CQUNIVERSITY RESEARCH

RESEARCH WITH IMPACT

The level and pattern of physical activity among fifth-grade students in Ho Chi Minh City, Vietnam

Q.G.To ; D.Gallegos ; D.V.Do ; H.T.M.Tran ; K.G.To ; L.Wharton ; S.G.Trost

Please do not remove this page

1   **Abstract**

2   **Objectives:** Despite the benefits of physical activity (PA), a significant proportion of children do

3   not meet physical activity guidelines. However, most studies were among secondary-school-aged

4   youth and relied on PA self-report. Additionally, information regarding children's PA behaviours

5   during specific segments of day/week are not usually collected. This study, therefore,

6   investigated the level and pattern of PA among fifth-grade students in Ho Chi Minh city

7   (HCMC), Vietnam.

8   **Study design:** A complex cross-sectional survey was conducted on a representative sample of

9   619 fifth-grade students in eight public schools in urban areas of HCMC in 2016.

10 **Methods:** Demographic/anthropometric characteristics were measured using standard protocols.

11 PA was measured using pedometers. After-school activities were measured using the Previous

12 Day Physical Activity Recall questionnaire. Survey procedures with sampling weights were used

13 for analyses.

14 **Results:** Approximately 18% children met the physical activity guideline; 52.7% were

15 overweight/obese. On average, students recorded about 8800 steps/day. Boys were more active

16 than girls at school and on weekdays. Students were more active at school on PE days vs. non-

17 PE days, and weekdays vs. weekends. Overweight/obese students were more active at school on

18 PE days. After-school physical activities differed between boys and girls, while sedentary

19 activities were popular among both genders.

20 **Conclusions:** A majority of fifth-grade students had insufficient PA levels. Patterns of PA are

21 different at various times during the day and week. The finding emphasized an urgent need for

22 interventions to improve children's PA and obesity in this area.

23

Introduction

Physical activity (PA) is an important factor influencing health. In children, PA is associated

with multiple health-related benefits including cardio-metabolic, skeletal, muscular, and mental

health.[1-3] Despite the benefits, significant proportions of children/youth do not meet the physical

activity guideline (PAG) of engaging in daily moderate-to-vigorous PA (MVPA) for

≥60minutes/day.[2] The percentage of meeting the PAG is 42% (6-11 years) in the U.S[4], 19% (5-

17 years) in Australia[5], and 23% (11 years) in European countries.[6]

PA levels are also low among youth from low to middle-income countries (LMIC). Data from

the 34 LMICs indicated that on average, <25% youth (13-15 years) met the PAG.[7] Other studies

showed the percentages were 23.3% (aged 6-17 years) for Thailand[8] and 66% (aged 13-17 years)

for Dhaka city, Bangladesh.[9] Although, national data on children's PA are unavailable in

Vietnam, the percentage of students (11-16 years) self-reporting having ≥3 bouts of vigorous

activity for ≥20 minutes/week, or ≥5 bouts of moderate activities for ≥30 minutes/week in urban

areas of HCMC in 2004 was 75.7%.[10] However, most studies were among secondary-school

aged youth (i.e. >11years) and relied on PA self-report, with the exception of the U.S data that

used accelerometers. Therefore, there is a lack of population-based studies among primary-

school-aged children measuring PA objectively.

Although it is important to have estimates of daily PA levels, there is also a need for information

regarding children's PA behaviours during specific segments of the day/week which are not

usually collected by public health surveillance systems.[11] This information, if available, is

critical, particularly for LMIC, in assisting policymakers to identify, plan and allocate resources

48 to areas with top priority. The information can also be used by schools to inform their revision or

49 for the establishment of policies. This study, therefore, was conducted to investigate the level

50 and pattern of PA among fifth-grade students in HCMC, Vietnam.

