Author(s): Huhtiniemi, Mikko; Jaakkola, Timo; Seppälä, Sanni; Lahti, Jukka; Salin, Kasper; Hakonen, Harto; Stodden, David F.

Title: Motor competence, perceived physical competence, physical fitness, and physical activity within Finnish children

Year: 2019

Version: Accepted version (Final draft)

Please cite the original version:

Huhtiniemi, M., Jaakkola, T., Seppälä, S., Lahti, J., Salin, K., Hakonen, H., & Stodden, D. F. (2019). Motor competence, perceived physical competence, physical fitness, and physical activity within Finnish children. Scandinavian Journal of Medicine and Science in Sports, 29(7), 1013-1021. https://doi.org/10.1111/sms.13412

DR TIMO JAAKKOLA (Orcid ID : 0000-0003-1227-2460)

DR MIKKO HUHTINIEMI (Orcid ID : 0000-0002-1643-2671)

Article type : Original Article

Motor competence, perceived physical competence, physical fitness, and physical activity within Finnish children

Jaakkola, T[1]., Huhtiniemi, M[1]., Salin K[1]., Seppälä, S[1]., Lahti, J[1]., Hakonen, H[2]. & Stodden, D.F. [3]

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

[2]LIKES Research Centre for Physical Activity and Health, Jyväskylä, Finland.

[3]Department of Physical Education, University of South Carolina, US.

Running head: Motor performance and physical activity

Corresponding author:

Dr 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

This article has been accepted for publication and undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process, which may lead to differences between this version and the Version of Record. Please cite this article as doi: 10.1111/sms.13412

Abstract

The purpose of this study was to investigate reciprocal relationships among students' motor competence (MC) (leaping, throwing, catching, jumping skills), perceived physical competence, health-related fitness (HRF) (20 m. shuttle run, push-up, abdominal muscles endurance tests) and objectively measured moderate-to-vigorous physical activity (MVPA). Participants included 422 Grade 5 Finnish children (246 girls). Two separate structural equation models investigated paths 1) from MC through both perceived physical competence and HRF to MVPA, and 2) from MVPA through both perceived physical competence and HRF to MC. Model 1 demonstrated an indirect path from MC through HRF to MVPA and a direct path from MC to perceived physical competence for both boys and girls. Additionally, model 1 revealed a direct path from perceived physical competence to MVPA for the girls and from MC to MVPA for the boys. MC, perceived physical competence and HRF explained 13% of variance in MVPA for the girls and 25% for the boys. Model 2 indicated indirect paths from MVPA through perceived physical competence to MC and from MVPA through HRF to MC for both boys and girls. Additionally, a direct path from MVPA to MC was found in the boys' group. MVPA, perceived physical competence and HRF explained 48% of variance in MC for the girls and 53% for the boys. Results of this study provide preliminary support for the reciprocal nature of relationships among MC development, perceived physical competence, HRF and MVPA.

Introduction

Children and adolescents' engagement in physical activity has decreased and sedentary behavior has increased in most Western countries across the previous three decades.[1,2] Motor skill development and physical fitness also have demonstrated secular decline.[3,4] Declining levels in these important health-related variables in youth are suggested to negatively impact various outcomes including cardiovascular and metabolic disease, diabetes[5] and academic performance.[6] Unfortunately, reversing secular decline in these precursors to long-term health has proven to be difficult.[7] However, emerging evidence indicates the development of a strong foundation of motor competence (MC) may be a critical antecedent to promoting and sustaining positive trajectories of physical activity (PA) and health-related fitness (HRF).[7,8] Specifically, Stodden et al[8] suggest the development of adequate PA, fitness and MC levels should be viewed using a developmental perspective. This unique perspective suggests that causal pathways among variables are not necessarily unidirectional in nature. Antecedent/consequent mechanisms are hypothesized to change based on important developmental windows across childhood. One critical developmental change is a child's cognitive development, which is linked to children's ability to more accurately estimate their own competence (e.g., in fundamental movement skills). The linking of physical and psychological development across time and the hypothesized reciprocal relationships among variables in the Stodden et al[8] model has led to a substantial increase in studies on the importance of developing MC.[7]

The development of MC constitutes a foundation for human motor behavior as these skills are noted as both direct and indirect building blocks for a multitude of lifetime activities.[8,9,10] The development of a strong foundation of MC requires the development of coordination and control of complex multisegmental movements that are grouped according to their focus on stability, locomotion, and manipulation/projection of objects.[11] The development of MC does not occur "naturally" and requires sufficient practice and experiences to successfully apply these skills in various activities that inherently require their application[8,11]. Strong evidence demonstrates that MC performance is positively associated with both physical activity engagement in childhood and adolescence[7,10,12,13,14] and multiple aspects of health-related fitness.[15] Also, influencing the relationship between MC development and PA and physical fitness is an individual's perception of their competence in MC[8].

