Reference standards to assess physical fitness of children and adolescents of Brazil: an approach to the students of the lake Itaipú region - Brazil

Edilson Hobold [1] , Vitor Pires-Lopes [2] , Rossana Gomez-Campos [3, 4] , Miguel Arruda [4] , Cynthia Lee Andruske [5] , Jaime Pacheco-Carrillo [6] , Marco Antonio Cossio-Bolaños [Corresp. 4, 7, 8]

[1] Universidade Estadual do Oeste do Paraná, Parana, Brazil

[2] Research Center in Sports Sciences, Health Sciences and Human Development (CIDESD) and Department of Sports Science of Polytechnic Institute of Bragança, Braganca, Portugal

[3] Universidad Autonoma de Chile, Talca, Chile

[4] Faculty of Physical Education, State University of Campinas, Campinas, Brazil

[5] Faculty of Educational Sciences,, Universidad de Talca, Linares, Chile

[6] Universidad del Bio Bio, Chillan, Chile

[7] Universidad Católica del Maule, Talca, Chile

[8] Instituto del Deporte Universitario, IDUNSA, Universidad Nacional de San Agustín, Arequipa, Arequipa, Perú

Corresponding Author: Marco Antonio Cossio-Bolaños
Email address: mcossio1972@hotmail.com

Background. The importance of assessing body fat variables and physical fitness tests play an important role in monitoring the level of activity and physical fitness of the general population. The objective of this study was to develop reference norms to evaluate the physical fitness aptitudes of children and adolescents based on age and sex from the lake region of Itaipú, Brazil. **Methods.**A descriptive cross-sectional study was carried out with 5,962 students (2938 males and 3,024 females) with an age range of 6.0 and 17.9 years. Weight (kg), height (cm), and triceps (mm), and sub-scapular skinfolds (mm) were measured. Body Mass Index (BMI kg/m^2) was calculated. To evaluate the 4 physical fitness aptitude dimensions (morphological, muscular strength, flexibility, and cardio-respiratory), the following physical education tests were given to the students: sit-and-reach (cm), push-ups (rep), standing long jump (cm), and 20-m shuttle run (m). **Results and Discussion.**Females showed greater flexibility in the sit-and-reach test and greater body fat than the males. No differences were found in BMI. Percentiles were created for the 4 components for the physical fitness aptitudes, BMI, and skinfolds by using the LMS method based on age and sex. The proposed reference values may be used for detecting talents and promoting health in children and adolescents.

1   **Reference standards to assess physical fitness of children and adolescents of Brazil: an**

2   **approach to the students of the lake Itaipú region – Brazil**

3

4   Edilson Hobold[1], Vítor P. Lopes[2], Rossana Gómez-Campos[3,4], Miguel de Arruda[4], Cynthia Lee

5   Andruske[5], Jaime Pacheco-Carrillo[6], Marco Antonio Cossio-Bolaños[4,7,8]

6

7   [1]Universidade Estadual do Oeste do Paraná

8   [2]Research Center in Sports Sciences, Health Sciences and Human Development (CIDESD) and

9   Department of Sports Science of Polytechnic Institute of Bragança, Portugal.

10   [3]Universidad Autónoma de Chile, Talca, Chile

11   [4]Faculty of Physical Education, State University of Campinas, Sao Paulo, Brazil

12   [5]Faculty of Educational Sciences, Universidad de Talca (Campus Linares), Chile

13   [6]Universidad del Bio Bio, Chillán, Chile

14   [7]Universidad Católica del Maule, Talca, Chile

15   [8]Instituto del Deporte Universitario, IDUNSA, Universidad Nacional de San Agustín, Arequipa,

16   Perú.

17

18   **Corresponding author:**

19   Marco A. Cossio-Bolaños.

20   Faculty of Physical Education, State University of Campinas. Av. Erico Verissimo 851, Cidade

21   Universitaria, Barao Geraldo, Campinas, Sao Paulo. Email: mcossio1972@hotmail.com

22

23

24

25

ABSTRACT

Background. The importance of assessing body fat variables and physical fitness tests play an important role in monitoring the level of activity and physical fitness of the general population. The objective of this study was to develop reference norms to evaluate the physical fitness aptitudes of children and adolescents based on age and sex from the lake region of Itaipú, Brazil.

Methods. A descriptive cross-sectional study was carried out with 5,962 students (2938 males and 3,024 females) with an age range of 6.0 and 17.9 years. Weight (kg), height (cm), and triceps (mm), and sub-scapular skinfolds (mm) were measured. Body Mass Index (BMI kg/m^2) was calculated. To evaluate the 4 physical fitness aptitude dimensions (morphological, muscular strength, flexibility, and cardio-respiratory), the following physical education tests were given to the students: sit-and-reach (cm), push-ups (rep), standing long jump (cm), and 20-m shuttle run (m).

Results and Discussion. Females showed greater flexibility in the sit-and-reach test and greater body fat than the males. No differences were found in BMI. Percentiles were created for the 4 components for the physical fitness aptitudes, BMI, and skinfolds by using the LMS method based on age and sex. The proposed reference values may be used for detecting talents and promoting health in children and adolescents.

