (22.60)
Cardiovascular fitness T0	25.53.67 (15.74)	35.38 (15.13)	49.70 (16.84)
Physical activity T0			
MVPA T0	50.13 (20.81)	57.85 (21.29)	69.53 (23.84)
Outcome variables			
MVPA T0	50.13 (20.81)	57.85 (21.29)	69.53 (23.84)
MVPA T1	51.20 (19.73)	52.95 (20.04)	63.24 (21.44)
MVPA T2	45.64 (18.96)	53.71 (21.46)	58.72 (23.17)
MVPA T3	52.49 (22.94)	55.79 (25.43)	63.17 (27.60)
LPA T0	215.52 (39.02)	214.85 (37.70)	228.07 (42.56)
LPA T1	211.26 (43.07)	208.97 (40.16)	235.22 (45.30)
LPA T2	189.52 (41.67)	201.44 (43.05)	216.80 (45.40)
LPA T3	171.74 (38.51)	175.91 (44.98)	193.39 (54.22)

were allowed to correlate. After this, the model showed an acceptable model fit ($\chi^2(25) = 65.24$, $p < 0.001$, $CFI = 0.93$, $TLI = 0.90$, $RMSEA = 0.056$, $90\%\ CI$ [0.04, 0.07], $SRMR = 0.058$).

The results for the standardized model showed that the level of LPA was relatively high ($\beta = 6.79$, $SD = 11.53$, $p < 0.001$) compared to that of MVPA ($\beta = 2.29$, $SD = 6.34$, $p < 0.001$), that LPA decreased over time ($\beta = -1.54$, $SD = 6.72$, $p < 0.001$) (Appendix 2), while MVPA remained stable ($\beta = -0.09$, $SD = 7.96$, $p = 0.794$) (Appendix 3), and that the level of LPA correlated positively with the level of MVPA ($\beta = 0.35$, $SD = 3.09$, $p < 0.05$).

Significant covariate effects of group membership on LPA level ($\beta = 0.14$, $SD = 1.49$, $p < 0.05$) and MVPA level ($\beta = 0.38$, $SD = 1.56$, $p < 0.001$) were found. Wald's tests confirmed that the Desirable group had a higher LPA level than the At-risk group ($p < 0.001$) or Intermediate group ($p < 0.001$), and that the Intermediate group had a higher LPA level than the At-risk group ($p < 0.001$). In addition, the Desirable group had a higher MVPA level than the At-risk group ($p < 0.001$) or Intermediate group ($p < 0.001$), and the Intermediate group had a higher MVPA level than the At-risk group ($p < 0.001$). The variances of the MVPA level also differed between the Desirable and At-risk group ($p < 0.05$) and between the Desirable and Intermediate group ($p < 0.05$). Squared multiple correlations revealed that the model explained 14% of the variability of the MVPA level ($\beta = 0.14$, $SD = 1.17$, $p < 0.01$).

4 | DISCUSSION

This study examined the three-year development of LPA and MVPA in fitness profiles derived from perceived motor competence, motor competence, health-related fitness, and MVPA. The key findings were as follows: (1) Three profiles, labeled At-risk, Intermediate, and Desirable, were identified; (2) the Desirable group had higher LPA and MVPA levels than other two groups and the Intermediate group had higher levels of LPA and MVPA than the At-risk group; and (3) LPA decreased over time, while MVPA remained stable in all three fitness profiles.

The distribution of children in the three fitness profiles was as expected, supporting the earlier findings with Finnish school children,[33] in which the variables included in the latent cluster analysis were exactly the same as in this study whereas the past total sample was smaller. It should be considered that the PMC scale used in the study was a holistic instrument for sports competence perceptions rather than perceived motor competence, which comprises subdomains of competence in stability, locomotion, object control, and active play skills.[21] However, the present between-group differences in initial perceived motor competence, motor competence, health-related fitness, and MVPA were as expected.[12] Specifically, the Desirable group had higher locomotor, object control, muscular and cardiovascular fitness scores and higher MVPA engagement than the other two groups, and the Intermediate group had higher scores higher than the At-risk group. The At-risk group had by far the lowest scores in all the fitness tests, that is, perceived motor competence, motor competence, health-related fitness, and MVPA. This group comprised 27% of the present sample and thus highlights the importance of identifying the less competent children when planning the future physical activity programs and interventions in schools. At-risk children, in particular, could be closely monitored and given additional low-threshold exercises that might lead them toward adopting a more physically active lifestyle.[5,19] For this group of children, an increase of any intensity in their physical activity could help them to accumulate more overall daily physical activity.[15,16]

