Identifying childhood movement profiles and comparing differences in mathematical skills between clusters : A latent profile analysis

Jaakkola, Timo

2021-11-02

Jaakkola , T , Hakkarainen , A , Gråsten , A , Sipinen , E , Vanhala , A , Huhtiniemi , M , Laine , A , Salin , K & Aunio , P 2021 , ' Identifying childhood movement profiles and comparing differences in mathematical skills between clusters : A latent profile analysis ' , Journal of Sports Sciences , vol. 39 , no. 21 , pp. 2503-2508 . https://doi.org/10.1080/02640414.2021.1949114

http://hdl.handle.net/10138/345771
https://doi.org/10.1080/02640414.2021.1949114

Identifying childhood movement profiles and comparing differences in mathematical skills between clusters: A Latent Profile Analysis

Jaakkola, T[1]., Hakkarainen, A[2]., Gråsten, A[1]., Sipinen, E[3]., Vanhala, A[3]., Huhtiniemi, M[1]., Laine, A[3]., Salin K[1]., & Aunio, P[3]

[1]Faculty of Sport and Health Sciences, University of Jyväskylä, Finland

[2]Open University of Helsinki, University of Helsinki, Finland

[3]Faculty of Educational Sciences, University of Helsinki, Finland

Running head: Physical and mathematical skills

Word count: 3371 words

Date of submission: 22.6.2021

Corresponding author:

Associate Professor Timo Jaakkola
University of Jyväskylä, Faculty of Sport and Health Sciences
Rautpohjankatu 8
P.O. Box 35 (L)
40014 Jyväskylän Yliopisto
Finland
Email: timo.jaakkola@jyu.fi

Abstract

The aims of this study were; 1) to identify different movement profiles in sixth graders, and 2) to investigate if there are differences in their mathematical basic (BasicMath) and problem solving (ProbSol) skills between existing movement profiles. The sample included 461 (223 girls, 238 boys) students with a mean age of 11.27 ± .32 years from southern and middle Finland. A latent profile analysis (LPA) revealed four movement profiles: “poor movers”, “average movers”, “skilled movers” and “expert movers”. These profiles differed substantially in their motor competence (MC) and health-related fitness (HRF). A multivariate analysis of variance (MANOVA) also revealed that “poor movers” and “average movers” obtained lower results in BasicMath comparing with “skilled movers”. The results of this study suggest that cardiorespiratory and muscular fitness, MC and BasicMath are interrelated.

Keywords: motor competence, cardiorespiratory fitness, muscular fitness, basic mathematical skills, mathematical problem-solving skills

Introduction

In western countries, fewer children and adolescents achieve the recommended international physical activity (PA) of 60 minutes daily of moderate-to-vigorous PA (MVPA).[1] This negative behavioural trend has also led to secular decline in motor skill development and physical fitness.[2,3] Interestingly, there is a growing amount of research evidence that shows that the physical fitness and MC of children and adolescents are positively related to their academic performance.[4] Therefore, there is a need to identify different movement profiles among children and investigate if there are differences in the academic skills across the identified clusters of children.

BasicMath include computational arithmetic skills (i.e., addition, subtraction, multiplication, and division skills), fraction comparison skills, computational fraction skills, and arithmetic word problem-solving skills.[5] During elementary schooling, increasing the understanding of numerical magnitudes is a common core of numerical development, which affects the development of arithmetic and more-advanced mathematical skills.[6] In addition, mathematical problem-solving tasks need to be separated from mathematical word problems. Mathematical problem-solving tasks can be presented without words, for example, as a picture. They are considered more difficult than mathematical word problem tasks[7] as mathematical problem-solving demands, first, that a student has a goal to solve a novel task, and second, that the student discovers how to solve the task in a nonroutine manner, that is, how to use acquired knowledge and skills in a new way.[8] Together, these BasicMath and ProbSol create a foundation for the mathematical skills that are needed in adulthood. Earlier studies have shown that weak mathematical skills increase the risk of developing mathematical learning difficulties, and therefore, increase the risk of educational exclusion during compulsory education and upper secondary education.[9]