Perceived competence has been defined as judgement of personal ability that generalizes across domains, such as physical activity, sport, school, or social interaction.[16] Perceived physical competence is suggested to be comprised of interactions within different PA environments.[17] The development of perceived physical competence specifically aligns with the development of competence in MC as children's cognitive capacity to understand their own competence improves across time.[17,18] However, a recent article of Estevan et al[19] suggested there is a controversy in the literature based on what concept researchers are attempting to address when referring perceived physical competence (e.g., perceived physical competence, perceived motor competence, perceived motor proficiency, perceived physical ability, perceived physical self-concept, perceived sports/athletic competence).

Notwithstanding the language controversy, systematic reviews have demonstrated the association between perceived physical competence and children's physical activity[20,21], with a recent meta-analysis specifically noting it as the strongest predictor of physical activity among various aspects of self-concept.[22] Longitudinal data also demonstrates the long-term impact of perceived physical competence (i.e., sports competence and physical competence) on physical activity from childhood into adolescence.[23,24] Importantly, it is hypothesized that the strength of association between perceived physical competence and physical activity may increase as children age[22], perhaps as a consequence of the concomitant increase in strength of associations between actual MC and perceived physical competence.[18]

When including actual MC and perceived physical competence to predict PA levels, research has consistently demonstrated that both variables influence physical activity levels with perceived physical competence tending to demonstrate, in a few studies, stronger direct associations with physical activity in late childhood into adolescence.[23,25] However, when assessing PA objectively (e.g., accelerometry) as opposed to subjectively (e.g., self-report), actual competence rather than perceived physical competence has shown to be more predictive of PA levels.[7,26,27] The equivocal nature of data examining the potential impact of actual competence and perceived physical competence indicates that further research is necessary to elucidate the relationships among these variables. The changes in strength of associations among actual MC and perceived physical competence across age speaks to the developmental trajectory hypothesis noted in Stodden and colleagues [8] conceptual model. This additional hypothesis may provide insight on equivocal data relating to the impact of perceived physical competence and MC on PA.

Sex, skill type and culture may be additional confounding factors when addressing relationships among MC and perceived physical competence and PA. Barnett et al[23] and Khodaverdi et al[28] found that physical self-perception mediated the relationship between childhood MC proficiency and subsequent adolescent self-reported physical activity. However, the Barnett et al[23] data indicated only object projection/manipulative skills in both Australian boys and girls predicted PA; whereas Kodaverdi et al[28], (in a sample of Iranian girls) found only locomotor skills to predict PA. In contrast, De Meester et al[29], in a sample of 7-11 children from the U.S., did not find that perceived physical competence mediated the relationship between actual competence and PA. Overall, limited studies have addressed the mediating influence of physical self-perception on the PA-MC relationship and additional study is warranted to address the multiple potential confounding factors in this relationship and how it impacts other outcome variables.

Another important construct that plays a role in children's physical activity levels is health-related fitness. Increased fitness levels (i.e., cardiorespiratory endurance, musculoskeletal fitness and a healthy body weight status) may promote sustained physical activity for a longer period of time and also is consistently associated with MC across childhood and into early adulthood[15,30]. It also is hypothesized to mediate the relationship between actual MC and physical activity.[8] Khodaverdi et al[28] is the only known study to demonstrate the hypothesized mediating role of health-related fitness on the MC-PA relationship. Overall, the interplay among MC and perceived physical competence and physical fitness also seems critical for promoting health-enhancing physical activity across childhood and adolescence.[8]

While the potential impact that MC and perceived physical competence have on PA and health-related fitness has gained increased attention in the public health realm, tenets of the entire Stodden et al[8] model have not yet been empirically tested. Specifically, limited studies have tested the hypothesized reciprocal nature of all the variable interactions and pathways in the model.[26,31] Overall, examining interactions and the potential reciprocal nature among all variables in the model across time will be a significant addition to the literature in this area.

The aim of this study was to investigate associations among MC and perceived physical competence, health-related fitness and objectively measured moderate-to-vigorous physical activity in a large sample of Finnish children. As the suggested relationships among these variables may be reciprocal, two models were created to investigate pathways among variables in both directions; a) from MC to MVPA, and b) from MVPA to MC. Additionally, the moderating effect of gender was examined to delineate potential differences between the boys and the girls pathways in the interactions among variables.[14] The hypothesized model is presented in the figure 1.

Methods

Participants and procedure

A convenience sample of 422 (176 boys and 246 girls, M = 11.26; SD = 0.31) Finnish children from Southern and Western Finland participated in the study. Researchers collected MC and physical fitness data during their physical education classes. Accelerometers were provided to students and the perceived physical competence questionnaire was collected in classroom at school. A letter on the appropriate use of accelerometers were given to the parents. Additionally, teachers were informed to confirm every morning that the students wore accelerometers. Parental/guardian consent and verbal assent from students was attained before participating in the study. The Human Research Ethics Committee of the local University gave permission to conduct the study. Consent rate of participants was 81 %.