The development of both MVPA and LPA was similar in all fitness groups; however, the variability between individuals was evident. Contrary to expectations,[1,5] the stable development of MVPA in all three fitness profiles over three years was clearly a positive finding, especially as the data collection period included the transition from elementary to secondary school. Although the children transferred to secondary level including the changes in teachers, a typical decrease in MVPA did not materialize.[1] Aira et al.[34] recently reported that physical activity domains may differ between subgroups, that is, while some adolescents decrease activity, others increase or maintain high or low activity in the sample of Finnish adolescents. The current sample represented Finnish school children, all of whom have very similar in-school and out-of-school opportunities to be physically active on a daily basis. The stable development of MVPA in the current study may be an outcome of a nationwide action plan, Finnish Schools on the Move, launched in 2016.[35] In the plan, active recess time and other activities were made available to all children during the school day. In addition, active transportation was strongly encouraged for school-aged children. These initiatives may have countered the typical decrease in MVPA levels, which were found to be stable in the present sample. It is interesting that the longitudinal studies reviewed by Reilly[20] revealed that MVPA already begins to decline at around the age of school entry, not as earlier suggested, primarily during adolescence. Thus, it is possible that MVPA had declined earlier in the present sample, as the data only included the children's physical activity scores from Grades 5–8. Thus, the first four school years, during which MVPA levels are still unclear, were excluded. Moreover, the stable development of MVPA found here may give a more positive picture of children's physical activity behavior than it really is, as there was substantial variation between individuals. For this reason, special

attention could be paid to the children in most need, that is, at-risk children, preferably already at school entry.

A particular concern is the decline in LPA observed over the three follow-up years in the current sample. It is possible that increasing sedentary behavior during adolescence displaces light-intensity physical activities.[20] Based on the current data, it is difficult to make clear conclusion for the reason behind declining LPA levels. Smith et al.[36] pointed out some types of sedentary behaviors being very important to a child's development, such as reading, writing, and fine motor tasks. However, something could be done about this undesirable development, as all three fitness profiles followed the same pattern. It should be noted that the first wave of the worldwide COVID-19 pandemic was still spreading at the time of the last physical activity measurement. This may have exerted a negative influence LPA levels, although Finnish society and schools were not under lockdown during the last follow-up.

Both LPA and MVPA levels of school children could be promoted in several ways. For instance, reducing restrictions on active play and avoiding over-protectionism,[5] promoting and facilitating safe active transport to school and other destinations,[5] and ensuring the acquisition of motor competence skills in early childhood as a way of encouraging habitual physical activity.[2] In addition, as Tremblay et al.[5] suggest, ensuring that children and their families are continually educated on the importance of balancing different activity types (eg, reading for school vs. screen time for entertainment). A more radical way to promote LPA and MVPA behavior in children might be to improve "unavoidable" activities during school days by favoring smart designs when building new campuses and school playgrounds.[37] As any activity is better than none, corridors and recess areas in schools could offer a variety of motivating activities, for instance jumping on footprints, climbing a wall hanging from pull-up bars, or instructions to walk backward. In addition, the parents of at-risk children could be more effectively informed and educated about the importance of engaging daily in light-intensity physical activities.[5] As the above suggestions indicate, there are many inexpensive ways of promoting physical activity behavior in children. Raising awareness of the importance of motor competence acquisition in children, schools, and families appears to be necessary, even though the health benefits of regular physical activity engagement are generally well known.