51

52 **Methods**

53 <u>Study design and population</u>

54 A cross-sectional survey using a two-stage stratified cluster sampling was conducted between

55 January and September 2016. Public schools with more than two fifth-grade classes in urban

56 areas of HCMC were eligible to participate. These schools were stratified into "nationally

57 recognized schools" and "not nationally recognized schools" and then into "high socio-economic

58 status (SES)" and "low SES". National recognition is awarded to schools meeting criteria set by

59 the Ministry of Education and Training[12] including number of classes and students, area of a

60 class and playground, and infrastructure/equipment for teaching and learning. The classification

61 for SES was based on the statistics of HCMC[13] and used in previous studies.[10,14] In each stratum,

62 two schools were randomly selected using a probability-proportional-to-size method. The

63 number of selected schools, therefore, was eight including two half-day (7:00am-11:00am) and

64 six full-day schools (7:00am-4:00pm). Four fifth-grade classes (five classes in one school and

65 three for another school) were randomly selected from each school. A total of 32 classes were

66 selected.

67

68 All students in the selected classes were invited to participate. Written consent forms were

69 obtained from the parents. Written approvals from the schools and the HCMC Department of

70 Education and Training were also obtained. Ethics approval from Queensland University of

71 Technology Human Research Ethics Committee was also obtained (1500000549).

72

73 <u>Measurement</u>

74 Research assistants were recruited from the University of Medicine and Pharmacy at HCMC and

75 formally trained on data collection procedures before data collection. Students self-reported age

76 and gender. Student's height and weight were measured at school following the methods outlined

77 by WHO.[15] Weight was measured to the nearest 0.1 kg without shoes and heavy clothing using

78 an electronic scale (Tanita BF 571, Japan). Standing height was measured twice to the nearest

79 0.1cm without shoes, or caps/hair ornaments using a stadiometer; BMI calculated by

80 weight(kg)/height(m)^2 was used to classify students as overweight (z-score>1) obese (z-

81 score>2), or underweight (z-score<-2). Details on this calculation have been published

82 elsewhere.[16]

83

84 The Previous Day Physical Activity Recall (PDPAR) was used to collect data on students' after-

85 school activities using procedures described by Trost.[17] The PDPAR is a self-report instrument

86 designed specifically for the cognitive abilities of children and adolescents. To help children and

87 adolescents recall their past behavior more accurately, the previous day is divided into 30-minute

88 time blocks that, in turn, are grouped into broader time periods such as morning, lunchtime,

89 afternoon, and evening. To further enhance recall accuracy, the instrument provides a numbered

90 list of commonly performed activities grouped into the following broad categories: eating,

91 sleeping/bathing, transportation, work/school, spare time, physical activities, and sports. To help

92 students rate the intensity of the reported physical activities, the instrument includes cartoon

93 illustrations depicting light, moderate, hard, and very hard activities[18]. As schools closed at

94 different times, the after-school time started at 4:00pm/4:30pm instead of 3:30pm. The PDPAR

95 has been validated in fifth-grade[17] and 7-12-grade U.S students.[19] A modified version was also

96 validated in Singaporean adolescents.[20] Depending on the end time of school, student completed

97 fourteen to fifteen 30-minute blocks. Students with >4 incompatible responses between an

98 activity and its intensity (e.g. the activity is sleeping and the intensity is hard) or four blocks of

99 missing values were excluded.

100

101 Pedometers (SW200), which are cost-effective and provide valid measurement of PA among

102 children, were used to record steps.[21] The pedometer protocol from Rowe[22] was modified and

103 used. Pedometers were worn for seven days. Students recorded steps on reporting cards at the

104 beginning and end of school during weekdays, but only once in the morning during weekends.

105 Text messages were sent to parents to remind students to wear pedometers and record the step

106 counts.

107

108 <u>Data preparation</u>

109 Step data were entered into Excel spreadsheets, scrutinized, and corrected as follows: 1) if

110 students forgot to wear pedometers in the morning, the step count on the following morning was

111 corrected to be that of the previous morning as they were asked not to wear pedometers for the

112 rest of the day; 2) if a step count on the following morning was smaller than the count on the

113 previous evening, the count in the morning was set to a sum of two counts as students may have

114 reset the count; 3) if pedometers stopped working during school and were fixed that evening,

115 daily steps and school steps for that day were set to missing; 4) if a student was absent in the

116   morning but was at school in the afternoon, the step count was set to missing for that evening

117   and the following morning.