Measurements

Motor competence. MC was assessed via the measurement of the following fundamental movement skills: 1) 5-leaps test[32]; 2) throwing-catching combination test[33]; and 3) two-legged jumping from side to side test.[34] All assessments MC have been used extensively in Finnish sport science studies and tests have indicated acceptable validity and reliability within children and adolescents.[31,32] More accurate description of each test is provided in Table 1. Because all three MCMC tests had different scales, a standardized MC variable was created using Z-scores and used for further analyses.[29]

Perceived physical competence. Perceived physical competence was assessed by using the Finnish version of the sport competence dimension of the Physical Self-Perception Profile (PSPP).[35] The individual item stem of the scale is: ”*What am I like?*”, and all five items of the PSPP are rated on a five-point scale (e.g., *1 = I'm among the best when it comes to athletic ability… 5 = I'm not among the best when it comes to athletic ability*). A previous study with Finnish children has demonstrated the Finnish version of the sport competence dimension of the PSPP has acceptable construct validity (confirmatory factor analysis; CFI = .98, TLI = .97, RMSEA = .074) and internal consistency (Cronbach's alpha .90).[36]

Moderate-to-vigorous physical activity. Objective MVPA was measured by Actigraph wGT3X+ accelerometers. Participants were instructed to continuously wear a device on the right hip during waking hours for seven consecutive days, except while bathing or doing other water-based activities. Data was collected as raw accelerations a frequency of 30 Hz, standardly filtered and converted into 15-s epoch counts. A customized Visual Basic macro for Excel software was used for data reduction. A valid day of PA monitoring included measured values ≥500 min/day for at least two weekdays and one weekend day between general waking hours (i.e., between 7:0023:00). Periods of 30 min of consecutive zero counts were defined as non-wearing time, and values over 20,000 counts per minute (cpm) were ruled out as spurious accelerations[37]. Evenson et al's[38] cut-points were used to calculate MVPA (≥2296 cpm).

Physical fitness. Physical fitness for boys and girls was analyzed by three tests: 1) 20 meter shuttle run test[39]; 2) abdominal muscle endurance test[33]; and 3) push-up tests[33.] All tests have been extensively used in Finnish sport science studies and they have demonstrated satisfactory validity and reliability within children and adolescent samples[33,34]. Descriptions of each test are provided in Table 1. Because all physical fitness tests have different scales, a standardized physical fitness sum variable was created by using Z-scores and used for analyses.[30]

Data Analyses

Before conducting statistical analyses, we imputed missing values, removed outliers and checked normality of the data. Descriptive statistics were used to summarize the data. Pearson's correlation coefficients and multigroup structural equation modeling (SEM)[40] was used to investigate associations among MC, perceived physical competence, MVPA and physical fitness for girls and boys separately. Two separate models were created to investigate paths 1) from MC through perceived physical competence and HRF to MVPA, and 2) from MVPA through perceived physical competence and HRF to MC. Roles of perceived physical competence and HRF were tested by analyzing indirect associations between independent and dependent variables in both models. To determine the appropriateness of the two SEM models, the Comparative Fit Index (CFI), the Tucker-Lewis Index (TLI), and the Root Mean Square Error of Approximation (RMSEA) indices were conducted[41]. The CFI and TLI indices vary from 0 to 1, and indices greater than 0.90 represent satisfactory model fit. Additionally, an RMSEA index score of lower than 0.10 shows acceptable model fit. Lastly, the normed chi-square index ($\chi 2/df$) representing parsimonious fit is suggested to be below the marginal maximum of 3.00.[42] Mplus 7.2 software was used to conduct all statistical analyses.[41]

Results

Descriptives and correlations. Descriptive statistics are presented in Table 2. Correlation coefficients showed that MC had moderate to high positive intercorrelations and high correlations with the MC sumscore. A similar pattern of results was found from tests measuring students' physical fitness and physical fitness sumscore. Correlations also indicated that MC sumscore and physical fitness sumscore had moderate positive associations with MVPA in both boys and girls. Subsequently, perceived physical competence had low to moderate positive associations with MC sumscore, physical fitness sumscore and with MVPA. Correlations among study variables are presented in Table 3.

Structural equation modeling (SEM). Descriptive statistics demonstrated that all scale scores were normally distributed. Therefore, we applied Maximum likelihood estimation method (ML) as suggested by Muthen and Muthen.[41] Additionally, we used squared multiple correlations (R^2) to calculate the proportion of explained variance of dependent variables. Subsequently, the equality of the coefficients between the girls and the boys were compared by using the χ^2 difference test.

