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Title: Actual and Perceived Motor Competence, Cardiorespiratory Fitness, Physical Activity, and Weight Status in Schoolchildren : Latent Profile and Transition Analyses

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Abstract

Engagement in physical activity plays a central role in the prevention and treatment of childhood overweight/obesity. However, some children may lack the skills and confidence to be physically active. This three-years follow-up study aimed to form profiles based on cardiorespiratory fitness, actual motor competence, perceived motor competence, physical activity, and weight status, and to examine if these profiles remain stable from late childhood to early adolescence. All these variables were annually assessed in 1 162 Finnish schoolchildren (girls = 583, boys = 564, Mage = 11.27 ± 0.32 years). Latent profile analysis was used to identify profiles and latent transition analysis to examine the stability of latent statuses. Three profiles were identified: normal weight with high movement (NW/MOVE+), normal weight with low movement (NW/MOVE-) and overweight-obese with low movement (OW-OB/MOVE-). Profile memberships remained relatively stable over time, indicating that children with low actual and perceived motor competence, cardiorespiratory fitness, and physical activity in late childhood also tended to exhibit these characteristics also in early adolescence.

Key words: motor development, adolescence, children, physical activity

Introduction

Childhood obesity has increased globally over recent decades (NCD risk, 2017). Children with overweight/obesity are at risk for multiple health consequences (dos Santos et al., 2015) and are likely to become adults with overweight/obesity (Singh et al., 2008). Engagement in physical activity plays a central role in the prevention and treatment of childhood overweight/obesity (Mahumud et al, 2021). This has led to calls for further research into the mechanisms underlying the synergistic development of physical activity and a healthy weight status from late childhood to early adolescence (Stodden et al., 2008; Robinson et al., 2015; Barnett et al., 2021).

The conceptual model of Stodden et al. (2008) titled "A Developmental Perspective on the Role of Motor Skill Competence in Physical Activity" has been widely used to explain physical activity and weight development from childhood to adolescence (Robinson et al., 2015). It postulates motor competence (i.e., fundamental movement skills: locomotor, object control, and stability skills) (Goodway, Ozmun & Gallahue, 2021) as a driver of physical activity, and (self-)perceived motor competence (De Meester et al., 2020) and health-related fitness (i.e., cardiorespiratory fitness and muscular fitness) (Bouchard & Shephard, 1994) as mediators between actual motor competence and physical activity engagement. According to the model, reciprocal and dynamic relationships between these variables form either a positive spiral of engagement or negative spiral of disengagement that directs the development of body weight over time in childhood and adolescence. The model suggests that children with high actual and perceived motor competence and high health-related fitness can continue physical activity engagement for longer periods, which in turn gives them more possibilities for the further development of motor competence. Thus, they have the skills and confidence to be physically active, and thus enhanced possibilities to maintain a healthy weight status. In contrast, low actual and perceived motor competence and low health-related fitness may have the opposite

46 outcomes. This in turn may lead to an unhealthy weight status, further straining the

47 aforementioned variables (Stodden et al., 2008). The hypothetical theoretical relationships

48 between the variables in the model have been demonstrated in many studies (Robinson et al.,

49 2015). Overweight/obesity has consistently been associated with poor actual motor

50 competence (Barnett et al., 2021), low cardiorespiratory fitness (Kolunsarka et al., 2021), low

51 perceived motor competence (Jones et al, 2010) and low physical activity engagement (Janssen

52 et al., 2019). However, a recent systematic review by Barnett et al. (2021) called for

53 longitudinal studies across childhood and into adolescence that include all the variables

54 presented in the conceptual model by Stodden et al. (2008), including multiple time points and

55 controlling for potential confounding factors.