Thus, weak mathematical skills not only hamper success in the educational pathway but also increase the risk of poorer employment prospects in adulthood.[10]

HRF is a combination of different aspects of physical fitness. HRF has typically been determined to include cardiorespiratory fitness, muscular fitness, flexibility, and body composition.[11] Cross-sectional studies have indicated that cardiorespiratory fitness is positively related with math performance in childhood and adolescence.[12,13] In their systematic review, Santana et al. stated that positive cross-sectional relationships between cardiorespiratory fitness and academic performance seems to be strong.[14] However, it should be recognised that longitudinal studies in the area are scarce.[14]

A review of the literature demonstrates that only a few studies have been conducted to investigate the relationship between muscular fitness and mathematical skills.[14] It has been demonstrated that adolescent girls who had better muscular fitness performed better in math tests than girls who had weak muscular fitness, but this association was not observed for boys.[15] Additionally, it has been recognised that children and adolescents who obtained better results in an abdominal strength test also performed better on math tests than children who had weaker abdominal muscles.[16] Subsequently, it was determined that muscular strength and endurance associated positively with mathematical skills in childhood and adolescence.[17] Although there is some evidence on the positive association between muscular fitness and mathematical skills, it should be recognised that in the systematic review these associations remain ambiguous.[14]

MC is typically determined to include fundamental movement skills. More specifically, these gross motor skills include balance, locomotor, and object control skills.[4] Empirical evidence has recently indicated the positive association between MC and mathematical skills.[18]

Few cluster analytic studies have demonstrated that it is possible to identify different movement profiles from samples, including children and adolescents. According to results of these studies, identified profiles differ substantially in MC and cardiorespiratory and muscular fitness[19], as well as PA engagement.[20] Children and adolescents who belong to clusters that have high MC typically demonstrate higher engagement in PA than youth who belong to clusters that demonstrate low qualities.[20]

Although there is a plethora of studies that investigate associations among MC, HRF and academic performance, to our knowledge, this study is the first attempt to utilise cluster analytic techniques to analyse these associations. This study adds to the current knowledge base by examining if adolescent clusters that have similar MC and HRF differ in their BasicMath and Probsol. Building on the current knowledge and addressing the shortcomings of previous studies, the aim of this study was 1) to identify different movement profiles in sixth graders and 2) to investigate if there are differences in their BasicMath and Probsol among the existing movement profiles.

Materials and methods

Participants

The sample in this study included 461 (223 girls, 238 boys) elementary school students with a mean age of 11.27 ± .32 years from southern and middle Finland. Researchers collected MC and HRF data during physical education (PE) classes. Mathematical skills data were obtained in the classroom. Students and their guardians were informed about the study protocols, and written consent for their participation in the study was obtained. The study protocol was approved by the ethics committee of the local university.

Measures

Motor competence. Students' MC was measured using the following product-oriented fundamental movement skill tests: 1) two-legged jumps from side-to-side test (balance skills)[21], 2) throwing-catching combination test (object control skills)[22], and 3) five-leaps test (locomotor skills)[22]. In the two-legged jumps from side-to-side test, a participant jumps over a small wooden beam (60 × 4 × 2 cm) from one side to another side for 15 consecutive seconds. A participant performs jumps with their legs in a parallel position. The test is conducted twice, and the total score is the average of these two attempts. In the throwing-catching combination test, a participant throws a tennis ball to a 1.5 x 1.5 m-sized target area that is situated on the wall 90 cm above the floor. The throwing distances are 7 meters and 8 meters for girls and boys, respectively. The participants have 20 attempts to throw the ball behind a marked line, hit the target area, and catch the ball after one bounce. The final score of the test is the number of correctly performed throwing-catching combinations. In the five-leaps test, a participant completes five leaps beginning and finishing with their legs in a parallel position. The score of the test is the distance from the starting position to the finish position (measured from the heel of the nearest foot). All MC tests show acceptable validity and reliability in Finnish children[22]. The scores of the MC tests were standardised, and the analyses were performed using Z-scores.