Results indicated that the model 1 had a good fit to the data: $\chi2$ (7) = 10.47; p = .16; CFI = .99; TLI = .99; RMSEA = .048). Model 1 showed three direct paths in both gender groups: 1) from MC to perceived physical competence; 2) from MC to HRF; and 3) from HRF to MVPA. Additionally, model 1 demonstrated a direct path from perceived physical competence to MVPA for the girls and from MC to MVPA for the boys. Model 1 also indicated a significant indirect path from MC through perceived physical competence to MVPA for the girls (standardized estimate = .06 (.03); p = .015). Subsequently, model 1 revealed significant indirect paths from MC through HRF to MVPA for the girls (standardized estimate = .19 (.04); $p < .001$) and for the boys (standardized estimate = .20 (.06); p = .001). Squared multiple correlations showed that MC, perceived physical competence and HRF explained 13 % of variance in MVPA for the girls and 25 % for the boys.

Model 2 also had a good fit to the data: $\chi2$ (6) = 8.30; p = .22; CFI = 1.00; TLI = .99; RMSEA = .043). Model 2 showed four direct paths in both gender groups: 1) from MVPA to perceived physical competence; 2) from MVPA to HRF; 3) from perceived physical competence to MC; and 4) from HRF to MC. Additionally, model 2 demonstrated direct path from MVPA to MC for the boys. Model 2 revealed also significant indirect paths from MVPA through perceived physical competence to MC for the girls (standardized estimate = .04 (.02); p = .015) and for the boys (standardized estimate =.06 (.02); p = .010). Model 2 also revealed indirect paths from MVPA through HRF to MC for the girls (standardized estimate = .21 (.04); p = .000) and for the boys (standardized estimate =.25 (.04); p < .001). Squared multiple correlations indicated that MVPA, perceived physical competence and HRF explained 48 % of variance in MC for the girls and 53 % for the boys. Both models are presented in Figure 2.

Discussion

The aim of this study was to investigate reciprocal relations among motor competence, perceived physical competence, health-related physical fitness, and objectively measured moderate-to-vigorous physical activity in Finnish children. Two separate models were created to investigate paths 1) from MC through perceived physical competence and HRF to MVPA, and 2) from MVPA through perceived physical competence and HRF to MC. To our knowledge, this was the first attempt to examine relations among all variables in the Stodden et al[8] model, via a large cross-sectional sample of boys and girls.

Both models demonstrated satisfactory fit and, thus, provided preliminary support for the assumption of the reciprocal nature of relationships among all variables in the model. More specifically, the model suggests that in middle and late childhood associations among independent and dependent variables are reciprocal.[8] Data from this study almost fully supported these assumptions. The boys' path between perceived physical competence and MVPA was the only nonsignificant association suggested in both models.[8]

Data indicated that MC and MVPA were reciprocally and directly associated with each other but only in the boys' group. Thus, the reciprocal associations between MC and MVPA for the boys only partially supported the developmental model.[8] An important developmental aspect of the conceptual model[8] suggests the strength of association between MC and physical activity should increase across early to middle and late childhood. As this sample of children was limited to one age group, this aspect of the model could not be tested. However, the data suggests that the MVPA pathway model demonstrated stronger predictive utility for MC levels, as opposed to MC levels predicting MVPA. The fact that MC and MVPA were not directly associated in the girls' group was an additional interesting finding and suggests the direct association between MC proficiency and participation in moderate-to-vigorous PA may be different for 11 years-old girls and boys.

This study also demonstrated some significant indirect paths between independent and dependent variables. One interesting finding was that there was an indirect path from MC through perceived physical competence to PA engagement for the girls but not for the boys. This finding contrasts with Babic et al[22] systematic review which suggested that sex was not a moderator in the association between perceived physical competence and PA engagement. However, our finding suggests that an individual's perceptions of their competence in sport and physical activity settings, where perceived physical competence also is aligned with their actual competence,[25] may significantly affect PA more for the girls than the boys. This may imply that physical education teachers should support girls' perceived physical competence and their continued participation in various sport and physical activity settings.

This study also demonstrated indirect paths from MC through HRF to PA and from PA through HRF to MC for the boys and the girls. To our knowledge, this is only the second attempt to investigate indirect associations among these variables[28] and the first with objectively assessed MVPA. This finding supports the Stodden et al (2008)[8] proposition suggesting that improved HRF would facilitate sustained engagement in PA, specifically moderate and vigorous types of activities, and vice versa.

Limitations and future studies. One limitation of this study is cross-sectional design of data collection process. This shortcoming confounds drawing causal conclusions among study variables and whether associations among variables changes over time, which are important aspects of the Stodden et al[8] model yet to be assessed. Another limitation is the lack of maturational data on children, which may have impacted associations among study variables. The third limitation of this study is that we measured a limited number of MC and HRF variables due to constraints of the study. Assessing a broader range of both process- and product-oriented aspects of MC will provide a more comprehensive assessment of MC and potentially provide great predictive utility on outcome variables.[7] Future longitudinal and experimental studies also are needed to better understand associations and causative pathways among actual and perceived physical competence, HRF and PA across childhood, as well as into adolescence and adulthood.