56 Research has shown that children present markedly different developmental trajectories of

57 actual motor competence (Coppens et al., 2019), physical activity behavior (Lounassalo et al.,

58 2019), cardiorespiratory fitness (Raghuveer er al., 2020), and body weight status

59 (Oluwagbemigun et al., 2019) over time. This is one reason why studies utilizing sophisticated

60 person-oriented statistical methods are needed. Unlike traditional variable-oriented methods,

61 person-oriented methods (e.g., latent profile analysis) use latent variables and enable the

62 description of population heterogeneity for example in individuals' developmental differences

63 (Ferguson, Moore & Hull, 2020). Another advantage of using person-oriented statistical

64 methods, when investigating a whole theoretical model such as that of Stodden et al. (2008), is

65 that they allow longitudinal analysis of hypothesized dynamic and synergistic relationships

66 between variables. To date, only a few longitudinal studies have used person-oriented

67 methodologies including latent variables. Jaakkola et al. (2020; 2021) and Estevan et al. (2021),

68 for example, found that children with high actual and perceived motor competence and high

69 physical fitness displayed higher levels of physical activity and were more likely than other

70 children to have a healthy weight status in childhood. Furthermore, Jaakkola et al. (2020)

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71   identified a profile in which children's levels of actual and perceived motor competence and

72   fitness were significantly lower and who were less physically active than the two other profiles

73   identified. Thus, these previous studies (Jaakkola et al., 2020; Jaakkola et al., 2021; Estevan et

74   al., 2021) have provided support for the positive and negative spirals of engagement that direct

75   the development of body weight over time in childhood and adolescence, as presented in the

76   model of Stodden et al. (2008).

77   However, this one is the first study of children to apply latent profile analysis (LPA) utilizing

78   all the variables in the model of Stodden et al. (2008) and, further, to use latent transition

79   analysis (LTA) to examine to what extent children transition between the identified profiles

80   from late childhood to adolescence. Moreover, this study includes sex as a covariate, because

81   previous studies have shown gender differences in object control (Barnett et al., 2010) and

82   cardiorespiratory fitness (Raghuveer et al., 2020), in which boys outperform girls. Thus, the

83   aim of this study was to extend our understanding of the conceptual model of Stodden et al.

84   (2008) using all the variables and implementing a longitudinal design with original collected

85   data. The research questions were: 1) Can qualitatively distinct subgroups of children based on

86   cardiorespiratory fitness, motor competence, perceived motor competence, physical activity,

87   and weight status be identified? 2) Do these profiles remain stable over time?

88   **Materials and methods**

89   *Participants and procedure*

90   This three-year follow-up study was conducted in Finland during 2017-2020. Participants were

91   recruited from 35 randomly selected elementary schools in four municipalities. All 5th graders

92   were given the opportunity to participate, and a total of 1 162 (girls = 583, boys = 564, Mage

93   = 11.27 ± 0.32 years) volunteered. These children accounted for 2 % of the Finnish population

94   of that age, and all samples were representative of their local population. Data on actual motor

competence, cardiovascular fitness, and anthropometric measurements (height and weight) were collected annually between August and October over four consecutive years (T0-T3) by trained researchers during physical education classes. The questionnaire on perceived motor competence was administered in the classroom setting. Accelerometers were used to collect device-based moderate-to-vigorous physical activity (MVPA). Participants were instructed to wear accelerometers for one week during the annual data collection periods (T0-T3). Verbal consents were obtained from the participating children and informed written consents from their guardian prior to the start of the study. The study was approved by the human research ethics committee of the local university.

Measurements

Actual motor competence. Actual motor competence was measured using three skill tests including object control and locomotor skills. The throw-catch test (Jaakkola et al., 2012) was used to assess participants' object control skills. A target square (1.5 x 1.5 meters) was marked on a wall at 90 centimeters above floor level. Throwing distance depended on the participant's grade and sex and ranged from 7 to 10 meters. Participants were instructed to throw a tennis ball with their desired hand directly at the target and to catch the ball after one bounce back from the floor with one or both hands. Participants were allowed 20 trials and the result was the number of successfully completed trials (i.e., the ball hit the target and was caught after one bounce back from the floor). This test is widely used in Finnish sport science studies (Jaakkola et al., 2021) and has shown acceptable test-retest reliability (ICC = .692, p < .001) in children and adolescents (Jaakkola et al., 2012). Locomotor skills were assessed by the 5-leap test (Jaakkola et al., 2012) and two-legged side-to-side jump test (Kiphard & Schilling, 2007). The 5-leap test consists of five consecutive strides with feet together at the start and end of the five leaps. Participants were allowed to start the strides with their desired leg. The test was performed twice, and the better result (i.e., the overall distance covered in meters rounded to

120   two decimals) was recorded. In the two-legged side-to-side jump, the participant jumped from

121   side-to side over a low wooden beam with legs in parallel continuously for 15 seconds as fast

122   as possible. The test is performed twice, and the result is the sum of the number of successful

123   jumps in each trial.