43

44

45

46

47

48

49

50

51

52

INTRODUCTION

54   Physical fitness is a strong indicator of health in childhood years as well as in adulthood

55 (*Blaes A, 2011; Ortega et al., 2008*). It is associated the with decrease in the risk of

56 cardiovascular diseases (*Soares-Miranda et al., 2015*) and to the development of a healthy body

57 weight (*Lu et al., 2014*), among other aspects.

58   In general, physical fitness tests within the school educational system are an important

59 tool to measure the achievements of the learning standards associated with physical education

60 (*Tremblay & Lloyd, 2010a*). These standards are set by the results of field physical tests (*Golle et*

61 *al., 2015*). These are commonly used by international schemes to assess the levels of physical

62 wellbeing of children and adolescents in schools (*Catley & Tomkinson, 2013; De Miguel-Etayo*

63 *et al., 2014; Meredith & Welk, 2007; Ruiz et al., 2011; Tremblay et al., 2010b*).

64   In Brazil, currently, reference standards to evaluate physical fitness associated with health

65 are missing. These standards are necessary to rank children and to monitor physical fitness of the

66 school community (*De Miguel-Etayo et al., 2014*).

67   Currently, the test models used nationally and internationally allow us to analyze the

68 results using the morphological, muscular strenght, flexibility, and cardiovascular factors.

69 Nonetheless, to our knowledge, no recent studies exist that are capable of assessing the wide

70 range of factors associated with the physical fitness of Brazilian children and adolescents. This is

71 due to the fact that it is generally known that today's children and adolescents have a variety of

72 paces and patterns of physical development throughout the world. In addition, the multiple

73 protocols developed by countries to measure the components of physical aptitude and the

74 indicator values for human development are not adequate for comparing the references for levels

75 of physical aptitude between regions. This forces the countries and their administrative regions to

76 establish their own models to measure the general wellbeing of their populations, all physical

77 fitness factors included.

78 Consequently, the regulatory data from field tests represents the possibility to analyze and

79 study health promotion and sports skills. Therefore, this would provide objective

80 recommendations for assessing physical fitness during physical education classes (*Golle et al.,*

81 *2015*). Furthermore, in the past few years, the increasing number of publications about obesity,

82 cardiovascular diseases, and metabolic problems (*Association Diabetes Association, 2000*) show

83 the emergence and the importance of these health problems that today's society faces.

84 In that context, studying physical fitness using its four factors and the chronological age

85 as starting points could provide a way towards achieving relevant data and reaching a common

86 references to describe physical fitness patterns of students of the Itaipú (Brazil). This is

87 particularly feasible since physical education classes are held for 50 minutes two to three times a

88 week.

89 Thus, the goal of this study was to develop reference standards that allow us to assess the

90 physical fitness factors of children and adolescents based on age and gender in the Lake Itaipú

91 region-Brazil.

92

93 **MATERIALS**

94 The researcher team designed a cross-sectional descriptive study that included 5,962

95 students (2,938 men and 3,024 females) from the Lake Itaipú region in Paraná (Brazil). The age

96   range ranged from 6.0 to 17.9 years old. Sample selection was probabilistic (stratified). Age and

97   sex was used to randomly select the sample from the total available population of students. The

98   sample selection process is illustrated in the flowchart of Figure 1. The educational system for

99   the state of Paraná (Brazil) provides physical education for elementary education in the

100   development of sports, games, gymnastics, boxing, and dance (DCEBEF, 2008). Physical

101   education classes are 50 minutes a day three times a week for elementary (6-14 years old) and

102   two times a week for high school students (15-18 years old). The study was conducted in

103   accordance with the guidelines established by the Ethics Committee of the School of Medical

104   Sciences of the University of Campinas (São Paulo, Brazil)- 2012-785.

105

106   **Insert figure 1**

107   There were 34 public education schools (elementary and high school education) included

108   in the study. These schools are located in 11 counties that are part of the Lake Itaipú region in the

109   state of Paraná (Brazil). This region is located in the west of Paraná, 627 km from the capital of

110   Curitiba. It is bordered and contained by the neighboring country of Paraguay. According to the

111   United Nations Program (*PNUD 2010*), the Human Development Index (HDI) of this region in

112   2010 was between 0.700 and 0.799.

113   Students with physical or mental limitations and subjects with a Body Mass Index (IBMI)

114   greater than the p97 percentile based on cut off points from the Centers for Disease Control and

115   Prevention were not included in the study (Kuczmarski et al., 2000). Written informed consent

116   was obtained from the parents or guardians and students. The study was approved by the ethical

117   committee of the Medical School of the State University of Campinas SP (Brazil).

118

119 **METHODS**

120   The anthropometric evaluation and the physical fitness testing were conducted from April

121 to November 2012. The data collection was done from Monday to Friday during mornings and

122 afternoons (8 am to 12 pm and 1 pm to 5 pm) inside the facilities of the respective schools.

123

124 **Anthropometric Measures**

125   All of the anthropometric measurements were carried out by five experienced

126 anthropometrists. The technical measurement error was below 1.5%. Standard anthropometric

127 measurement protocol was adopted as described by Ross and Marfell-Jones (1991).