Perspective

Insufficient physical activity and increased sedentariness will lead to issues with children and adolescents' health and well-being. There are many studies demonstrating that motor and perceived physical competence and health-related fitness are significant variables linked physical activity engagement. There is, however, a lack of research investigating associations among all these variables in childhood and adolescence. This study provided preliminary support for the assumption of the reciprocal nature of relationships among motor and perceived physical competence, health-related fitness and physical activity engagement in late childhood. School physical education, sport clubs and other community organizations are important contexts to foster and support the development of motor skills, facilitate health-enhancing physical fitness and promote positive self-perception towards physical activity engagement.

References

1. Nelson M., Neumark-Stzainer D, Hannan PJ, et al. Longitudinal and Secular Trends in Physical Activity and Sedentary Behavior During Adolescence. *Pediatrics.* 2006;118(6):1627–1634.
2. Tremblay MS, Barnes JD, 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:S343 -S366.
3. Huotari PRT, 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.

4. Huotari PRT, Nupponen H, Laakso L, et al. Secular trends in aerobic fitness performance in 13–18-year-old adolescents from 1976 to 2001. *Brit J Sport Med.* 2012;44:968-972.

5. Janssen I, LeBlanc AG. Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *Int J Behav Nutr Phys Act.* 2010;7:40.

6. Donnelly JE, Hillman CH, Castelli D, et al. Physical Activity, Fitness, Cognitive Function, and Academic Achievement in Children: A Systematic Review. *Med Sci Sports Exerc.* 2016;48(6):1197-222.

7. Robinson LE, Stodden DF, Barnett LM, et al. MC and its effect on positive developmental trajectories of health. *Sports Med*. 2015;45(9):1273–1284.

8. Stodden DF, Goodway JD, Langendorfer SJ, et al. A developmental perspective on the role of motor skill competence in physical activity: An emergent relationship. *Quest*. 2008;60:290–306.

9. Hulteen RM, Morgan PJ, Barnett LM, et al. Development of foundational movement skills: A conceptual model for physical activity across the lifespan. *Sports Med.* 2018;7:1533–1540.

10. Barnett LM, Stodden DF, Kohen CE, et al. Fundamental movement skills: An important focus. *J Teach Phys Educ.* 2016;5:219 -225.

11. Donnelly FC, Mueller SS, Gallahue DL. Developmental physical education for all children. Theory into practice. Champaign, IL: Human Kinetics; 2017.

12. Barnett LM, van Beurden E, Morgan PJ, et al. Childhood motor skill proficiency as a predictor of adolescent physical activity. *J Adolesc Health*. 2009;44:252–259.

13. Jaakkola T, Yli-Piipari S, Huotari P, et al. Fundamental movement skills and physical fitness as predictors of physical activity: A 6-year follow-up study. Scand J Med Sci Sports 2016;26:74-81.
14. Logan SW, Webster K, Getchell N, et al. Relationship between Fundamental Motor Skill Competence and Physical Activity During Childhood and Adolescence: A Systematic Review. *Kines Rev.* 2015;4(4):416–426.
15. Cattuzzo MT, Dos Santos Henrique R, Ré AH, et al. MC and health related physical fitness in youth: A systematic review. J Sci Med Sport. 2016;19(2):123-9.
16. Fox KR. The physical self and processes in self-esteem development. In: Fox KR, ed. The physical self: from motivation to well-being. Champaign, IL, Human Kinetics; 1997:111–139.
17. Harter S. Effectance motivation reconsidered: toward a developmental model. *Hum Develop*. 1978;21;34–64.
18. True L, Brian A, Goodway J, Stodden DF. Relationships among product and process-oriented measures of motor skill competence and perceived competence in boys and girls. *J Mot Learn Dev.* 2017: 1-23.
19. Estevan I, Barnett LM. Considerations Related to the Definition, Measurement and Analysis of Perceived Motor Competence. *Sports Med*. 2018.
20. Seabra AC, Seabra AF, Mendonca DM, et al. Psychosocial correlates of physical activity in school children aged 8–10 years. *Eur J Public Health.* 2013;23:794–798.5.
21. Sallis JF, Prochaska JJ, Taylor WC. A review of correlates of physical activity of children and adolescents. *Med Sci Sports Exerc.* 2000;32:963–975.