To conclude, the findings of the study indicate that initially more advanced motor competence, perceived motor competence, health-related fitness, and MVPA behavior predict higher levels of long-term engagement in LPA and MVPA, and thus underline the importance of acquiring good motor competence skills[9,10] and health-related fitness[11–13] in the early school years. Attention should also be paid to increasing light physical activities in all groups of children, especially high risk children. Future studies could attempt to track motor competence, health-related fitness, and physical activity levels from school entry to early and even late adolescence. This might reveal the long-term role of motor competence acquisition in physical activity development and provide more evidence on the timing of age-related declines in physical activity behavior, and so support future interventions. The main strength of this study was the objective assessment of motor competence, health-related fitness, and both LPA and MVPA engagement on four successive occasions.

4.1 | Limitations

The study also has its limitations. As participation was voluntary, it is impossible to know whether the sample was representative of children whose motor competence skills are weaker and who participate less frequently in daily physical activities than their peers. It may be that the most physically active, more highly motivated children were more interested in participating in follow-ups than the less motivated. Second, a decline in the proportion of study participants at follow-up always raises the question of reliability. However, under present circumstances, this was unavoidable, and on the positive side, the sample size remained at least satisfactory across the follow-ups based on the results of the missing value analysis. Finally, causal relationships between fitness profiles and MVPA and LPA engagement should be carefully interpreted, as there may be multiple causes behind physical activity behavior.

5 | PERSPECTIVES

The findings suggest that special attention could be paid to increasing LPA with the children in most need, especially at-risk children could be closely monitored and given additional low-threshold activities. Declining physical activity levels could be intervened, preferably already at school entry. Raising awareness of the importance of motor competence acquisition in children appears to be necessary.

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CONFLICT OF INTERESTS

Authors declare no conflict of interests.

DATA AVAILABILITY STATEMENT

Due to the nature of this research, participants of this study did not agree for their data to be shared publicly, so supporting data are not available.

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APPENDIX 1

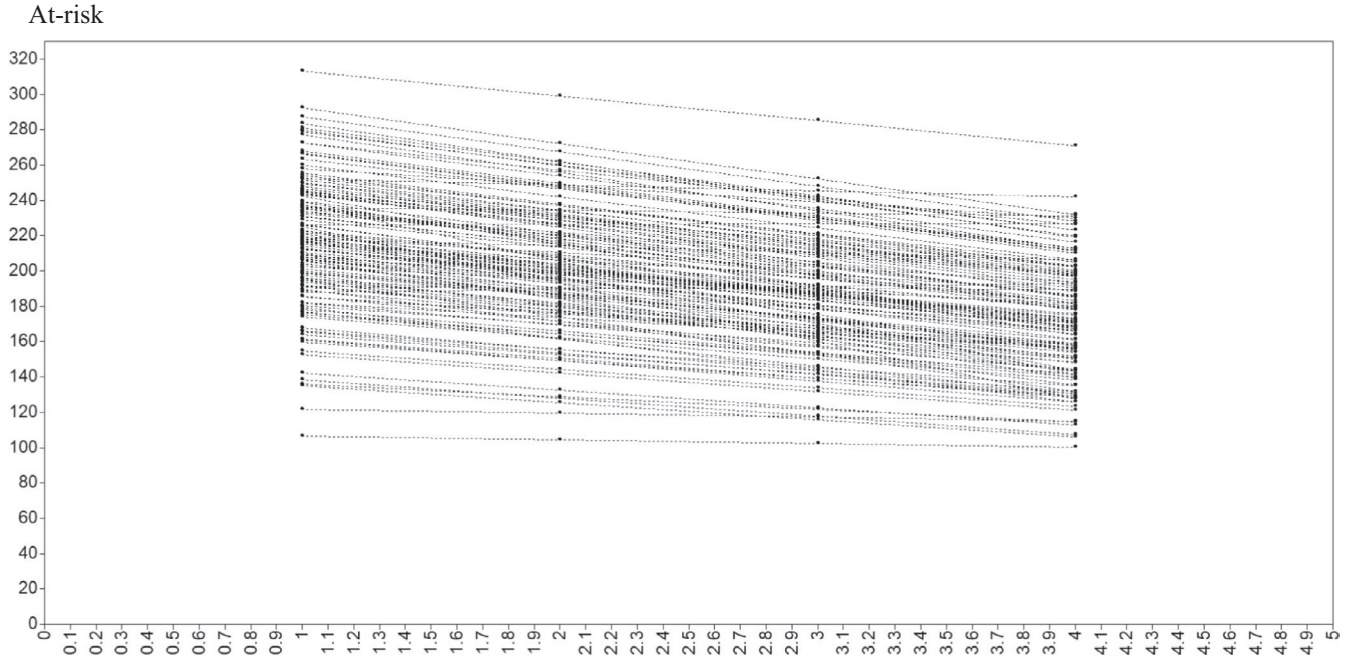
Intraclass correlation coefficients between school classes at T0 to T3