128   Body weight and height were measured with the students in bare feet and with as few

129 clothes on as possible. A digital scale (Tanita United Kingdom, Ltd, model BC601) and a

130 portable stadiometer (Seca Gmbh & Co. KG, Hamburg, Germany, model 217) were used to take

131 all respective measurements. Body Mass Index (BMI) was calculated using the standard

132 equation: weight (kg)/height squared (m^2). Triceps and subscapular skinfolds were measured

133 with a Harpenden skinfold caliper (Harpenden, England).

134 **Physical Fitness**

135 The test battery was designed from 4 dimensions of physical fitness (morphological, muscular

136 strength, flexibility, and cardio-respiratory). Figure 2 illustrates the organization of the tests for

137 each dimension.

138 **Insert figure 2**

139

140   In all of the cases, the highest points obtained were interpreted as indicators of better

141 physical performance. During the physical tests carried out in each of the schools, a nurse was

142 always present. The nurse was to assist in case of an emergency during the physical tests. All of

143 the tests, except for the 20-m Shuttle Run Test, were conducted twice (n=596). The purpose was

144 to verify the Technical Error of Measurement (TEM) of 10% of the sample in the research study.

145 The values varied from 0.8 to 2.7%.

146 Physical fitness evaluation included the following test items:

147 (1) sit-and-reach to measure flexibility of the hamstrings muscles and lower back. The

148 procedures followed the YMCA (2000) suggestions. Three trials were conducted, and the best

149 performance was recorded.

150 (2) push-ups test to measure muscle endurance. For girls, the push-up test was modified by

151 resting on the knees (as opposed to toes). The number of push-ups was registered. (CSTFOM,

152 1986)

153 (3) standing long jump to measure power muscular fitness of leg muscles. Three trials were

154 carried out, and the best performance was recorded (Castro-Piñero et al., 2010).

155 (4) 20-m shuttle run to measure aerobic fitness (Leger, 1998). The running pace was imposed by

156 a sound signal. The initial speed was 8.5 km/h-1, and it increased in 0.5 km/h in 1 minute

157 intervals. The testing finished when the student stopped, due to fatigue, or when he/she did not

158 reach the line at the same time as the audio signal, on two consecutive occasions. This test was

159 performed only once. A group of 6-8 students were tested simultaneously.

160 The evaluation of physical testing was performed in the facilities of each school.

161 Previously, a warm up of about 10 to 15 minutes was carried out to familiarize the students with

162 the procedures. Afterwards, the tests were carried out in the following order: sit-and-reach, push-

163 ups, standing long jump and Shuttle Run test.

164

165 **Statistics**

166   The normal distribution of the data was verified by using the Kolmogorov-Smirnov Test.

167 descriptive statistics of the arithmetic average, standard deviation, frequencies, and percentages.

168 The differences between both sexes were determined by a t-test of independent samples.

169 Smoothed percentile curves were created for physical fitness for each sex based on the LMS

170 method (Cole et al.,2000). LMS Chart Maker Pro Version 2.3 software (Pan & Cole, 2006) was

171 used. The final percentile curves were the result of smoothing three age-specific curves: L

172 (lambda; skewness), M (Mu; median), and S (sigma; coefficient of variation). P10, P50, and P85

173 to BMI and to the sum of skinfolds. P15, P50, and P85 to the physical tests.

174 **RESULTS**

175   Table 1 shows the descriptive statistics (mean and standard-deviation) for all variables

176 measured.

177   In general, male subjects showed greater weight and stature and better performance in

178 push-ups, standing long jump, and 20-m shuttle run (p<0.001). On the contrary, female students

179 demonstrated better performance in the sit-and-reach test. No significate differences were

180 observed in the BMI (p=0.3345). However, females showed a greater sum of skinfolds than

181 males.

182

183 ******Table 1 near here******

184

185   The physical fitness dimension norms distributed in percentiles by age and sex are

186   illustrated in Tables 2 and 3. For the morphological dimension (BMI and skinfolds), the P10,

187   P50, and P85 percentiles have been used and for the other dimensions in P15, P50, and P85.

188   Smoothed curves are also shown through the LMS method for the four dimensions of physical

189   fitness by age and sex (Figures 3 and 4).

190

191   ******Table 2 near here******

192   ******Table 3 near here******

193   ******Figure 3 near here******

194   ******Figure 4 near here******

195

196   **DISCUSSION AND CONCLUSIONS**

197

198   This study developed percentiles based on the LMS method to evaluate the physical fitness of

199   children and adolescents of both sexes and ages 6.0 to 17.9. The battery of the tests given in the

200   study evaluated four dimensions: For example, the morphological dimensions were determined

201   by BMI and the sum of two skinfolds (tricipital + subescapular), the muscular dimension by the

202   Push-up Test and standing long jump, and flexibility the Sit-and-reach Test, and the cardio-

203   respiratory dimension by the Shuttle Run Test (20m).

204   Therefore, to date, no general consensus exists about the definition of the key

205   components and/or dimensions of physical fitness. However, the majority of the studies are in

206   agreement about two defined objectives: health and sports achievements (Cvejic et al., 2013).

207   In general, independent of the objectives, both depend on the level of physical fitness

208   performed inside and outside of the school system. The percentile values proposed in this study

209 may be useful for identifying children and adolescents with high health risks as well as
210 identifying individuals with moderate and elevated levels of physical fitness.