22. Babic MJ, Morgan PJ, Plotnikoff C, et al. Physical activity and physical self-concept in youth: A systematic review and meta-analysis. *Sports Med.* 2014;44:1589–1601.
23. Barnett LM, Morgan PJ, van Beurden E, et al. Perceived sports competence mediates the relationship between childhood motor skill proficiency and adolescent physical activity and fitness: a longitudinal assessment. *Int J Behav Nutr Phys Act.* 2008;5:40.
24. Jaakkola T, Yli-Piipari S, Watt A, et al. Perceived physical competence, motivation and enjoyment in physical education as longitudinal predictors of adolescents' self-reported physical activity. J Sci Med Sport. 2016;9(9):750-754.
25. De Meester A, Maes J, Stodden D, et al. Identifying configurations of actual and perceived MC among adolescents: associations with motivation towards physical education, physical activity and sports participation. *J Sports Sci.* 2016;34(21); 2027-2037.
26. Barnett LM, Morgan PJ, van Beurden E, et al. A reverse pathway? Actual and perceived skill proficiency and physical activity. *Med Sci Sports Exerc.* 2011;43:898–904.
27. McIntyre F, Parker H, Chivers P, et al. Actual competence, rather than perceived competence, is a better predictor of physical activity in children aged 6-9 years. *J Sports Sci.* 2018;36(13):1433-1440.
28. Khodaverdi Z, Bahram A, Stodden DF, et al. The relationship between motor skill competence and physical activity in children: Mediating roles of perceived MC and health-related physical fitness. *J Sports Sci.* 2016;34(16), 1523-1529.

29. De Meester A, Stodden DF, Goodway J, et al. Identification of a motor competence proficiency barrier for meeting physical activity guidelines. *J Sci Med Sport*. 2018;21:58-62.

30. Stodden DF, Langendorfer SJ, Roberto, MA. Associations among motor skill competence and physical fitness in young adults. *Res Quarter Exerc Sport.* 2009;80:223-229.

31. Lima RA, Pfeiffer KA, Larsen LR, et al. Physical activity and MC present a positive reciprocal longitudinal relationship across childhood and early adolescence. *J Phys Act Health.* 2017;14:440-447.

32. Nupponen H, Soini H, Telama R. Koululaisten kunnon ja liikehallinnan mittaaminen. [Measurement of school students' physical fitness and motor skills]. Research Reports on Sport and Health. 118. Jyväskylä: Research Center for Sport and Health Sciences; 1999.

33. 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.

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

35. Fox KR, Corbin CB. The physical self-perception profile: Development and preliminary validation. *J Sport Exerc Psyc*.1989;11:408-430.

36. Gråsten A. Students' physical activity, physical education enjoyment, and motivational determinants through a three-year school-initiated program. Studies in Sport, Physical Education, and Health, University of Jyväskylä, 205; 2014.

37. Heil DP, Brage S, Rothney MP. Modeling physical activity outcomes from wearable monitors. *Med Sci Sports Exerc.* 2012;44:S50–S60.

38. Evenson KR, Catellier DJ, Gill K, et al. Calibration of two objective measures of physical activity for children. *J Sports Sci.* 2008;26:1557–65.

39. Léger A, Lambert L. A multistage 20 m shuttle run test to predict VO2max. *Eur J Appl Physiol.* 1982;49:1–12.

40. Bentler PM. EQS structural equations program manual. Encino, CA: Multivariate Software; 1995.

41. Muthén LK, Muthén BO. Mplus user's guide. 7th ed. Los Angeles, CA: Muthén & Muthén; 1998-2014.

42. Kline RB. Principles and practice of structural equation modeling. 3rd ed. New York, NY: The Guilford Press; 2011.

Table. 1 Motor competence and physical fitness tests.

Tests	Method	Scoring
Motor competence		
Leaping test (leaping skill).	Complete five leaps, beginning with both legs, and finishing with legs in parallel position.	Length of the five leaps from the starting position to the heel of the leg furthest back upon landing.
The throwing-catching combination test (throwing and catching skills).	Throw a tennis ball to a 1.5 meters x 1.5 meters sized target area situated on the wall 90 centimeters above the floor level. Throwing distance for the girls is 7 meters and for the boys 8 meters. Students had 20 attempts to throw the ball behind the marked line, hit the target area and catch the ball after one bounce.	The number of correctly performed throwing-catching combinations are counted.
Two-legged jumping from side to side test (dynamic balance and agility).	Jump consecutively 15 seconds over a small wooden beam (60 × 4 × 2 cm) from one side to another. Jumps are performed legs in the parallel position.	The number of jumps over wooden beam in 15 seconds are counted. The test is conducted twice and the total score is the sum of these two attempts.
Physical fitness		
20 meters shuttle run test (cardiorespiratory endurance).	Run continuously between two lines 20 meters apart in time of recorded beeps from the tape. The time between recorded beeps decrease each level (Initial running velocity of 8.5 km/hr, and increasing by 0.5 km/hr each minute).	Number of shuttles reached before participants participant is unable to keep on pace (coming from tape) are counted.
Push-up tests (upper body muscular endurance/strength).	Boys' version: Start in up position where: 1) hands and toes touch floor; 2) body and legs are in a straight line; 3) the arms are at shoulder width apart; 4) feet are together. Keeping back and knees straight lower body until there is a 90-degree angle in elbows (with the upper arms parallel to the floor). Girls' version: Start in up position where: 1) hands and knees touch floor; 2) body and thighs are in a straight line; 3) the arms are at shoulder width apart; 4) knees are together. Keeping back and thighs straight lower body until there is a 90-degree angle in elbows (with the upper arms parallel to the floor).	Number of correctly completed push-ups are counted (max. 60 repetitions).
Abdominal muscles endurance test (abdominal muscles muscular endurance/strength).	Start by lying on your back and keep: 1) knees bent at 120 degrees; 2) legs slightly apart; 3) both feet on floor; 4) arms straight and parallel to the trunk with palms of hands resting on the floor; 5) stretch fingers out and keep head on floor. The measuring tape is located under participant's legs so that their fingertips are just resting on the	Number of correctly completed curl-ups reached before participant is unable to keep on pace (coming from tape) are counted.