118

119   As literature regarding thresholds for outliers is scarce, a statistical package in R

120   (ROBUSTBASE) incorporating "medcouple", a robust measure of skewness, was used to draw

121   adjusted boxplots. Based on graphical analyses (using a criterion of 2.5 times interquartile

122   range), outliers were identified as follows. For full-day schools, thresholds were 200-19,077

123   (home steps) and 108-19,565 (school steps); for half-day schools, thresholds were 500-29,364

124   (home steps) and 102-11,704 (school steps). For daily steps, the same threshold of 1,000-32,183

125   steps was applied for full-day and half-day schools. As a result, 2.25% of daily step data (119

126   data points), 0.94% home step data, and 0.21% school step data were excluded.

127

128   Intraclass correlation coefficients (ICC) and the Spearman Brown prophecy formula were used to

129   determine the number of days needed to achieve a reliability of 0.75, which is four days. Given

130   the difference in average step counts between weekdays and weekends, those with ≥3 weekdays

131   and one weekend day of daily step data were included.

132

133   Statistical analysis

134   Sampling weights were used to account for difference in selection probability and non-responses.

135   PROC SURVEYMEANS/SURVEYFREQ in SAS v9.4 were used to generate weighted

136   descriptive statistics. As 12,000 steps/day is considered a benchmark for meeting the PAG of 60

137   MVPA minutes/day[23], this percentage was also calculated. The prevalence of after-school

138 activities was also examined. These statistics were presented by gender and weight status with

139 95% confidence intervals (CI).

140

141 PROC SURVEYREG/PROC SURVEYLOGISTIC were used to test differences between PA

142 outcomes with gender and weight status, and differences between weekdays step vs. weekend

143 steps, and PE-day steps vs. non-PE-day steps. Differences between school steps vs. out-of-school

144 steps were tested for full-day and half-day schools. Taylor series linearization was used for

145 variance estimation. P-values were two-sided and considered significant if <0.05.

146

147 **Results**

148 Among 1235 students invited to participate, 757 consents were obtained generating a response

149 rate of 61.3%. However, 619 students (81.8%) with ≥3 weekdays and one weekend day of

150 pedometer data were included in the analysis. Average students' age was 10.4 years ranging

151 from 9.7 to 12.6 years. Although boys (52.8% of the sample) were not different from girls in age

152 and height, they had higher weights and BMIs. More than half were classified as

153 overweight/obese (OW/OB). The prevalence of obesity was greater in boys than girls.

154

155 <u>PA level</u>

156 On average, students recorded about 8800 steps/day; 5500 steps (full-day) and 2300 steps (half-

157 day) at school; 9400 steps (full-day) and 8900 steps (half-day) on weekdays; 8300 steps (full-

158 day) and 8200 steps (half-day) on weekends; 10100 steps (full-day) and 8600 steps (half-day) on

159 PE days; and 9100 steps (full-day) and 8900 steps (half-day) on non-PE days. There was no

160 difference in daily steps between full-day and half-day students.

161

162   The numbers of steps/day and percentages of students meeting the PAG are presented by gender

163   in Figure 1. Boys recorded more steps than girls ($p<0.01$). Approximately 18% of students met

164   the PAG. Boys were more likely to meet the PAG than girls (OR=2.3, 95% CI = 1.1, 4.5).

165

166   INSERT FIGURE 1 NEAR HERE

167

168   OW/OB and non-overweight students respectively recorded about 9300 and 8500 steps/day in

169   full-day schools; and 8600 and 8800 steps in half-day schools. Percentage of non-overweight and

170   OW/OB students meeting the PAG respectively was 21.6% and 15.3% for all schools.

171   Associations between weight status and PA were insignificant.

172

173   <u>PA patterns</u>

174   Differences in PA levels by gender and weight status are presented in Table 1. Boys were more

175   active than girls at school and on weekdays (including PE and non-PE days) but not at home and

176   on weekends. OW/OB students were not more active than non-overweight students with the

177   exception of average school steps on PE days when OW/OB students were significantly more

178   active.