Cardiorespiratory fitness. Students' cardiorespiratory fitness was evaluated using the 20mSRT[23]. The participants run continuously between two lines that are positioned 20 m apart following the progressive cadence. The final result of the test is the number of shuttles that are reached before the participant is unable to keep pace. Research has demonstrated that the 20mSRT test achieves adequate reliability and validity[24].

Muscular fitness. Students' muscular fitness was measured by push-up and curl-up tests[22]. The push-up test is administered differently for boys and the girls. In the boys' version, the boys use a starting position where their hands and toes touch the floor, whereas in the girls' version, the girls use a starting position in which their hands and knees touch the floor. In both versions of the test, the body and legs are oriented in a straight line, the arms are shoulder-width apart and the feet are aligned. In the test, a participant lowers their body until there is a 90-degree angle in the elbows (with the upper arms parallel to the floor). The final score is the number of correctly completed push-ups. The curl-up test has a starting position where a participant lies on the floor on her/his back; their knees bent at 100 degrees; their legs are slightly apart; both of their feet are on the floor; their arms are straight and parallel to the trunk with the palms of their hands resting on the floor and fingers stretched out and their head rests on the floor. A measuring tape is located under the participant's legs so that their fingertips are just resting on the nearest edge of the tape. The heels of their feet are kept on the mat as they slowly perform a curl-up. While curling up, the participant's fingers slide across the measuring tape until their fingertips reach the other side of the tape. Next, the participant curls back down until her/his head touches the floor. The performance rhythm is derived from the tape. The final score is the number of correctly completed curl-ups that is reached before the participant is unable to keep pace (maximum: 75 repetitions). Push-up and curl-up tests have shown adequate reliability and validity in Finnish children[22]. For the analyses, a composite score of muscular fitness was created from the standardised Z-scores.

Mathematical skills. Children's BasicMath were measured using the test for basic mathematical skills (KTLT)[25], which is a standardised screening test designed for seventh to ninth grades. The test was carried out towards the end of the spring term in the sixth grade, and therefore, it was considered to be suitable for the age group in the study. The KTLT is a paper-and-pencil test with 40 items with a time limit of 40 minutes. The internal consistency of the test was good (Cronbach's alpha: .86). ProbSol were measured by a newly developed measure (Authors, in progress) designed for sixth to ninth grade students. The measure consisted of a multiple-choice paper-and-pencil test with a time limit of 30 minutes. The test consisted of seven closed problems, i.e., problems with one correct answer. The problems had been correctly answered by 40 to 70% of the Finnish students who were participating in an international problem-solving contest, the Kangaroo Contest. The internal consistency of the test was modest (Cronbach's alpha: .53).

Statistical analyses

The normal distribution, outliers, and missing values of the study variables were examined at the beginning. In addition, descriptive statistics, including correlation coefficients, means, standard deviations for the study variables, and the differences between girls and boys using the Wald's test of parameter equality were examined. The standardised test scores from push-up and sit-up tests (muscular fitness) and the throwing-catching combination test, two-legged jumps in side-to-side test, and five-leaps test (MC) were combined to create new sum variables for the subsequent LPA.

To identify groups with homogenous profiles in MC, muscular fitness, and cardiorespiratory fitness, a series of LPAs was tested. The maximum likelihood ratio (MLR) estimator and maximum number of 500 iterations were employed. The parameters for one to eight clusters were estimated using the Akaike information criterion (AIC), Bayesian information criterion (BIC), sample-size adjusted BIC (SSA-BIC), and Lo-Mendell-Rubin (LMR) likelihood ratio test. Lower values for AIC, BIC, and SSA-BIC indicated a more appropriate model fit. The LMR test was performed to compare the estimated model with a model with one class less than the estimated model. A statistically significant p-value indicated that the LMR test supported the retention of the model related to the number clusters. Cluster solutions with small number of cases may not have been meaningful with a large sample size, as in the current study, therefore, only clusters with more than 5% of the cases were be considered as adequate.[26] Descriptive statistics for each cluster were provided when the most appropriate model was determined.