	nearest edge of tape. Keep heels on mat and curl up slowly. While curling up fingers slide across the measuring tape until fingertips reach the other side of tape. After that curl back down until head touches the floor. Performance rhythm comes from the tape.	

Table 2. Descriptive statistics of the study variables.

Variable	Girls		Boys	
	M	SD	M	SD
20 m. shuttle run test	33.96	15.27	41.45	20.48
5-leaps test	7.75	0.87	7.82	0.90
Abdominal muscles endurance test	41.64	23.59	38.80	21.36
Push-up tests	27.62	11.72	18.45	11.60
Throwing-catching combination test	9.92	4.98	12.50	4.93
Two-legged jumping from side to side test	77.64	12.52	74.28	12.87
MC sumscore (Z-score)	0.06	0.75	0.15	0.82
Perceived physical competence	2.62	0.87	2.38	0.87
MVPA min/day	55.25	21.01	64.08	24.65
Physical fitness sumscore (Z-score)	0.20	0.96	0.07	1.02

Table 3. Correlations among study variables. Girls above the main diagonal. Boys below the main diagonal.

Variable	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1. 20 m. shuttle run test	-	0.58***	0.33**	0.46***	0.44***	0.47***	0.63***	0.40***	0.38***	0.73***
2. 5-leaps test	0.63***	-	0.51***	0.42***	0.41***	0.46***	0.80***	0.38***	0.28***	0.65***
3. Abdominal muscles endurance test	0.27***	0.31***	-	0.36***	0.22***	0.41***	0.49***	0.19**	0.20**	0.85***
4. Push-up tests	0.58***	0.49***	0.38***	-	0.30***	0.49***	0.52***	0.31***	0.25***	0.70***
5. Throwing-catching combination test	0.59***	0.51***	0.25***	0.42***	-	0.38***	0.76***	0.25***	0.22***	0.37***
6. Two-legged jumping from side to side test	0.58***	0.62***	0.22**	0.49***	0.54***	-	0.79***	0.23***	0.25***	0.57***
7. MC sumscore (Z-score)	0.72***	0.85***	0.31***	0.56***	0.81***	0.86***	-	0.37***	0.32***	0.68***
8. Perceived physical competence	0.40***	0.36***	0.05	0.25***	0.36***	0.39***	0.45***	-	0.26***	0.36***
9. Moderate-to-vigorous physical activity	0.52***	0.37***	0.21**	0.33***	0.42***	0.34***	0.46***	0.22**	-	0.33***
10. Physical fitness sumscore (Z-score)	0.81***	0.60***	0.77***	0.76***	0.55***	0.54***	0.68***	0.31***	0.47***	-