Outcome	Grouping variable	Time	*β*	SE	*p*
LPA	Class	T0	0.07	0.03	0.053
		T1	0.04	0.04	0.298
		T2	0.05	0.13	0.712
		T3	0.09	0.14	0.498
MVPA	Class	T0	0.14	0.05	0.002**
		T1	0.09	0.04	0.024*
		T2	0.06	0.08	0.497
		T3	0.21	0.09	0.013*

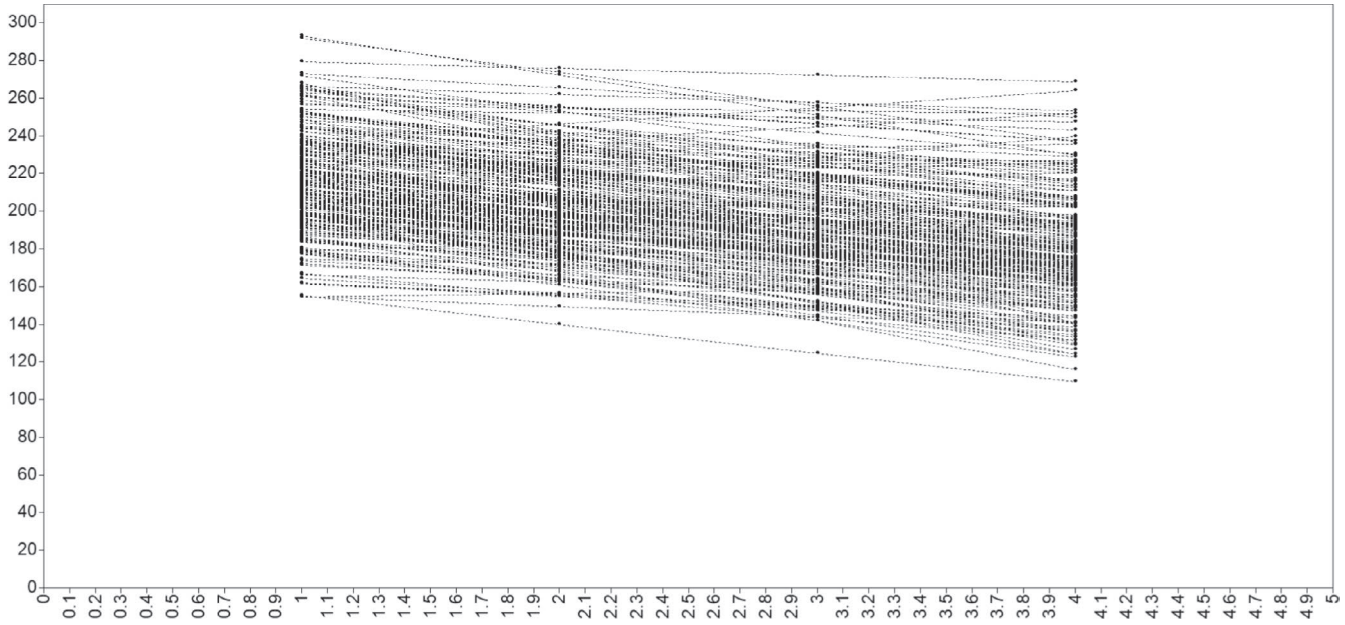
** $p < .01$, *$p < .05$.