To examine the significant interaction effects of gender and cluster membership as independent variables on the total scores of BasicMath and ProbSol skills as dependent variables, a multivariate analysis of variance (MANOVA) with Tukey's post hoc tests was implemented. The results were considered statistically significant at the $p < .05$ level. The Missing Completely at Random (MCAR) test for missing values and MANOVA models were performed using SPSS Version 22.0, and the LPA models were performed using Mplus Version 8.3.

Results

A graphical analysis indicated that the data were normally distributed and no significant outliers were observed based on the standardised values (± 3.0). The data matrix included 9.5% of the missing values of a total of 3688 measured values. The MCAR test (χ^2 = 115.79, df = 111, p = .359) indicated no differences between data with missing values and data without missing values, and therefore, the missing scores were expected to be MCAR. Missing values were not imputed but were estimated using full information maximum likelihood procedures, which have been shown to produce unbiased parameter estimates and standard errors in MCAR conditions. A sample size analysis suggested that the minimum number of participants to be obtained should be 216 to meet statistical constraints with a confidence level of 95% and a margin of error $p < .05$.[27] The current sample size of 461 was adequate for the main objectives of this study.

The correlation coefficients, means, and standard deviations of the study variables and differences between girls and boys were examined (Table 1). The strongest positive correlations were observed between two-legged jumps from side-to-side test scores and push-up tests scores in both girls and boys. Boys had higher cardiorespiratory fitness scores than girls, whereas girls had higher push-up and sit-up tests scores than boys.

The results of the LPA, including MC, muscular fitness, and cardiorespiratory fitness, were examined (Table 2). The AIC, BIC, and SSA-BIC indices decreased when the number of groups increased, but the three group solution indices remained similar. The *p* values of the LMR for the K class versus K-1 class were also non-significant for each higher group solution, with an exception of six clusters. However, the six-group solution had one cluster that contained less than 1% of the participants. Based on all indices, a four-group solution was considered the most justifiable. The means and standard deviations of the study variables for each four clusters were examined (Table 3).

Cluster 1 was labelled as the "*poor movers*" group. Students of this group reported the lowest MC, lower muscular, and cardiorespiratory fitness scores compared to those of the other clusters. This cluster comprised 61 girls and 68 boys, 28% of the total sample size. Cluster 2 was named the "*average movers"* group (85 girls, 92 boys), including 38% of the total sample. Members of this cluster reported moderate MC and moderate muscular and cardiorespiratory fitness scores compared to those of the other groups. Cluster 3 was labelled the "*skilled movers"* group, which represents students with higher MC, higher muscular and cardiorespiratory fitness scores than two other clusters. This group comprised nearly 19% (49 girls, 38 boys) of the total sample. Cluster 4, which was identified as the *"expert movers"* group, comprised 15% of students (28 girls, 40 boys) with the highest MC, muscular and cardiorespiratory fitness scores compared to all other clusters. Based on the one-way ANOVA, the mean age ($F(3, 439) = .896$, $p = .443$) and variances ($F(3, 439) = .869$, $p = .457$) were equal in all clusters.

First, the results of the MANOVA, including gender and cluster membership as independent variables and BasicMath and ProbSol skills as dependent variables, showed no significant interaction effect between gender and cluster membership in ProbSol ($F(3, 378) = 1.89$, $p = .130$) nor BasicMath ($F(3, 378) = .57$, $p = .638$). Conversely, a significant main effect between cluster membership and BasicMath emerged ($F(3, 378) = 5.47$, $p <$

.001). No further significant main effects between cluster membership and ProbSol (F(3, 378) = 1.55, p = .200) or between gender and ProbSol (F(1, 378) = .65, p = .422) and BasicMath (F(1, 378) = 3.40, p = .066) were identified. Tukey's post hoc tests confirmed that Cluster 1 students (p < .001) and Cluster 2 students (p < .05) had lower BasicMath scores than Cluster 3 students. Adjusted squared multiple correlations (R^2) showed that the effect sizes were low, which explains 1.4% of the variance in the ProbSol scores and 3.7% of the variance in the BasicMath scores. Interestingly, results demonstrated that cluster 4 students did not have statistically significantly higher BasicMath scores than other clusters (p > 0.05).