179

180   INSERT TABLE 1 NEAR HERE

181

182   Differences in PA levels between segments are presented in Table 2. In general, full-day students

183   were more active at school and on weekdays (including PE and non-PE days) compared to home

184 and weekends. Half-day students were more active at home compared to school. Although the

185 difference between average school steps on PE and non-PE days was insignificant for half-day

186 students, the difference was significant combining full-day and half-day schools (p<0.05).

187

188 INSERT TABLE 2 NEAR HERE

189

190

191 <u>After-school activities</u>

192 Among 757 students in the original sample, nine did not return the PDPAR and 35 had >4

193 response errors. A total of 44 (5.8%) questionnaires were excluded from the PDPAR analysis.

194 Percentages of students reporting participation in common activities (≥ one 30-min block) during

195 after-school period are presented in Figure 2. Activities were grouped into domains of studying,

196 spare time use, and sports/PA. Three-quarters reported doing homework and approximately 40%

197 attending private tutoring. Most (86%) reported watching TV/movies; <50% reading; and about

198 one-third playing video games, using the computer/internet, or listening to music. Physical

199 activities were reported including bicycle riding (31%), walking (30%), and jogging/running

200 (29%). Popular sports among girls were rope jumping (24.4%) and badminton (23.5%); among

201 boys were soccer (28.5%), shuttlecock (16.7%), and badminton (15.7%).

202

203 Percentages reporting undertaking at least one PA/sport during the after-school period were

204 79.4% (95% CI=63.4%, 95.4%), 80.2% (95% CI=62.9%, 97.5%) for boys and 78.5% (95%

205 CI=64.2%, 92.9%) for girls. When walking and jogging were excluded, percentages were 64.9%

206 (95% CI=51.0%, 78.7%), 68.9% (95% CI=57.5%, 80.3%) for boys and 60.4% (95% CI=46.1%,

207 74.7%) for girls.

208

209   INSERT FIGURE 2 NEAR HERE

210

211 **Discussion**

212 The results showed that a majority of fifth-grade students (82%) in urban schools in HCMC were

213 not sufficiently active. Although it is difficult to compare the PA level among studies given

214 discrepancies in methodologies and students' ages, students in HCMC have lower daily steps

215 than those in studies conducted in the U.S, Australia, and New Zealand.[24-27] The percentage of

216 students meeting the PAG was also smaller than those in Australia (40%)[28], the U.S (42%)[4], and

217 Bangladesh (Dhaka city).[9] The percentage, however, is similar to those reported in a study of 39

218 high income countries (23% children aged 11 years[6]), Indonesia and Myanmar (about 20%

219 children aged 13-15 years[7]), Thailand (23.3% children aged 6-17 years).[8] This result supports

220 findings from an adolescent study in 2004 that students in urban areas of HCMC were not

221 sufficiently active.[10] It indicates that effective interventions are urgently needed to improve

222 children's PA.

223

224 The findings are also consistent with current literature that boys are more active than girls.[29-31]

225 Explanations are that girls may enjoy PE classes less than boys[32], and be less likely to participate

226 in organized sports than boys.[33] In support of this hypothesis, the PDPAR data showed that the

227 percentage of girls participating in at least one after-school sport was lower than boys. However,

228 it is worth noting that no significant difference between boys and girls was found for home steps

229 and weekend steps when sport participation typically occurs. As our study was not designed to

230 test this hypothesis, data including frequency/length of sport attendance were not collected;

231 therefore, a firm conclusion cannot be made. Lack of social support may be another reason for

232 girls to have less PA, as studies found boys perceive more peer support[34] and parental support

233 than girls.[35] Although interventions for both genders are needed, additional efforts to improve

234 girls' PA are required given that compliance to the PAG among girls was only half of that among

235 boys. Gender-specific interventions, especially school interventions may be more effective as PA

236 patterns at school and on weekdays were different for boys and girls.

237

238 The result also showed that full-day students undertook about 62% of their daily steps at school.

239 They also accumulated more steps in school than out-of-school, which is contrary to findings

240 from previous studies.[25,26,36,37] However, the difference is likely due to the longer time full-day

241 students in HCMC spend at school (9 hours). Assuming that students in the previous studies

242 spent six hours at school, they had more average steps/hour at school than those in this study.