124   *Perceived motor competence.* Participants' perceived motor competence was assessed

125   using the Finnish version of the sport competence dimension of the Physical Self-Perception

126   Profile (PSPP) (Fox & Corbin, 1989). Each of the five items (i.e., good at sport, athletic ability,

127   confidence to move, among the best when it comes to joining sport activities, among the first

128   to join in sport activities) was preceded by the stem: "*What am I like*?" and rated on a five-

129   point scale (e.g., 1 = *I'm among the best when it comes to athletic ability, 5 = I'm not among*

130   *the best when it comes to athletic ability*). A previous study with Finnish children demonstrated

131   acceptable construct validity (CFI = .98, TLI = .97, RMSEA = .074) and internal consistency

132   (Cronbach's alpha = .90) (Gråstén, 2014).

133   *Cardiorespiratory fitness.* The 20-meter shuttle run test (Leger & Lambert, 1982) was

134   used to assess participants' cardiorespiratory fitness. A 20-meter track was marked on the floor

135   by two parallel lines and the running pace for each 20-meter shuttle was determined by the

136   frequency of recorded beeps. Participants were instructed to run continuously up and down the

137   20-meter track in time to the beeps. The initial running velocity was 8.5 km/h for the first

138   minute, after which it increased by 0.5 km/h for each successive minute. When participants

139   were no longer able to keep pace with the beeps, they were instructed to terminate the test. The

140   result was the number of completed shuttles.

141   *Weight status.* Participants' body mass index (BMI) was calculated using a weight (kg)

142   and height (m) formula (kg/m^2). Body weight was measured to the nearest 0.1 kg using

143   calibrated scales (Point Electronic Personal Scale), with the children wearing light clothing and

144   barefoot. Height was measured to the nearest 0.1 cm using portable measuring equipment

145 (measuring tape). Extended international body mass index cut-offs values (IOTF) were used to

146 determine participants weight status (thinness, normal weight, overweight, obese) (Cole &

147 Lobstein, 2012).

148 *Device-measured MVPA*. Participants' MVPA was measured using Actigraph

149 wGT3X+ accelerometers. Participants were instructed to wear the device for seven consecutive

150 days on their right hip at all times during their waking hours, except while bathing or doing

151 water-based activities. Data were collected as raw accelerations at a frequency of 30 Hz and

152 converted into 15-s epoch counts. Customized Visual Basic Macro for Excel software was used

153 for data reduction. A valid day of physical activity monitoring included measured values ≥500

154 min/day for at least two weekdays and one weekend day between general waking hours (i.e.,

155 7:00-23:00). Periods of 30 min of consecutive zero counts were defined as non-wear time, and

156 values over 20 000 counts per minute (cpm) were considered spurious accelerations and

157 discarded (Heil, Brage & Rothney, 2012). Cut points (Evenson et al., 2008) were used to

158 calculate MVPA (≥2296 cpm).

159 *Data analysis*

160 Data were examined for normality, outliers, and missing values. Correlations and descriptive

161 statistics including means and standard deviations were computed for the observed variables.

162 In addition, Cronbach alphas were determined for the perceived competence scale. To conduct

163 a latent transition analysis, a 5-step model was applied following the procedures of Nylund,

164 Asparouhov & Muthén (2007) (cross-sectional data diagnosis and exploration using latent

165 profile analysis (Step 1), testing for longitudinal measurement invariance (Step 2), defining

166 latent statuses (Step 3), testing latent statuses for multiple-group latent transition analysis and

167 transition probability invariance (Step 4), and testing latent transition analysis with the

168 covariate sex (Step 5)).