Discussion

The aim of this study was to identify different movement profiles in adolescence and investigate if there are differences in BasicMath and ProbSol skills among existing movement profiles. This study revealed four movement profiles, which we named “poor movers”, “average movers”, “skilled movers” and “expert movers”. The results showed that “poor” and “average movers” exhibited lower levels of BasicMath skills than “skilled movers”. There were no differences among the profiles for ProbSol skills.

Our findings are consistent with previous studies, which revealed three or four movement profiles[19, 20] and demonstrated substantial differences in the MC and HRF variables among clusters.[20] Especially, rather large (n = 129, 28% of the total sample) cluster “poor movers” received much lower results in all physical measures than any other clusters. Note that the results of the “poor movers” cluster in the 20mSRT were below the healthy fitness zone described in Fitnessgram reference guide. These results are worrisome as it is well known that sufficient cardiorespiratory fitness in childhood affects health and cardiorespiratory risk factors in adulthood.[28] A similar alarming trend was observed in muscular fitness test results, where “poor movers” had remarkably poorer performances than any other cluster. Research has indicated that muscular fitness is related to several positive health effects in childhood and adolescence.[29] Therefore, weak performances of the “poor movers” in the muscular fitness tests should be considered an incentive to implement PA interventions for these students.

To our knowledge, this research was the first study to investigate if different movement profiles differ in BasicMath and ProbSol skills. The results showed that “poor” and “average movers” exhibited lower levels of BasicMath skills than “skilled movers” but no differences existed in ProbSol skills between clusters. These results partly support previous studies, which indicated associations between cardiorespiratory fitness, muscular fitness, MC and mathematical skills.[14,15,17,18] The results of this study suggest that children who have lower cardiorespiratory and muscular fitness and MC also perform poorer in BasicMath skills than their peers who perform better in physical tests. This is an alarming finding because it demonstrates some students have challenges in both physical and academic domains.

Previous studies have demonstrated that socioeconomic status influences neural development in childhood and adolescence.[30] Although this mechanism remains unclear, students’ socioeconomic status may have caused the association between physical and basic math skills in this sample. Students with higher socioeconomic status may have, for example, more opportunities for organized sports[31] and live in an environment that values intellectual knowledge comparing with students with lower socioeconomic status.[32] Therefore, differences in physical and math performances may be influenced by various inputs for exercise and academic domain in childhood and adolescence. It should be recognized that we did not measure students’ socioeconomic status in this study and therefore this remain speculation. Previous research has also explained relations of MC, HRF and academic performance by the beneficial effect of physical exercise on cognitive skills (e.g., executive functions).[33] However, it should be recognized that the focus of this study was not to analyze the effect of MC and HRF on brain functioning.

It was an interesting finding that the best physical performance profile, “expert movers”, did not address the statistically significantly better BasicMath skills than the two lowest profiles. The reason may be that these students are physically very active in sport clubs and during their leisure time. It is possible that this active time reduces the time spent on homework. This explanation is based on the fact that especially BasicMath skills are learned in school-based activities such as through homework.[5,6] However, it should be recognised that although the differences were not statistically significant, “expert movers” achieved better results in the BasicMath and ProbSol tests than the two lowest profiles.