243 This suggests that more could be done to improve students' PA level during school in HCMC.

244

245 Consistent with previous studies, full-day students were more active on school days vs.

246 weekends.[24,27,38,39] Although the association was insignificant for half-day students, average

247 weekday steps were higher than that on weekends. This emphasizes the need for additional

248 interventions targeting students' activities during weekends.

249

250 Our study also showed that PE positively contributed to students' PA which is consistent with a

251 conclusion from a previous review.[40] However, contribution of PE to students' PA was greater

252 for full-day vs. half-day schools (about 1100 vs. 700 steps/day), and boys vs. girls (about 1100

253 vs. 750 steps/day). This improvement was also smaller compared to the finding of a U.S. study in

254 which the least, moderate, and most active children recorded about 1700, 1100, and 2500 more

255 steps on school PE days, respectively.[41] Therefore, adjustments to the PE program could be made

256 to improve effectiveness of PE, especially in half-day schools. More girl-friendly activities also

257 need to be included to help girls be more active.

258

259 Although more than half of students were classified as OW/OB in this study, there were no

260 differences in the level and pattern of PA between OW/OB and non-overweight, with the

261 exception of average school steps on PE days. This finding is contrary to previous studies which

262 reported OW/OB children to be less active[37,42-45], but consistent with the results of a review of

263 reviews concluding that BMI was not associated with PA.[46] In fact, OW/OB students

264 accumulated significantly more school steps than non-overweight students on PE days. Although

265 speculative, it may be that the OW/OB students received more attention and support from PE

266 instructors, who may encourage or provide them with more opportunities to be active than non-

267 overweight students. Efforts should be focused not only on the PE curriculum but also on

268 creating school health policies which encourage all school staff to provide opportunities and

269 support for students to be involved in more PA.

270 Finally, the PDPAR results showed that the most common sedentary activities reported by

271 students during the after school period were homework and watching TV/movies. Boys were

272 more likely to report playing video games and talking on the phone, while girls were more likely

273 to report listening to music. Although bicycling, walking, and jogging/running were popular

274 among both genders, playing badminton and rope jumping were the most prevalent after-school

275 sports reported by girls whereas playing soccer and shuttlecock were by boys. If an intervention

276 is going to target after-school activities, it may do so specifically for boys and girls, and these

277 activities are good candidates for consideration.

278

279 <u>Strengths and limitations</u>

280 This is the first population-based study among primary school students in Vietnam using

281 pedometers to objectively measure PA. The sample was relatively large and representative of

282 urban areas of HCMC. The response rate was acceptable at 61.3%. However, the study has some

283 limitations. First, as SW200 can only record steps, the intensity of activity was not measured.

284 Recall bias may also be possible with self-reported data on after-school activities. As the sample

285 was drawn from public urban schools, the findings are not generalizable to rural and

286 international/private schools. However, majority of schools in HCMC are public schools. The

287 study also did not collect PA data for segments of weekend days and therefore was not able to

288 make comparison between segments on weekend days as well as between weekdays and

289 weekend days. Finally, it was not possible to collect data during the summer holidays; therefore,

290 the results only represent a school year not a whole year.

291

292 **Conclusion**

293 A majority of fifth-grade students in public schools from urban areas in HCMC did not have

294 sufficient PA levels. Boys were more active than girls at school and on weekdays. Full-day

295 students accumulated a majority of steps at school whereas half-day students did so at home.

296 Students were more active during weekdays compared to weekends, but the association was only

297 significant among full-day students. Students were more active at school on PE days compared

298   to non-PE days. OW/OB students were more active at school on PE days. After-school physical

299   activities were different between boys and girls, while sedentary activities such as studying were

300   popular among both genders.

301

302   This study emphasized an urgent need for interventions to improve not only children's PA, but

303   reduce excess adiposity given that more than half of the students were considered OW/OB. As

304   Vietnam is undergoing a nutrition transition and rapid urbanization, the situation could worsen

305   unless effective interventions are implemented. To improve effectiveness, future PA

306   interventions would have general components targeting all students but also specific components

307   for each gender.