APPENDIX 2

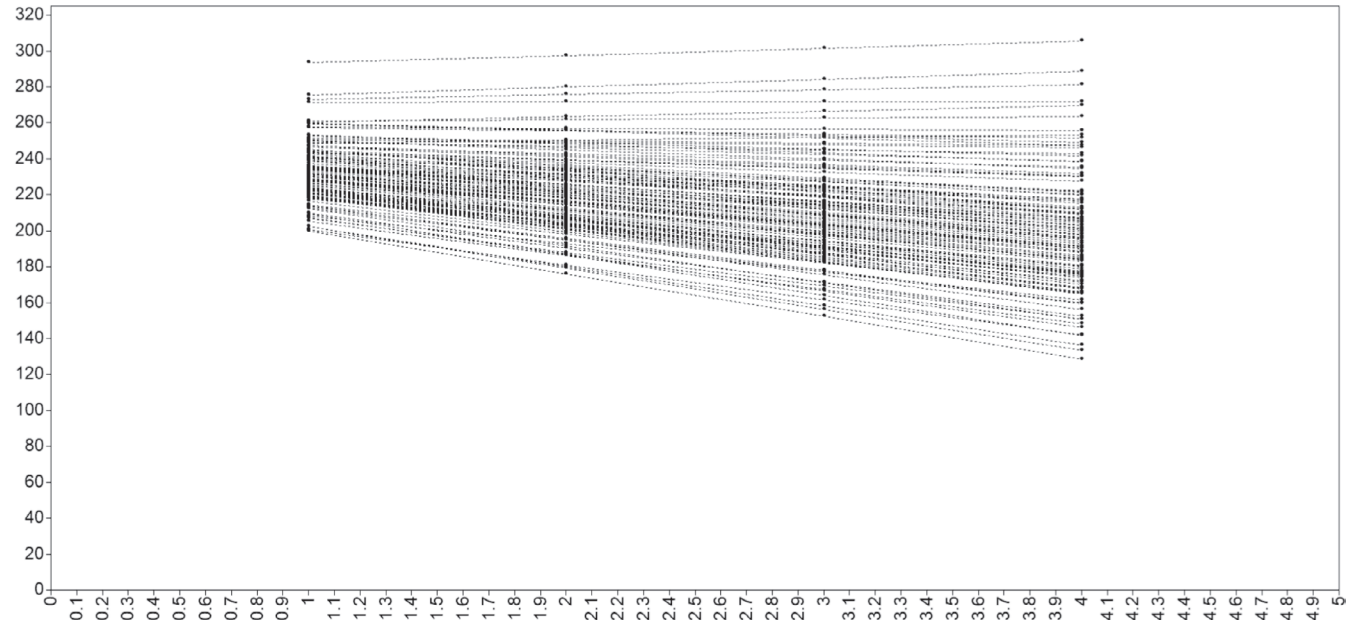
Individual developmental trajectories of LPA by fitness profiles (y = minutes per day, x = time points)