This study has few limitations. First, we were not able to measure socioeconomic status of students’ families. Secondly, cross-sectional data does not allow us to draw causal conclusions. Thirdy, it should be recognised that “skilled movers” and “expert movers” profiles were rather small, which weakens the statistical power of the analyses. Lastly, one of the limitations is that we only measured math performance. Future studies should also investigate if other academic domains (e.g. reading) have associations with students’ motor performance. In future studies, it would be beneficial to add open problems with multiple correct answers to ProbSol instrument to enhance students’ creativity. Additionally, previous studies have demonstrated that PA interventions have also contributed to academic performance[34], including mathematical skills.[18] In the future, these intervention studies should be targeted especially for students who have weak HRF and MC and investigate whether increases in PA engagement, and subsequently, physical performance have a positive association with BasicMath and ProbSol skills.

Acknowledgements

Authors want to acknowledge Finnish Ministry of Culture and Education which funded this study.

Declaration of interest statement

No competing agreements, professional relationships and financial interests existed where a third party may benefit from the presented results.

References

1. Tremblay MSJ, Barnes DJ, González SA, et al. Global matrix 2.0: report card grades on the physical activity of children and youth comparing 38 countries. J Phys Act Health, 2016; 13(2):s343-s366.
2. Huotari P, Watt A, Heikinaro-Johansson P. et al. Fundamental movement skills in adolescents: Secular trends from 2003 to 2010 and associations with PA and BMI. Scand J Med Sci Sports, 2018;28(3): 1121-1129.
3. Huotari P, Nupponen H, Laakso L, et al. Secular trends in aerobic fitness performance in 13–18-year-old adolescents from 1976 to 2001. Bri J Sports Med, 2012; 44(13):968-972.
4. Syväoja HJ, Kankaanpää A, Joensuu L, Kallio J, Hakonen H, Hillman CH, Tammelin TH. The Longitudinal Associations of Fitness and Motor Skills with Academic Achievement. Medicine and Science in Sports and Exercise, 2079;51(10):2050-2057.
5. Geary DC, Hoard MK, Nugent L, et al. Adolescents' Functional Numeracy is predicted by their school entry number system knowledge. PloS ONE 2013; 8(1):e54651.
6. Siegler RS, Braithwaite DW. Numerical development. Annu Rev Psychol 2017; 68(1):187-213.
7. Schoenfeld AH. Learning to Think Mathematically: Problem Solving, Metacognition, and Sense Making in Mathematics. J Educ 2016; 196(2):1-38.

8. Grønmo LS, Lindqvist M, Arora A et al. TIMSS 2015 Mathematics Framework, Chapter 1 in TIMSS 2015 Assessment Frameworks, Boston College, 2013, 11-27.
9. Hakkarainen A, Holopainen L, Savolainen H. A five-year follow-up on the role of educational support in preventing dropout from upper secondary education in Finland. J Learn Disab 2015; 48(4) 408-421.
10. McCloskey M. Quantitative literacy and developmental dyscalculias, in Why is math so hard for some children? The nature and origins of mathematical learning difficulties and disabilities, 415-429, Baltimore, Paul H. Brooks Publishing Co., 2009.
11. Caspersen CJ, Powell KE, Christenson GM. Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. Public Health Rep 1985; 100(2):126-131.
12. Chaddock-Heyman L, Erickson KI, Kienzler C, et al. The role of aerobic fitness in cortical thickness and mathematics achievement in preadolescent children. PLoS One 2015; 12(10):e0134115.
13. Huang, T, Tarp J, Domazet SL, et al. Associations of Adiposity and Aerobic Fitness with Executive Function and Math Performance in Danish Adolescents. J Pediatr 2015; 167(4):810-815.
14. Santana CCA, Azevedo LB, Cattuzzo MT, et al. Physical Fitness and academic performance in youth: A systematic review. Scand J Med Sci Sports 2017; 27(6):579-603.
15. Bass RW, Brown DD, Laurson KR, et al. Physical fitness and academic performance in middle school students. Acta Paediatr 2013; 102(8):862-837.
16. Wittberg RA, Northrup KL, Cottrell LA. Children's aerobic fitness and academic achievement: a longitudinal examination of students during their fifth and seventh grade years. Am J Public Health 2012; 102(12):2303-2307.