169   In Step 1, to identify childhood movement profiles, a cross-sectional LPA was conducted for

170   each time point (T0-T3). The explorative analyses were conducted for models including two

171   to five profiles at each time point. Several indices were used to compere the models and thus

172   to confirm the most reasonable model with optimal number of profiles. Statistical indicators

173   included the Bayesian information criterion (BIC), the adjusted BIC (ABIC), Akaike's

174   information criterion (AIC), entropy, and the adjusted Lo-Mendell-Rubin likelihood ratio test

175   (ALMR-LTR). Models with low BIC, ABIC, and AIC indices and higher entropy were

176   considered to show better fit to the data. In the ALMR-LTR, a p-value > .05 suggested that the

177   k-pattern solution did not fit to the data any better than the k-1 solution (Nylund, Asparouhov

178   & Muthén, 2007). Additionally, to avoid problematic models, profiles containing less than 1%

179   or 5% of participants were identified and excluded. Once the most reasonable model was

180   chosen, based on these several indices, a descriptive label was given to each profile and

181   ANOVAs with post hoc were conducted to identify statistical differences in each variable

182   between classes per time point.

183   In Step 2-4, the LTA, which is a longitudinal extension of the LPA method, was used to

184   examine the stability of the profiles and the probabilities of changes in profiles over time. In

185   Step 2, structural differences between the profiles at different time points were tested. Thus, to

186   explore if the profile indicators provided an unbiased reflection of the same construct across

187   time, longitudinal measurement invariance was tested by comparing the measurement

188   invariance model (equal indicator means) with the measurement variance model (freely

189   estimated profile indicator means). The Chi square ($\chi 2$) -test was conducted using the

190   maximum likelihood estimator (MLR) with Satorra-Bentler scaling correction to evaluate the

191   two models. In Step 3, the most reasonable solution was chosen for further analyses (i,e., if the

192   models differed significantly, the measurement variance model was chosen) and the latent

193   statuses were defined. In Step 4, the transition probability invariance was explored by fixing

194   the transition probabilities to be equal over time and by comparing it to the freely estimated

195   model. Finally, in Step 5, the covariate sex was added to the selected model. Results were

196   considered statistically significant at the p < .05 level. Latent profile and latent transition

197   analyses were performed by using Mplus version 8.2 and descriptive statistics, anova with post

198   hoc and the missing completely at random (MCAR) test by using SPSS 22.0.

Results

Preliminary analysis

201   Tests of normality demonstrated that the data were approximately normally distributed (p >

202   .05) and based on the standardized values (± 3.00) the data was free of outliers. As it was not

203   possible to provide all the participants with accelerometers and the proportions of students

204   completing all the measurements were lower at the later time points, missing values (9 651 out

205   of 33 698) accounted for 28 % of the data. The Missing Completely at Random (MCAR) test

206   indicated that the missing values ($\chi^2(9051) = 8494$, $p < .001$) were missing at random (MAR).

207   Moreover, a closer examination of the data matrix revealed that the missing values did not

208   represent any specific group or school. Consequently, the missing values were not imputed but

209   were estimated through the mixture likelihood procedure, which has been shown to produce

210   reliable parameter estimates and standard errors under MAR conditions (Hunt & Jorgensen,

211   2003).

Descriptive statistics

213   Descriptive statistics, including means, standard deviations, and proportion of students at each

214   time point are shown in Table 1. A statistical power analysis suggested that to meet statistical

215   constraints with a confidence level of 95% and a margin of error of p < .05, a minimum of 289

216   participants was required. Thus, the current sample size of 1 162 was adequate for the main

217   analyses of this study. At baseline the participants' mean age was 11.27 ± 0.33 years and mean

218   BMI 18.88 ± 3.12 kg/m2. At baseline (T0) 4.4 % of the participants were thin, 73.2 % normal

219   weight, 18.5 % overweight and 3.7 % obese. The Cronbach's alphas for the perceived

220   competence scale were relatively high at each time point (T0 = .87, T1 = .90, T2 = .89, T3 =

221   .89).