211   Various studies have proven that a low level of physical fitness during childhood and
212 adolescence is associated with overweight and obesity as well as cardiovascular diseases,
213 deterioration of bone health, and reduced quality of life (Vicente-Rodriguez et al., 2008;
214 Moliner-Urdiales et al., 2010; Morales et al., 2013), among other ailments.

215   For example, increase in muscular strength from childhood to adolescences related
216 inversely to changes in body fat. (Ruiz et al., 2011). Moreover, it has been demonstrated that
217 strength is positively associated with a better quality of bone health (Pitukcheewanont et al.,
218 2010). In addition, an adequate level of aerobic conditioning increases the capacity to work
219 efficiently and allow participation and enjoyment in physical activities such as sports, recreation,
220 and leisure (Carnethon & Gulati, 2005). Therefore, these benefits are associated with adequate
221 levels of flexibility, reduced risks of lesions, prevent and reduce pain, and improve motor
222 coordination (Castro-Piñero et al., 2010).

223   As a result, the importance of evaluating body fat variables and physical fitness tests play
224 an important role in monitoring the level s of physical activity and physical fitness of populations
225 in general. According to the World Health Organization (WHO, 2010), physical fitness should be
226 considered a priority for public health. Therefore, schools should play a central role in the
227 provision and promotion of physical activity and physical fitness of the young along with other
228 healthy behaviors since children and adolescents spend a majority of their time in the school
229 setting (Pate et al., 2006). This is an important opportunity to introduce physical activity
230 programs for specific work groups not only in schools but also in sports clubs and/or physical
231 sports rehabilitation centers, respectively

232   The accurate interpretation of physical fitness values requires the comparison of the
233 scores obtained from one person in particular with the normative valuies for the general
234 population of the same sex and age (Ortega et al., 2011). In this context, the normative values
235 proposed here may be used for different purposes, for example morphological dimensions (BMI
236 and skinfolds). The interpretation of >p85 may be considered excessive fat, between 10 to p85 as
237 normal, and <p10 as low levels of fat equal to the CDC-2000 cut-off scores (Kuczmarski et al.,
238 2000). On the other hand, for the physical fitness tests, the percentiles less than <p15 may be

239   interpreted as a low level or a warning sign, between p15 to p85 as adequate, and >p85 as an
240   elevated level of fitness.

241   In essence, to date, no defined consensus exists about the cut-off points for dimensions
242   used in the tests for determining physical fitness in pediatric populations. In spite of this, some
243   population studies use scales consisting of two to five categories (Meredith & Welk, 2007;
244   Ortega et al., 2011; Catley & Tomkinson, 2013; De Miguel-Etayo et al., 2014).

245   This current study opts for three categories. To do this, we took into account the reality of
246   the educational systems of the schools since the schools, just importantly, identified students
247   with low levels of physical fitness as well as identifying those student athletes (Golle et al.,
248   2015).

249   Moreover, the schools maintained and promoted adequate levels of physical activity
250   (related to health) for the students throughout the school years. Furthermore, this is an objective
251   that should be maintained in the short, medium, and long term. Thus, these objectives should not
252   be careless and of a permanent nature. They should be developed within the curriculum
253   programs in all of the educational systems.

254   In summary, taking into account the probabilistic sample selection, the use of the LMS
255   method to generate the percentiles and the proposed battery of tests with their four dimensions,
256   this study has a number of advantages. Based on its applicability to the Lake Itaipú region of
257   Brazil and the selected sample size, the results from this research may be generalized to other
258   geographical regions of Brazil, particularly those with similar demographic characteristics.

259   This study has a few limitations. For example, the (cross-sectional) design of the study
260   does not allow for changes to be described in physical fitness during growth and development.
261   Therefore, future studies should be designed longitudinally since physical fitness levels change
262   over time. Longitudinal research is better suited to track changes over time than are cross-
263   sectional studies (Golle et al., 2015). Furthermore, biological maturation could not be measured
264   in this study. Controlling for this variable would have diminished the range of variability
265   between individuals of the same chronological age during adolescence.

266   In conclusion, the results of this study show regional reference values for evaluating the
267   physical fitness of children and adolescents by chronological age and sex. The findings from this
268   research can be used for the detection and monitoring of the four dimensions of physical fitness
269   (morphological, flexibility, muscle strength, and cardiorespiratory) as a specific tool for health in

270   educational contexts. Nevertheless, to confirm these results, it is necessary to develop
271   longitudinal studies.

272

273   **REFERENCES**

274

275   **American Diabetes Association. 2000.** Type 2 diabetes in children and adolescents. *Pediatrics*,
276   105, 671–80.

277   **Blaes A, Baquet G, Fabre C, Van Praagh E, Berthoin S. 2011**. Is there any relationship
278   between physical activity level and patterns, and physical performance in children.
279   *International Journal of Behavioral Nutrition and Physical Activity,* 8, 122.

280   **Canadian Standardized Test of Fitness Operations Manual (CSTFOM)**, 3rd ed., Health
281   Canada, 1986.

282   **Carnethon M.R, Gulati M, Greenland P. 2005**. Prevalence and cardiovascular disease
283   correlates of low cardiorespiratory fitness in adolescents and adults. *JAMA,* 294: 2981–
284   2988.