308

309   In addition, the findings have a number of important implications for school health policy,

310   educators, and PE instructors in HCMC. Schools may want to establish a comprehensive school

311   PA program that coordinates multiple components including quality PE, PA before, during, and

312   after school, staff involvement, and family and community engagement[47]. Although this program

313   could be developed and implemented by PE instructors, classroom teachers and other staff also

314   play an important role so that PA opportunities are integrated into academic classes and breaks.

315   This program should also create an active school environment where school staff serve as role

316   models for students and to provide strong social and cultural support for all.

317

318   Finally, future research may examine ways to improve the PA engagement of girls; examine

319   school factors besides PE that contribute to the gender gap in PA; test the hypothesis that

320   OW/OB students are more active at school due to PE; and collect data for PA segments on

15

321   weekend days. Given that obesity is quite prevalent in big cities in Vietnam, parents and

322   teachers, may be aware that they need to provide more support for obese students to be more

323   active. This is also an interesting finding that may need further studies.

324

325

References

1. Okely AD, Salmon J, Vella S, Cliff D, Timperio A, Tremblay M, et al. *A systematic review to update the Australian physical activity guidelines for children and young people.* Canberra, Australia: Commonwealth of Australia.2012.
2. Physical Activity Guidelines Advisory Committee. Physical activity guidelines advisory committee report, 2008. *Washington, DC: US Department of Health and Human Services* 2008.
3. To QG, Frongillo EA, Gallegos D, Moore JB. Household food insecurity is associated with less physical activity among children and adults in the U.S. population. *The Journal of Nutrition* 2014;**144**(11):1797-802.
4. Troiano RP, Berrigan D, Dodd KW, Mâsse LC, Tilert T, McDowell M. Physical activity in the United States measured by accelerometer. *Med Sci Sports Exerc* 2008;**40**(1):181-8.
5. Australian Bureau of Statistics. Australian Health Survey: Physical Activity, 2011-12. http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/462FBA87B642FCA4CA257BAC0015F3CE?opendocument. Accessed 06 March 2018.
6. Currie C, Zanotti C, Morgan A, Currie D, de Looze M, Roberts C, et al. Social determinants of health and well-being among young people. Health Behaviour in School-aged Children (HBSC) study: international report from the 2009/2010 survey. 2012; http://www.euro.who.int/en/publications/abstracts/social-determinants-of-health-and-well-being-among-young-people.-health-behaviour-in-school-aged-children-hbsc-study. Accessed 07/08/2017.
7. Guthold R, Cowan MJ, Autenrieth CS, Kann L, Riley LM. Physical Activity and Sedentary Behavior Among Schoolchildren: A 34-Country Comparison. *J Pediatr* 2010;**157**(1):43-9.
8. Amornsriwatanakul A, Nakornkhet K, Katewongsa P, Choosakul C, Kaewmanee T, Konharn K, et al. Results from Thailand's 2016 Report Card on physical activity for children and youth. *Journal of Physical Activity and Health* 2016;**13**(11 Suppl 2):S291-S8.
9. Khan A, Burton N, Trost S. Patterns and correlates of physical activity in adolescents in Dhaka city, Bangladesh. *Public Health* 2017;**145**:75-82.
10. Trang N, Hong TK, Dibley MJ, Sibbritt DW. Factors associated with physical inactivity in adolescents in Ho Chi Minh City, Vietnam. *Med Sci Sports Exerc* 2009;**41**(7):1374-83.
11. IOM (Institute of Medicine). 2013. Educating the student body: Taking physical activity and physical education to school. Washington, DC: The National Academies Press.
12. Ministry of Education and Training. Ban Hanh Quy Dinh Ve Tieu Chuan Danh, Cong Nhan Truong Tieu Hoc Dat Muc Chat Luong Toi Thieu, Truong Tieu Hoc Dat Chuan Quoc Gia. 2012; http://thuvienphapluat.vn/van-ban/Giao-duc/Thong-tu-59-2012-TT-BGDDT-cong-nhan-truong-tieu-hoc-dat-chuan-quoc-gia-163114.aspx. Accessed 09/04/2017.
13. Department of Statistics. *Statistics of Ho Chi Minh City.* Ho Chi Minh City, Vietnam: Department of Statistics; 2004.
14. Trang NHHD, Hong TK, Dibley MJ. Active commuting to school among adolescents in ho chi minh city, vietnam change and predictors in a longitudinal study, 2004 to 2009. *Am J Prev Med* 2012;**42**(2):120-8.
15. World Health Organization. Physical status: The use of and interpretation of anthropometry, Report of a WHO Expert Committee. 1995; http://apps.who.int/iris/bitstream/10665/37003/1/WHO_TRS_854.pdf. Accessed 07/08/2017.
16. Onis Md, Onyango AW, Borghi E, Siyam A, Nishida C, Siekmann J. Development of a WHO growth reference for school-aged children and adolescents. *Bull World Health Organ* 2007;**85**(9):660-7.
17. Trost SG, Ward DS, McGraw B, Pate RR. Validity of the Previous Day Physical Activity Recall (PDPAR) in fifth-grade children. *Pediatr Exerc Sci* 1999;**11**(4):341-8.