222   *Latent profile analysis (Step 1)*

223   Students were clustered into homogeneous profiles at each time point (T0-T3) based on actual

224   motor competence, perceived motor competence, cardiorespiratory fitness, weight status, and

225   MVPA. Statistical indices (AIC, BIC, aBIC, ALMR-LTR and entropy) showed that the three-

226   profile model was the most reasonable at T0, T1 and T3. At each of these time points, the three-

227   profile model produced more optimal statistical indicators than two-profile model, whereas

228   four-profile model did not fit the data any better than three-profile model (p > .05). In addition,

229   the three-profile models did not include classes containing less than 5 % of participants. At T2,

230   the four-profile model indicated the best statistical fit but one of the classes contained less than

231   5 % of the participants, and therefore, the three-profile model was selected (Table 2). The

232   selected 3-3-3-3-model comprised three latent profiles at each time-point (T0-T3).

233   *Longitudinal measurement of invariance for the 3-3-3-3-model (Step 2)*

234   Longitudinal measurement invariance was examined for the 3-3-3-3-model by comparing the

235   measurement invariance model (equal indicator means) and the measurement variance model

236   (freely estimated profile indicator means). The χ^2-test using the maximum likelihood estimator

237   (MLR) with Satorra-Bentler scaling correction indicated that the full non-invariance model

238   exhibited improved fit over the 3-3-3-3-model (Table 2). This result was expected given the

239   large number of parameters and the developmental changes occurring over time in childhood

240   (Putnick & Bornstein, 2016). Thus, the full non-invariance model was selected for subsequent

241   transition analysis.

Definition of latent statuses (Step 3)

243   After careful examination of the models, the 3-3-3-3-model with freely estimated means was

244   selected for further analysis. The next step included more specific reportage of the three

245   clusters. Means and standard deviations of actual motor competence (locomotor and object

246   control skills), perceived motor competence, cardiorespiratory fitness, MVPA and weight

247   status prevalence were determined for each cluster and are presented in Table 3. Profile 3 was

248   labelled normal weight with high movement (NW/MOVE+). The participants in this profile

249   were mostly identified as normal weight or thin as less than 5 % was overweight or obese, and

250   showed statistically significantly higher values in motor competence, cardiorespiratory fitness,

251   MVPA and perceived motor competence at each time-point compared to their peers in the other

252   two profiles. The profile 1 was labelled overweight/obese with low movement (OW-

253   OB/MOVE-) as no children within this profile were identified as normal weight or thin, and

254   the profile 2 was labelled normal weight with low movement (NW/MOVE-) as less than 4 %

255   of the participants in this latter profile were overweight and none were identified as obese. The

256   participants in the OW-OB/MOVE- profile were overweight and showed significantly lower

257   values in locomotor competence and in the cardiorespiratory fitness measurements than their

258   peers in the NW/MOVE- profile, although they showed significantly higher values in object

259   control skills at T0, T1 and T3. No statistically significant differences were observed in MVPA

260   or perceived motor competence between the OW-OB/MOVE- and NW/MOVE- profiles over

261   time.

262   *Latent status and transition probability invariance tests (Step 4)*

263   The transition probability invariance result indicated that the model with transition

264   probabilities fixed to be equal over time and the freely estimated model differed from each

265   other. This result was expected given the large number of parameters and the developmental

266   changes occurring over time in childhood (Putnick & Bornstein, 2016). As the freely estimated

267   model allows for variation, it was chosen for further use. Thus, the results are based on a non-

268   invariance model (i.e., the freely estimated model). Examination of the transition probabilities

269   revealed that transition patterns were stable over time, indicating that participants remained in

270   the clusters identified during the first measurement phase (Table 4).

271   *Covariate effect of sex (Step 5)*

272   To determine covariate effects of sex on status prevalence at T0-T3, sex was added to the 3-3-

273   3-3 model as a covariate with free transition probabilities (Table 5). In a multinomial model,

274   the analysis does not provide regression coefficients for the reference group. Significant

275   covariate effects of sex on status prevalence were found for the memberships of the OW-

276   OB/MOVE- and NW/MOVE- profile at T0 and NW/MOVE- profile at T2. The odds ratios

277   indicated that girls were mostly likely to be in the NW/MOVE- profile at T0 and least likely to

278   be in NW/MOVE+. At T2 girls were more likely to be in NW/MOVE- profile than in two

279   others. There was no sample variance of sex at T1, indicating that girls and boys had an

280   identical likelihood for cluster membership at T1, and thus sex effects were restricted.