Intermediate



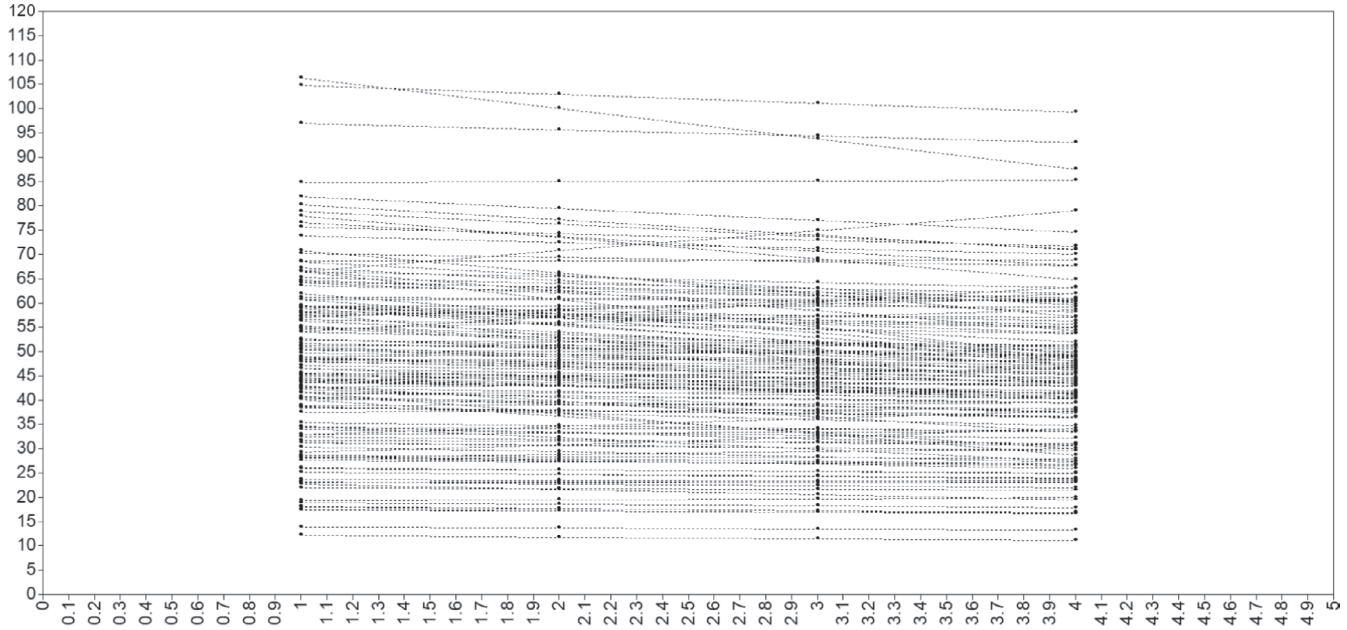
Desirable



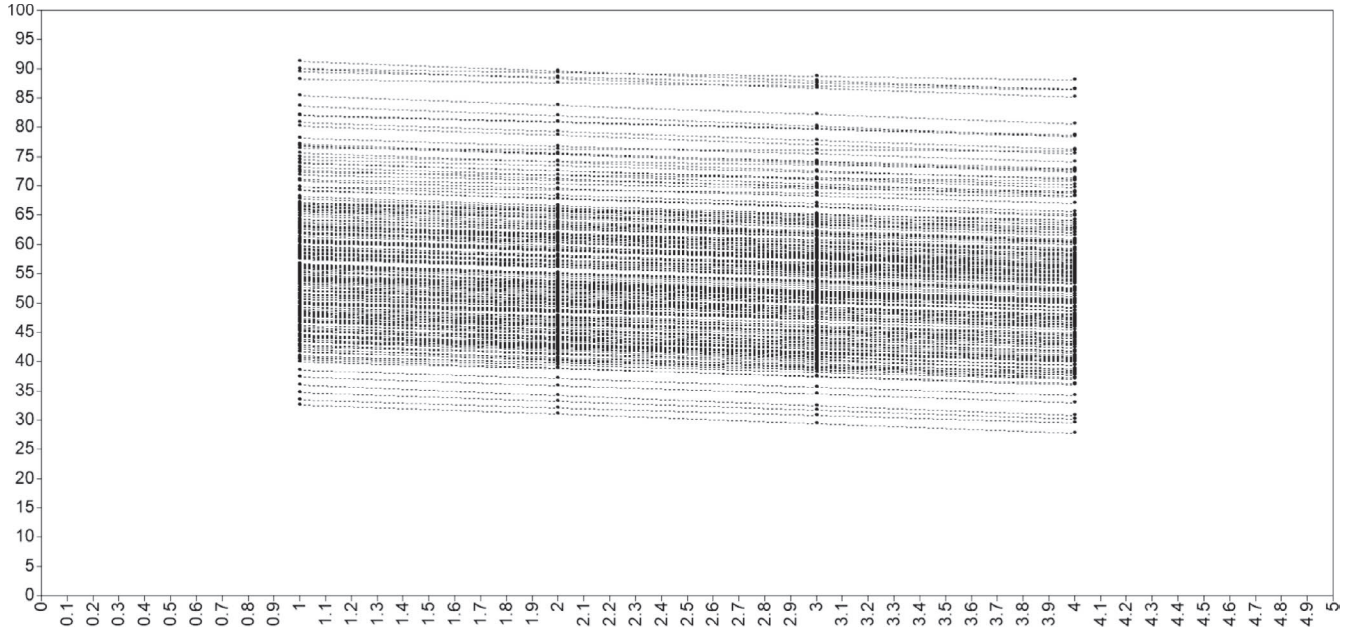
APPENDIX 3

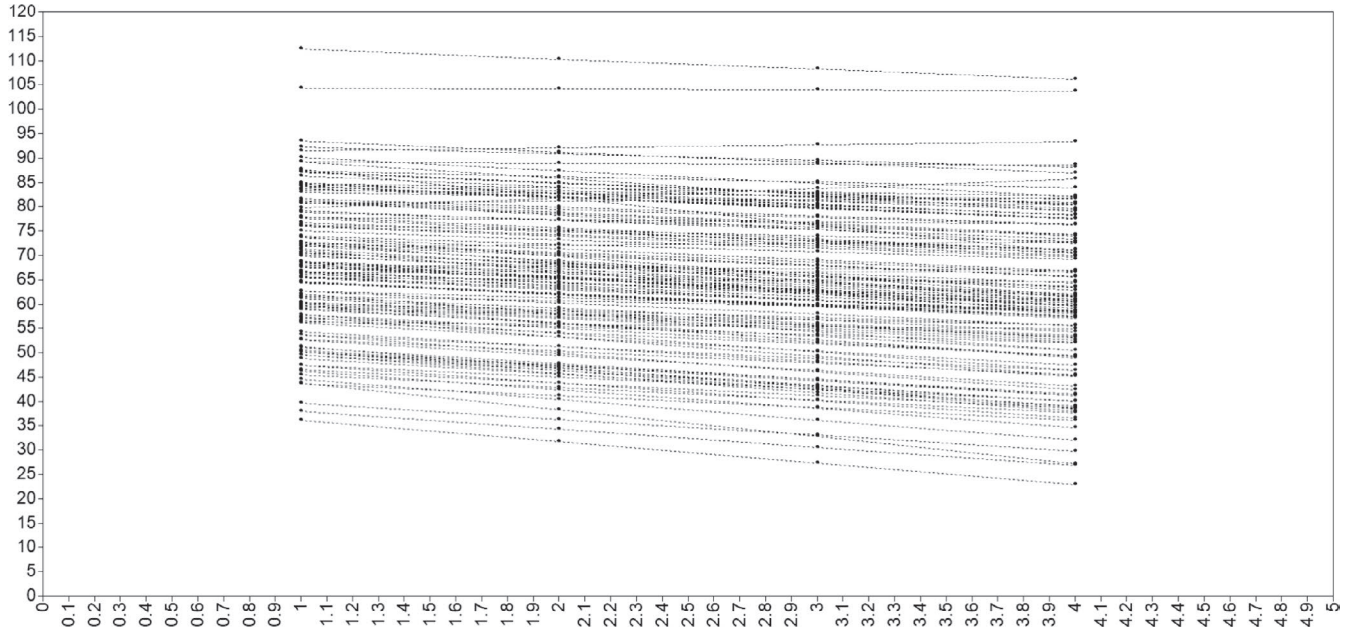
Individual developmental trajectories of MVPA by fitness profiles (y = minutes per day, x = time points)

At-risk



Intermediate




Desirable
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2 2.1 2.2 2.3 2.4 2.5 2.6 2.7 2.8 2.9 3 3.1 3.2 3.3 3.4 3.5 3.6 3.7 3.8 3.9 4 4.1 4.2 4.3 4.4 4.5 4.6 4.7 4.8 4.9 5