372 18. Trost SG. State of the art reviews: measurement of physical activity in children and adolescents. *Am J*
373   *Lifestyle Med* 2007;**1**(4):299-314.
374 19. Weston AT, Petosa R, Pate RR. Validation of an instrument for measurement of physical activity in
375   youth. *Med Sci Sports Exerc* 1997;**29**(1):138-43.
376 20. Lee KS, Trost SG. Validity and reliability of the 3-day physical activity recall in Singaporean adolescents.
377   *Res Q Exerc Sport* 2005;**76**(1):101-6.
378 21. Trost SG. Objective measurement of physical activity in youth: current issues, future directions. *Exerc*
379   *Sport Sci Rev* 2001;**29**(1):32-6.
380 22. Rowe DA, Mahar MT, Raedeke TD, Lore J. Measuring physical activity in children with pedometers:
381   Reliability, reactivity, and replacement of missing data. *Pediatr Exerc Sci* 2004;**16**(4):343-54.
382 23. Colley RC, Janssen I, Tremblay MS. Daily step target to measure adherence to physical activity
383   guidelines in children. *Med Sci Sports Exerc* 2012;**44**(5):977-82.
384 24. Telford RM, Telford RD, Cunningham RB, Cochrane T, Davey R, Waddington G. Longitudinal patterns
385   of physical activity in children aged 8 to 12 years: The LOOK study. *Int J Behav Nutr Phys Act*
386   2013;**10**(1):81-93.
387 25. Brusseau TA, Kulinna PH, Tudor-Locke C, Ferry M. Daily physical activity patterns of children living in
388   an american indian community. *Journal of Physical Activity & Health* 2013;**10**(1):48-53.
389 26. Cox M, Schofield G, Greasley N, Kolt GS. Pedometer steps in primary school-aged children: A
390   comparison of school-based and out-of-school activity. *J Sci Med Sport* 2006;**9**(1-2):91-7.
391 27. Harmon J, Brusseau TA, Collier D, Lenz E. Habitual physical activity patterns of inner-city children.
392   *Human Movement* 2013;**14**(4):305-9.
393 28. Commonwealth Scientific Industrial Research Organisation (CSIRO) Preventative Health National
394   Research Flagship and the University of South Australia. 2007 Australian National Children's Nutrition
395   and   Physical   Activity   Survey-Main   Findings.   2008;
396   https://www.health.gov.au/internet/main/publishing.../childrens-nut-phys-survey.pdf.   Accessed
397   07/08/2017.
398 29. Van der Horst K, Paw M, Twisk JW, Van Mechelen W. A brief review on correlates of physical activity
399   and sedentariness in youth. *Med Sci Sports Exerc* 2007;**39**(8):1241-50.
400 30. Sallis JF, Prochaska JJ, Taylor WC. A review of correlates of physical activity of children and adolescents.
401   *Med Sci Sports Exerc* 2000;**32**(5):963-75.
402 31. Trost SG, Pate RR, Sallis JF, Freedson PS, Taylor WC, Dowda M, et al. Age and gender differences in
403   objectively measured physical activity in youth. *Med Sci Sports Exerc* 2002;**34**(2):350-5.
404 32. Cairney J, Kwan MY, Velduizen S, Hay J, Bray SR, Faught BE. Gender, perceived competence and the
405   enjoyment of physical education in children: a longitudinal examination. *International Journal of*
406   *Behavioral Nutrition and Physical Activity* 2012;**9**(1):26-34.
407 33. Vella SA, Cliff DP, Okely AD. Socio-ecological predictors of participation and dropout in organised
408   sports during childhood. *International Journal of Behavioral Nutrition and Physical Activity*
409   2014;**11**(1):62-72.
410 34. Edwardson CL, Gorely T, Pearson N, Atkin A. Sources of activity-related social support and adolescents'
411   objectively measured after-school and weekend physical activity: gender and age differences. *Journal*
412   *of Physical Activity and Health* 2013;**10**(8):1153-8.
413 35. Trost SG, Sallis JF, Pate RR, Freedson PS, Taylor WC, Dowda M. Evaluating a model of parental influence
414   on youth physical activity. *Am J Prev Med* 2003;**25**(4):277-82.
415 36. Steele RM, van Sluijs EMF, Sharp SJ, Landsbaugh JR, Ekelund U, Griffin SJ. An investigation of patterns
416   of children's sedentary and vigorous physical activity throughout the week. *Int J Behav Nutr Phys Act*
417   2010;**7**(1):88-96.