17. Coe DP, Peterson T, Blair C, et al. Physical fitness, academic achievement, and socioeconomic status in school-aged youth. J Sch Health 2013; 83:500-507.

18. Ericsson I, Karlsson MK. Motor skills and school performance in children with daily physical education in school - a 9-year intervention study. Scand J Med Sci Sports 2014; 24(2):273-278.

19. Jaakkola T, Yli-Piipari S, Stodden DF, et al. Identifying Childhood Movement Profiles and Tracking Physical Activity and Sedentary Time Across One Year. Transl Sports Med 2020; 3: 480-487

20. De Meester A, Stodden DF, Brian A, et al. Associations among Elementary School Children's Actual Motor Competence, Perceived Motor Competence, Physical Activity and BMI: A Cross-Sectional Study. Plos ONE 2016; 11(10):e1064600.

21. Kiphard EJ, Schilling F. Körperkoordinationstest für Kinder 2, überarbeitete und ergänzte Aufgabe., Weinham: Beltz Test, 2007.

22. Jaakkola T, Sääkslahti A, Liukkonen J, et al. Peruskoululaisten fyysisen toimintakyvyn seurantajärjestelmä [The system to develop and follow Finnish students' physical fitness and motor skills]. University of Jyväskylä: Faculty of Sport and Health Sciences, 2012.

23. Léger LA, Mercier D, Gadoury C, et al. The multistage 20 metre shuttle run test for aerobic fitness. J Sports Sci 1988; 6:93-101.

24. Mayorga-Vega D, Aguilar-Soto P, Viciana J. Criterion-related validity of the 20-m shuttle run test for estimating cardiorespiratory fitness: A meta-analysis. J Sports Sci Med 2015; 14(3):536-547.

25. Räsänen P, Leino L. KTLT-Laskutaidon testi luokka-asteille 7-9 [KTLT–A test for basic mathematical skills for Grades 7-9]. Niilo Mäki Instituutti, Jyväskylä, 2005.

26. Mintjens S, Menting MD, Daams JG, et al. Cardiorespiratory Fitness in Childhood and Adolescence Affects Future Cardiorespiratory Risk Factors: A Systematic Review of Longitudinal Studies. Sports Med 2018; 48(11):2577-2605.

27. Smith JJ, Eather NMPJ, Plotnikoff RC, et al. The health benefits of muscular fitness for children and adolescents: a systematic review and meta-analysis. Sports Med 2014; 44(9):1209-1223.

28. Hackman DA, Farah MJ, Meaney MJ. Socioeconomic status and the brain: mechanistic insights from human and animal research. Nat Rev Neurosci 2010; 11(9):651–659.

29. Santos MP, Esculcas C, & Mota J. The relationship between socioeconomic status and adolescents' organized and nonorganized physical activities. Pediatr Exerc Sci 2004; 16(3): 210-218.

30. Blums A, Belsky J, Grimm K, & Chen Z. Building links between early socioeconomic status, cognitive ability, and math and sciecen achievement. J Cogn Dev 2016; 18(1): 16-40.

31. Howie EK, Pate RR. Physical activity and academic achievement in children: A historical perspective. J Sport Health Sci 2012; 1(3):160-169.

32. Singh AS, Saliasi E, Van Den Berg V, et al. Effects of physical activity interventions on cognitive and academic performance in children and adolescents: a novel combination of a systematic review and recommendations from an expert panel. Bri J Sports Med 2019; 53(10):640-647.

Table 1. Correlation coefficients, means, standard deviations, and gender differences in the study variables.