285   **Castro-Piñero J, Ortega FB, Artero EG, Girela-Rejón MJ, Mora J, Sjöström M, Ruiz JR.**
286   **2010.** Assessing muscular strength in youth: usefulness of standing long jump as a general
287   index of muscular fitness. *Journal Strength Condition Research,* 24: 1810–1817.

288   **Catley MJ, Tomkinson GR. 2013.** Normative health-related fitness values for children: analysis
289   of 85347 test results on 9–17-year-old Australians since 1985. *British Journal of Sports*
290   *Medicine*, 47, 98–108. doi:10.1136/bjsports-2011-090218

291   **Cole T.J, Bellizzi M.C, Flegal K.M, Dietz, W.H. 2000.** Establishing a standard definition for
292   child overweight and obesity worldwide: International survey. *BMJ*, 320, 1240–1243.

293   **Cvejić D, Pejović T, Ostojić S. 2013.** Assessment of Physical Fitness in Children and
294   Adolescents. Physical Education and Sport, 11(2): 135 – 145.

295   **Diretrizes curriculares da educação básica en educação física (DCEBEF).** 2008. Governo do
296   Paraná, secretaria de estado da Educação do Paraná, departamento de Educação básica,
297   Paraná, Brasil, 2008

298   **De Miguel-Etayo P. Gracia-Marco L, Ortega FB, Intemann T, Foraita R, Lissner L, Oja L,**
299   **Barba G, Michels N, Tornaritis M, Molnár D, Pitsiladis Y, Ahrens W, Moreno LA, on**
300   **behalf of the IDEFICS consortium. 2014.** Physical fitness reference standards in

301   European children: the IDEFICS study. *International Journal of Obesity*, 38, S57–S66.
302   doi:10.1038/ijo.2014.136

303 **Golle K, Muehlbauer T, Wick D, Granacher U. 2015.** Physical Fitness Percentiles of German
304   Children Aged 9–12 Years: Findings from a Longitudinal Study. *PLoS ONE,* 10(11),
305   e0142393. doi:10.1371/journal.pone.0142393

306 **Kuczmarski R, Ogden C, Grummer-Strawn L, Flegal KM, Guo SS, Wei R, Mei Z, Curtin**
307   **LR, Roche AF, Johnson CL. 2000.** CDC growth charts: United States. Advance data
308   from vital and health statistics. Hyattsville (MD): U.S. Department of Health and Human
309   Services.

310 **Leger LA, Mercier D, Gadoury C, Lambert J. 1998.** The multistage 20 metre shuttle run test
311   for aerobic fitness. *Journal of Sports Science*, 6, 93–101.

312 **Lu Y.J, Zheng X.D, Zhou F.S, Zuo X.B. 2014.** BMI and physical fitness in Chinese adult
313   students: a large school-based analysis. *International Journal of Clinical and Experimental*
314   *Medicine,* 7(10), 3630-3636.

315 **Meredith, M Welk G & the Cooper Institute.** Fitnessgram/Activitygram 2007 test
316   administration manual, Updated 3er edition. Human Kinetics: Champaign, IL, USA.

317 **Moliner-Urdiales D, Ortega FB, Vicente-Rodriguez G, Rey-Lopez JP, Gracia-Marco L,**
318   **Widhalm K, Sjöström M, Moreno LA, Castillo M.J, Ruiz JR. 2010.** Association of
319   physical activity with muscular strength and fat-free mass in adolescents: the HELENA
320   study. *European Journal of Applied Physiology*, 109: 1119–1127

321 **Morales PF, Sanchez-Lopez M, Moya-Martinez P, Garcia-Prieto JC, Martinez-Andres M,**
322   **Garcia NL, Martínez-Vizcaíno V. 2013.** Health-related quality of life, obesity, and
323   fitness in schoolchildren: the Cuenca study. *Quality of Life Research*, 22: 1515–1523.

324 **Ortega FB, Ruiz JR, Castillo MJ, Sjostrom M. 2008.** Physical fitness in childhood and
325   adolescence: a powerful marker of health. *International Journal of Obesity (Lond)*, 32, 1–
326   11.

327 **Ortega FB, Labayen I, Ruiz JR, Kurvinen E, Loit HM, Harro J, Veidebaum T, Sjöström**
328   **M. 2011.** Improvements in fitness reduce the risk of becoming overweight across puberty.
329   *Medicine Science Sports Exercise*, 43, 1891–1897.

330 **Pan   H,   Cole   TJ.   LMS   Chartmaker.   2006.**   Available   online   at:
331   http://www.healthforallchildren.co.uk (accessed March 28, 2015).

332   **Pate R.R, Davis M.G, Robinson T.N, Stone E.J, McKenzie T.L, Young, J. C. 2006.**
333   Promoting physical activity in children and youth: A leadership role for schools: A
334   scientific statement from the American heart association council on nutrition, physical
335   activity, and metabolism (physical activity committee) in collaboration with the councils
336   on cardiovascular disease in the young and cardiovascular nursing. *Circulation*, 114(11),
337   1214–1224.