281   **Discussion**

282   This study sought to profile children into homogeneous latent profiles and to explore their

283   probabilities to transition between these profiles over three years from late childhood to early

284   adolescence. The main finding based on actual and perceived motor competence,

285   cardiorespiratory fitness, physical activity, and weight status was the identification of three

286   latent profiles: OW-OB/MOVE-, NW/MOVE- and NW/MOVE+. This study also found that

287   the profile memberships remained relatively stable over the three-year follow-up.

288   The participants in the NW/MOVE+ profile were normal weight and showed the highest values

289   in all measurements, except in BMI. Compared to the other two profiles, their test results were

290   significantly higher in actual and perceived motor competence, cardiorespiratory fitness, and

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MVPA. Similar profiles were found by Estevan et al. (2021) and Jaakkola et al. (2020), both of whom reported one profile with high actual and perceived motor competence and high physical fitness. Estevan et al. (2021) also reported that this profile was characterized by the low membership of children with overweight/obesity and high engagement in physical activity. This profile demonstrates the positive spiral for engagement presented in the model of Stodden et al. (2008), positing that children with high actual and perceived motor competence and high cardiorespiratory fitness are more physically active and have a healthy weight status. Furthermore, according to Stodden et al. (2008), the children in this profile may have a lower risk for unhealthy weight development, as they have the tools to be physically active also later in life.

The participants in OW-OB/MOVE- and NW/MOVE- profiles had similar, although somewhat lower perceived motor competence and levels of MVPA, compared to their peers in the NW/MOVE+ profile. In addition, the participants in the OW-OB/MOVE- profile showed lower cardiorespiratory fitness and locomotor competence than those in the NW/MOVE- profile, but higher object control competence in T0, T1 and T3. As observed in previous studies (Moliner-Urdiales et al., 2011), children with overweight have a lower cardiorespiratory fitness than children with normal weight. Excessive body weight and/or fat mass increases the workload in the 20-meter shuttle run, which adversely affects test performance (Tomkinson et al., 2019). The participants in the OW-OB/MOVE- profile also showed significantly lower locomotor competence scores. However, poor performance in locomotor tasks such as jumping, and leaping may have less to do with motor coordination and more to do with the morphological limitations of overweight and obesity in transporting the body through space, and especially against gravity (Chivers et al., 2013; Webster et al., 2021). Overall, excess weight affects weight-bearing motor tasks, such as running and locomotion (Webster et al., 2021). In contrast, the children in the OW-OB/MOVE- profile showed significantly higher

316   values for object control skills at the three time-points (T0, T1, T3) than their peers in the

317   NW/MOVE- profile. This outcome contrasts somewhat with the findings of previous studies

318   (D'Hondt et al., 2009; Gentier et al., 2013) comparing object control skills across different

319   weight statuses, as they have concluded that children with obesity have lower scores in object

320   control skills compared to their normal weight peers. However, D'Hondt et al. (2009)

321   concluded that no differences in object control or motor skills in general were found between

322   children with normal weight and overweight and thus suggested there may be certain cut-off

323   from which movement difficulties appear. Also, previous studies have treated normal weight

324   group as one homogeneous group (D'Hondt et al., 2009; Gentier et al., 2013), whereas this

325   study showed that children with normal weight also have various levels of object control skills.

326   Thus, children with normal weight may also have impaired object control competence, which

327   may prevent them from being physically active in the future, as object control competence has

328   been shown to be more strongly associated with physical activity levels than locomotor

329   competence (Barnett et al., 2011). Moreover, according to Stodden et al. (2008), children in

330   both the NW/MOVE- and OW-OB/MOVE- profiles may, owing to their low motor

331   competence, be at higher risk for low engagement in physical activity, which in turn may lead

332   to unhealthy weight development in the future.