418 37. Brusseau TA, Kulinna PH, Tudor-Locke C, Ferry M, van der Mars H, Darst PW. Pedometer-determined
419   segmented physical activity patterns of fourth- and fifth-grade children. *Journal of Physical Activity &*
420   *Health* 2011;**8**(2):279-86.
421 38. Ramirez-Rico E, Hilland TA, Foweather L, Fernández-Garcia E, Fairclough SJ. Weekday and weekend
422   patterns of physical activity and sedentary time among Liverpool and Madrid youth. *European Journal*
423   *of Sport Science* 2014;**14**(3):287-93.
424 39. Brooke HL, Corder K, Atkin AJ, van Sluijs EM. A systematic literature review with meta-analyses of
425   within- and between-day differences in objectively measured physical activity in school-aged children.
426   *Sports Med* 2014;**44**(10):1427-38.
427 40. Pate RR, O'Neill JR, McIver KL. Physical activity and health: does physical education matter? *Quest*
428   2011;**63**(1):19-35.
429 41. Morgan CF, Beighle A, Pangrazi RP. What are the contributory and compensatory relationships
430   between physical education and physical activity in children? *Res Q Exerc Sport* 2007;**78**(5):407-12.
431 42. Page A, Cooper AR, Stamatakis E, Foster LJ, Crowne EC, Sabin M, et al. Physical activity patterns in
432   nonobese and obese children assessed using minute-by-minute accelerometry. *Int J Obes*
433   2005;**29**(9):1070-6.
434 43. Laguna M, Ruiz JR, Gallardo C, García-Pastor T, Lara MT, Aznar S. Obesity and physical activity patterns
435   in children and adolescents. *J Paediatr Child Health* 2013;**49**(11):942-9.
436 44. Dorsey KB, Herrin J, Krumholz HM. Patterns of moderate and vigorous physical activity in obese and
437   overweight compared with non-overweight children. *Int J Pediatr Obes* 2011;**6**(2-2):e547-e55.
438 45. Trost SG, Kerr L, Ward DS, Pate RR. Physical activity and determinants of physical activity in obese and
439   non-obese children. *Int J Obes* 2001;**25**(6):822-9.
440 46. Bauman AE, Reis RS, Sallis JF, Wells JC, Loos RJF, Martin BW, et al. Correlates of physical activity: why
441   are some people physically active and others not? *Lancet* 2012;**380**(9838):258-71.
442 47. Centers for Disease Control and Prevention. Comprehensive School Physical Activity Programs: A
443   Guide for Schools. Atlanta, GA: U.S. Department of Health and Human Services; 2013.
444