338   **Pitukcheewanont P, Punyasavatsut N, Feuille, M. 2010**. Physical activity and bone health in
339   children and adolescents. *Pediatric Endocrinology Reviews*: PER, 7(3), 275–282.

340   **Programa de las Naciones Unidas para el Desarrollo (PNUD). 2010.** Informe Sobre
341   Desarrollo Humano 2010. Edición del vigésimo aniversario: New York.

342   **Ross WD, Marfell-Jones MJ.** Kinanthropometry. In: MacDougall JD, Wenger HA, Green HJ,
343   eds. 1991. Physiological Testing of the High-Perfomance Athlete. Champaign, Illinois:
344   Human Kinetics Books, pp 223–308.

345   **Ruiz JR, España-Romero V, Castro-Piñero J, Artero EG, Ortega FB, Cuenca García M,**
346   **Jiménez Pavón D, Chillón P, Girela-Rejón MJ, Mora J, Gutiérrez A, Suni J, Sjöstrom**
347   **M, Castillo MJ. 2011.** ALPHA-fitness test battery: Health-related field-based fitness tests
348   assessment in children and adolescents. *Nutr Hosp*, 26(6), 1210–4.
349   http://dx.doi.org/10.1590/S0212-16112011000600 003. Spanish.

350   **Soares-Miranda L, Imamura F, Siscovick D, Jenny N.S, Fitzapatrick A.L, Mozaffarian D.**
351   **2015.** Physical Activity, Physical Fitness, and Leukocyte Telomere Length: The
352   Cardiovascular Health Study. *Medicine & Science in Sports & Exercise*, 47(12), 2525-
353   2534.

354   **Tremblay M, Lloyd M. 2010a**. Physical literacy measurement: The missing piece. *Physical and*
355   *Health Education Journal*, 76(1), 26-30.

356   **Tremblay MS, Shields M, Laviolette M, Craig CL, Janssen I, Connor Gorber S. 2010b.**
357   Fitness of Canadian children and youth: results from the 2007-2009 Canadian Health
358   Measures Survey. *Health Report*, 21, 7–20.

359   **Vicente-Rodriguez G, Urzanqui A, Mesana MI, Ortega FB, Ruiz JR, Ezquerra J, Casajús**
360   **JA, Blay G, Blay VA, Gonzalez-Gross M, Moreno LA; AVENA-Zaragoza Study**
361   **Group. 2008.** Physical fitness effect on bone mass is mediated by the independent

362   association between lean mass and bone mass through adolescence: a cross-sectional

363   study. *Journal of Bone Mineral Metabolims*, 26: 288–294

364   **WHO. 2010.** Global recommendations on physical activity for health.

365   YMCA, Fitness Testing and Assessment Manual 4th edition. 2000. with permission of YMCA

366   of the USA, 101 N. Wacker Drive, Chicago, IL 60606. http://www.fitnessgram.net/.

367   Virginia's Fitness Test Reporting Categories.

368

369

370

371

372

373

374

375

376

377

378

379

380

381

382

383

384

Figure 1. Flowchart outlined to select the study sample.

386

Figure 2. Organization of physical fitness dimensions.

388

Figure 3. Smoothed centile curves for BMI and Skinfolds (P10, P50 and P85) and physical

fitness tests (P15, P50 and P85) by chronological age in males.

391

Figure 4. Smoothed centile curves for BMI and Skinfolds (P10, P50 and P85) and physical

fitness tests (P15, P50 and P85) by chronological age in females.

394

395

396

397

398

399

400

401

402

403

404

405

406

407

Table 1(on next page)

Table 1

Descriptive statistics (mean ± standard-deviation) for somatic variables and physical fitness items for males and females, and results for differences between males and females.

1 Table 1. **Descriptive statistics (mean ± standard-deviation) for somatic variables and**

2   **physical fitness ítems for males and females. And results for difference between males**

3   **and females**

	Males (n=2938)	Females (n=3024)	p
	X±SD	X±SD	
Age (years)	11.7±3.2	12,1±3.2	
Somatic measures			
Weight (kg)	45.4±17.8	43.9±14.7	***
Height (cm)	151.1±18.8	149.1±15.1	***
Sitting height (cm)	77.9±9.3	78.3±8.1	
BMI (kg/m^2)	19.1±4.0	19.2±4.0	
Σ skinfolds (TR+SB)	20.5±12.4	26.8±12.9	***
Physical fitness			
Sit-and-reach (cm)	24.2±7.0	25.8±7.0	***
Push-ups (# Reps)	11.3±8.3	9.8±7.1	***
Standing long jump (cm)	142.2±33.8	113.9±23.0	***
20-m Shutle Run (m)	815.8±382.7	445.1±199.3	***

4 Notes. BMI = body mass index; *** significant for $p < 0.001$

5 For age [(F(df:5960) = 183.9); $p < 0.001$)],

6

Table 2(on next page)

Table 2

Smooth centile scores for body mass index (BMI), Skinfolds, sit-and-reach, push-ups test, standing long jump, and 20-m shuttle run by chronological age in males.