333   The profile memberships identified in this study were relatively stable over time, suggesting

334   that children in NW/MOVE- and OW-OB/MOVE- profiles with low actual and perceived

335   motor competence, cardiorespiratory fitness, and physical activity in late childhood also tend

336   to exhibit these characteristics in early adolescence. As in these profiles participants' level of

337   actual and perceived motor competence remains relatively low, they are unlikely to be

338   motivated to engage in physical activity either currently or later (Stodden et al., 2008;

339   Robinson et al., 2015). Previous studies have also shown that weight status (Singh et al., 2008)

340   and physical capabilities, such as physical fitness (True et al., 2021) and motor competence

341 (Jaakkola et al., 2021), tend to track from childhood to adolescence. Thus, it would be important

342 to identify children with poor movement profiles as early as possible for example by systematic

343 fitness and motor competence monitoring in schools and through actions and interventions in

344 schools and communities seek to enhance children's motor competence and further

345 engagement in physical activities.

346 Finally, the results indicated that at T0 and T2 girls were mostly likely to be in the NW/MOVE-

347 profile than in the other two profiles. A previous finding that girls are less competent than boys

348 in object control skills (Barnett et al., 2010) may, at least partially, explain this result. Girls

349 have also been shown to be less physically active than boys (Guthold et al., 2020). Further

350 conclusions on sex differences in profile membership cannot be drawn owing to the lack of

351 social support variables in the current data, as it has been suggested social support is an

352 important factor underlying participation in motor competence-related physical activities in

353 school-aged children (Biddle et al., 2011).

354 The strengths of this study were the large number of participants, a longitudinal design with

355 annual follow-ups, and the person-oriented statistical analyses. Moreover, the profile analyses

356 included all the variables presented in the model of Stodden et al. (2008) and thereby providing

357 further information on the model. However, the study has its limitations. Device-measured

358 MVPA may be underestimated because water-based activities could not be recorded. While

359 BMI is a widely used measure in tracking changes in adiposity, it is not unproblematic with

360 children and adolescents due to maturational growth and its inability to differentiate muscle

361 mass from fat (Nuttall, 2015). Also, the lack of maturation measurements is a notable limitation

362 of this study, as maturation is characterized by several physiological and psychological changes

363 that may over time influence an individual's BMI, actual motor competence, perceived motor

364 competence and cardiorespiratory fitness developmental trajectories (Malina, Bouchard & Bar-

365 Or, 2004). Perceived motor competence was assessed with the sport competence dimension of

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366 the Physical Self-Perception Profile (PSPP) by Fox & Corbin (1989), which is rather a measure

367 of perceived sport/athletic competence than perceived motor competence. Therefore, caution

368 should be exercised when comparing studies using different instruments to assess perceived

369 motor competence (Estevan & Barnett, 2018).

370 The findings of this study extended our understanding of the variables included in the model

371 of Stodden et al. (2008) and the role of weight status in this model from late childhood to early

372 adolescence. To summarize, excessive body weight and/or fat mass is a burden which hinders

373 performances in weight-bearing motor tasks. However, the fact that children with normal

374 weight have very different movement profiles raises the concern that children with normal

375 weight and a low movement profile may be at higher risk for unhealthy weight development in

376 later life (Stodden et al., 2008; Robinson et al., 2015). Moreover, girls compared to boys were

377 less likely to be in the high movement profile, which suggest that some gender differences can

378 be seen in the development of physically active lifestyle. A suggestion for future studies is to

379 repeat this study protocol in younger children and possibly follow them through adolescence.

380 Moreover, future studies should include the examination of organized sport participation, as it

381 seems to be important in this respect. To develop optimal overweight/obesity prevention

382 programs, future studies should examine whether children with low movement profiles are at

383 risk for low physical activity engagement and unhealthy weight development also in adulthood,

384 so that resources can be targeted where they are most needed, such as children's motor

385 competence development.

386 **Acknowledgements**

388 **Declaration of interest statement**

389 The authors declare no competing financial or non-financial interests.

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