		1	2	3	4	5	6	7	8	M	SD	W_t
1. Five-jump	♀	-	$.43^{***}$	$.54^{***}$	$.57^{***}$	$.52^{***}$	$.42^{***}$	$.22^{**}$	$.24^{***}$	8.06	.96	.03(.10)
	♂		$.29^{***}$	$.57^{***}$	$.57^{***}$	$.51^{***}$	$.41^{***}$	.05	.11	8.02	1.05	
2. Throw-catch	♀			$.36^{***}$	$.34^{***}$	$.30^{***}$	$.28^{***}$	.13	$.26^{***}$	12.18	4.69	-.46(.46)
	♂			$.44^{***}$	$.39^{***}$	$.40^{***}$	$.28^{***}$	.14	$.18^{*}$	12.67	5.13	
3. Side-to-side	♀				$.40^{***}$	$.63^{***}$	$.53^{***}$	$.23^{**}$	$.29^{***}$	39.92	6.54	.99(.67)
jump	♂				$.45^{***}$	$.66^{***}$	$.45^{***}$	.13	$.29^{***}$	38.84	7.67	
4. Cardiorespiratory	♀					$.50^{***}$	$.35^{***}$	.14	.13	37.76	17.76	$-4.19(1.92)^{*}$
fitness	♂					$.47^{***}$	$.32^{***}$	$.17^{*}$	$.17^{*}$	41.90	22.86	
5. Push-up	♀						$.55^{***}$	$.15^{*}$	$.26^{***}$	21.42	12.78	$7.51(1.20)^{***}$
	♂						$.45^{***}$	.13	$.18^{**}$	14.11	12.83	
6. Sit-up	♀							$.18^{*}$	$.25^{***}$	42.49	20.91	$4.47(2.00)^{*}$
	♂							.04	$.16^{*}$	38.84	21.65	
7. ProbSol total	♀								$.54^{***}$	3.55	1.89	-.14(.19)
	♂								$.59^{***}$	3.79	2.01	
8. BasicMath total	♀								-	16.12	6.07	-1.00(.57)
	♂									17.33	6.07	

Note 1. Girls (♀), boys (♂), mean (M), standard deviation (SD), Wald's test (Wt), standard errors in the parentheses.

Note 2. ***p < .001, **p < .01, *p < .05.

Table 2. The parameter estimates for the latent cluster solutions.

Group	Parameters	AIC	BIC	SSA-BIC	pLMR	LT1%	LT5%
1	6	4956	4981	4962	-	0	0
2	10	4643	4684	4652	.000	0	0
3	14	4570	4628	4583	.095	0	0
4	18	4537	4612	4555	.047	0	0
5	22	4513	4604	4534	.215	0	0
6	26	4501	4609	4526	.033	1	1
7	30	4486	4610	4515	.325	0	1
8	34	4480	4621	4513	.224	0	3

Note 1. AIC = Akaike's information criterion; BIC = Bayesian Information Criterion; SSA-BIC = Sample-size Adjusted Bayesian Information Criterion; pLMR = Lo-Mendell-Rubin likelihood ratio test; LT = less than.

Table 3. Means and standard deviations (in the parentheses) of the study variables by clusters.

	Cluster 1 N = 129 Mage = 12.27 (.34) “Poor”	Cluster 2 N = 177 Mage = 12.26 (.32) “Average”	Cluster 3 N = 87 Mage = 12.28 (.29) “Skilled”	Cluster 4 N = 68 Mage = 12.34 (.33) “Expert”
5-leaps	7.09 (.78)	8.11 (.71)	8.60 (.66)	9.12 (.72)
Throw-catch	8.65 (4.11)	13.10 (4.46)	14.22 (4.07)	16.05 (3.74)
Side-to-side jump	32.62 (5.22)	39.57 (4.96)	44.76 (4.95)	46.07 (5.81)
Cardiorespiratory fitness	20.81 (9.99)	40.95 (13.78)	41.38 (11.69)	74.08 (12.14)
Push-up	6.90 (8.41)	15.55 (8.78)	30.41 (10.70)	30.68 (11.81)
Sit-up	25.95 (14.29)	35.82 (16.19)	63.29 (16.23)	55.87 (19.76)
ProbSol total	3.46 (1.87)	3.52 (1.93)	3.96 (1.93)	4.13 (2.12)
BasicMath total	15.30 (6.44)	16.62 (5.78)	18.56 (5.95)	17.69 (5.74)