1 Table 2. **Smooth centile scores for body mass index (BMI), Skinfolds, sit-and-reach, push-ups test, standing long jump, and 20-m**

2 **shuttle run by chronological age in males.**

Age	n	L	M	S	P10	p50	P85	L	M	S	P15	p50	P85	L	M	S	P15	p50	P85
		BMI (kg/m^2)						Sit-and-reach test (cm)						Standing long jump (cm)					
6.0-6.9	284	-2.03	14.96	0,13	12,9	15,0	17,5	1,42	25,17	0,23	18,9	25,2	30,9	1,32	101,75	0,18	82,4	101,7	120,0
7.0-7.9	222	-1.91	15.44	0,14	13,2	15,4	18,3	1,40	24,32	0,24	17,9	24,3	30,2	1,29	110,90	0,17	90,5	110,9	130,2
8.0-8.9	210	-1.79	15.99	0,15	13,5	16,0	19,2	1,37	23,62	0,26	17	23,6	29,6	1,26	119,28	0,17	98,1	119,3	139,5
9.0-9.9	227	-1.67	16.53	0,16	13,9	16,5	20,1	1,34	23,13	0,27	16,4	23,1	29,3	1,24	126,26	0,16	104,4	126,3	147,2
10.0-10.9	236	-1.56	17.08	0,17	14,2	17,1	20,8	1,30	22,95	0,28	16	22,9	29,3	1,21	132,26	0,16	109,9	132,3	153,9
11.0-11.9	244	-1.46	17.66	0,17	14,6	17,7	21,6	1,24	23,02	0,28	15,9	23	29,6	1,17	138,55	0,16	115,5	138,5	161,0
12.0-12.9	297	-1.43	18.28	0,17	15,1	18,3	22,3	1,18	23,42	0,29	16,1	23,4	30,3	1,14	146,08	0,16	122,0	146,1	169,6
13.0-13.9	354	-1.47	18.85	0,17	15,7	18,9	23,0	1,10	24,14	0,30	16,6	24,1	31,5	1,12	154,85	0,16	129,5	154,9	179,7
14.0-14.9	326	-1.57	19.36	0,16	16,2	19,4	23,5	1,01	24,82	0,30	17	24,8	32,6	1,14	163,54	0,16	136,7	163,5	189,8
15.0-15.9	241	-1.70	19.87	0,16	16,7	19,9	24,1	0,91	25,41	0,31	17,4	25,4	33,6	1,18	171,38	0,16	143,0	171,4	199,0
16.0-16.9	167	-1.83	20.37	0,15	17,2	20,4	24,6	0,80	25,84	0,31	17,8	25,8	34,4	1,23	178,45	0,16	148,6	178,5	207,2
17.0-17.9	130	-1.96	20.85	0,15	17,7	20,8	25,1	0,69	26,14	0,32	18	26,1	35,1	1,30	185,35	0,16	153,9	185,4	215,3
Σ skinfolds (TR+SB)								Push-ups (# Reps)						20-m Shuttle run (m)					
6.0-6.9	284	-0,78	4,69	0,39	3,1	4,7	7,6	0,33	4,80	0,65	2	5	9						
7.0-7.9	222	-0,74	5,08	0,44	3,2	5,1	8,9	0,35	6,24	0,67	3	6	12						
8.0-8.9	210	-0,73	5,72	0,49	3,4	5,7	10,8	0,36	7,38	0,68	3	7	14						
9.0-9.9	227	-0,62	6,33	0,52	3,6	6,3	12,3	0,39	8,14	0,70	4	8	15						
10.0-10.9	236	-0,60	6,81	0,54	3,8	6,8	13,5	0,41	8,53	0,71	4	9	16	0,23	515,79	0,47	308,1	515,8	817,4
11.0-11.9	244	-0,63	7,21	0,54	4,1	7,2	14,4	0,44	8,84	0,72	4	9	17	0,33	565,85	0,47	331,2	565,9	892,5
12.0-12.9	297	-0,67	7,57	0,52	4,4	7,6	14,8	0,47	9,52	0,72	4	10	18	0,43	642,75	0,47	370,8	642,8	1003,0
13.0-13.9	354	-0,73	7,67	0,49	4,6	7,7	14,4	0,49	10,73	0,71	4	11	20	0,54	739,81	0,46	424,6	739,8	1133,6
14.0-14.9	326	-0,73	7,54	0,46	4,6	7,5	13,5	0,50	12,27	0,70	5	12	23	0,64	835,25	0,44	484,4	835,2	1249,0
15.0-15.9	241	-0,67	7,62	0,43	4,8	7,6	13,0	0,49	13,97	0,69	6	14	26	0,73	915,46	0,42	543,0	915,5	1334,2
16.0-16.9	167	-0,75	8,07	0,41	5,2	8,1	13,5	0,48	15,70	0,67	7	16	29	0,81	1010,66	0,39	617,7	1010,7	1436,3
17.0-17.9	130	-0,82	8,68	0,40	5,7	8,7	14,4	0,47	17,41	0,66	8	17	32	0,87	1131,05	0,36	715,4	1131,0	1567,9

3 Note: BMI = body mass index; TR+SB = triceps + subscapular; P = percentile, L = skew, M = median; S = coefficient of variation.

Table 3 (on next page)

Table 3

Smooth centile scores for body mass index (BMI), Skinfolds, sit-and-reach, push-ups test, standing long jump, and 20-m shuttle run by chronological age in females.