P<0.05*, P<0.01**, P<0.001***

Figure captions

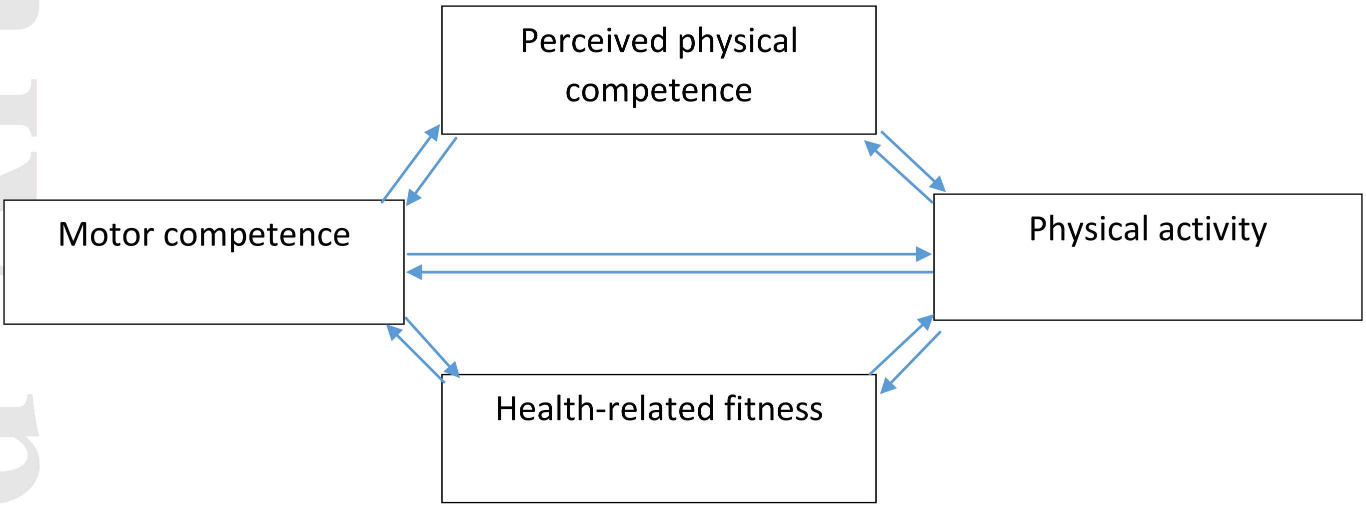

Figure 1. Model demonstrating hypothesized reciprocal relationships among variables. Adapted from Stodden et al., 2008.

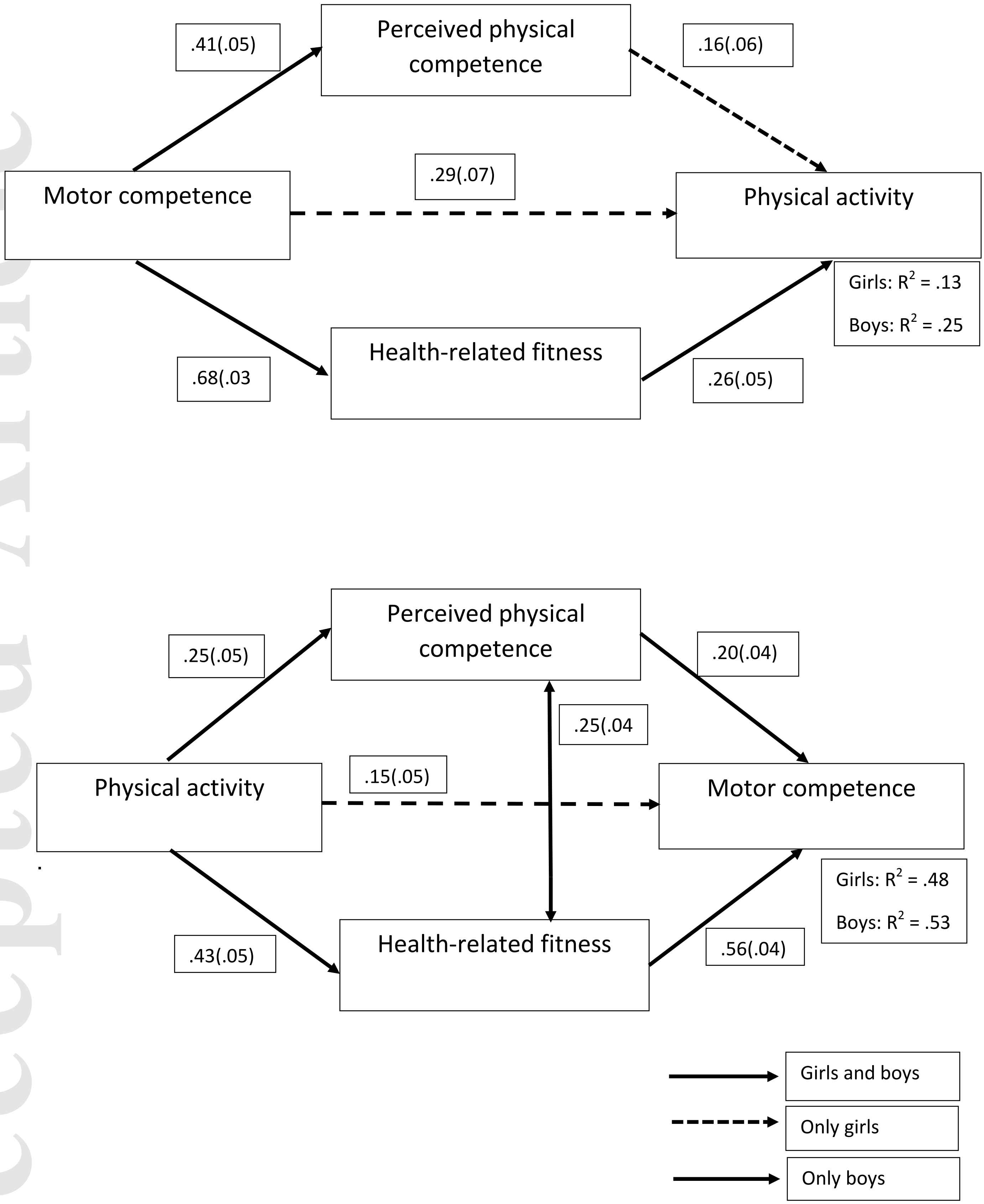

Figure 2. Structural equation models for the study variables. Model 1 above and model 2 below.