1   **Table 3. Smooth centile scores for body mass index (BMI), Skinfolds, sit-and-reach, push-ups test, standing long jump, and 20-**

2   **m shuttle run by chronological age in females.**

Age	n	L	M	S	P10	p50	P85	L	M	S	P15	p50	P85	L	M	S	P15	p50	P85
		BMI (kg/m^2)						Sit-and-reach test (cm)						Standing long jump (cm)					
6.0-6.9	241	-1,7	15,05	0,146	12,8	15,0	17,9	1,53	26,12	0,21	19,9	26,1	31,6	0,43	87,52	0,18	71,8	87,5	105
7.0-7.9	203	-1,58	15,49	0,154	13,1	15,5	18,6	1,45	25,83	0,23	19,3	25,8	31,7	0,64	96,09	0,18	78,5	96,1	114,9
8.0-8.9	170	-1,47	15,92	0,161	13,3	15,9	19,3	1,37	25,41	0,24	18,6	25,4	31,6	0,84	104,36	0,18	85	104,4	124,3
9.0-9.9	218	-1,38	16,41	0,166	13,6	16,4	20,0	1,29	25,08	0,26	18,1	25,1	31,5	1,01	111,13	0,18	90,3	111,1	131,9
10.0-10.9	276	-1,31	17,04	0,17	14,1	17,0	20,8	1,22	25,07	0,27	17,9	25,1	31,8	1,13	115,88	0,18	94	115,9	137,3
11.0-11.9	323	-1,24	17,75	0,172	14,6	17,7	21,7	1,18	25,4	0,27	18,1	25,4	32,4	1,19	119,20	0,18	96,6	119,2	141,1
12.0-12.9	311	-1,17	18,45	0,172	15,2	18,4	22,5	1,16	25,81	0,27	18,3	25,8	33	1,18	121,03	0,18	98,1	121	143,2
13.0-13.9	337	-1,12	19,12	0,171	15,7	19,1	23,3	1,18	26,22	0,27	18,5	26,2	33,5	1,11	121,40	0,18	98,6	121,4	143,8
14.0-14.9	332	-1,08	19,67	0,169	16,2	19,7	23,9	1,22	26,64	0,27	18,8	26,6	34	1,01	120,67	0,18	98,3	120,7	143
15.0-15.9	276	-1,04	20,06	0,167	16,5	20,1	24,3	1,27	26,93	0,27	19	26,9	34,3	0,86	119,29	0,18	97,6	119,3	141,6
16.0-16.9	198	-1,00	20,40	0,164	16,9	20,4	24,6	1,33	27,12	0,27	19,1	27,1	34,4	0,68	117,93	0,18	97	117,9	140,2
17.0-17.9	139	-0,96	20,77	0,162	17,2	20,8	24,9	1,39	27,38	0,27	19,3	27,4	34,6	0,48	116,72	0,18	96,5	116,7	139
Σ skinfolds (TR+SB)								Push-ups (# Reps)						20-m Shuttle run (m)					
6.0-6.9	241	-0,59	16,60	0,39	9,6	16,6	26,3	0,27	4,16	0,69	2	4	8						
7.0-7.9	203	-0,52	17,92	0,40	10,1	17,9	28,7	0,29	5,38	0,69	2	5	10						
8.0-8.9	170	-0,46	19,17	0,42	10,6	19,2	31,0	0,30	6,45	0,69	3	6	12						
9.0-9.9	218	-0,41	20,41	0,42	11,0	20,4	33,2	0,32	7,33	0,7	3	7	14						
10.0-10.9	276	-0,37	21,58	0,43	11,5	21,6	35,1	0,34	8,06	0,71	4	8	16	0,36	398,11	0,43	245	398,1	602,1
11.0-11.9	323	-0,33	22,63	0,43	12,0	22,6	36,7	0,35	8,67	0,72	4	9	17	0,37	414,97	0,44	251,2	415	633,2
12.0-12.9	311	-0,30	23,77	0,43	12,6	23,8	38,2	0,36	9,09	0,73	4	9	18	0,39	429,7	0,45	256,6	429,7	660,6
13.0-13.9	337	-0,27	25,32	0,42	13,5	25,3	40,2	0,38	9,48	0,74	4	10	19	0,39	419,45	0,46	248,8	419,4	647,8
14.0-14.9	332	-0,24	26,84	0,41	14,4	26,8	42,0	0,39	9,83	0,74	4	10	19	0,37	410,71	0,46	242,9	410,7	636,9
15.0-15.9	276	-0,20	27,93	0,40	15,1	27,9	43,0	0,41	10,02	0,75	4	10	20	0,34	410,87	0,46	242,8	410,9	641,8
16.0-16.9	198	-0,17	28,71	0,39	15,6	28,7	43,6	0,43	10,18	0,75	4	10	20	0,28	417,53	0,47	247,6	417,5	658,8
17.0-17.9	139	-0,13	29,44	0,38	16,2	29,4	44,1	0,44	10,37	0,76	4	10	20	0,18	428,36	0,47	256,5	428,4	684,3

3   Note: BMI = body mass index; TR+SB = triceps + subscapular; P = percentile, L = skew, M = median; S = coefficient of variation.

Figure 1

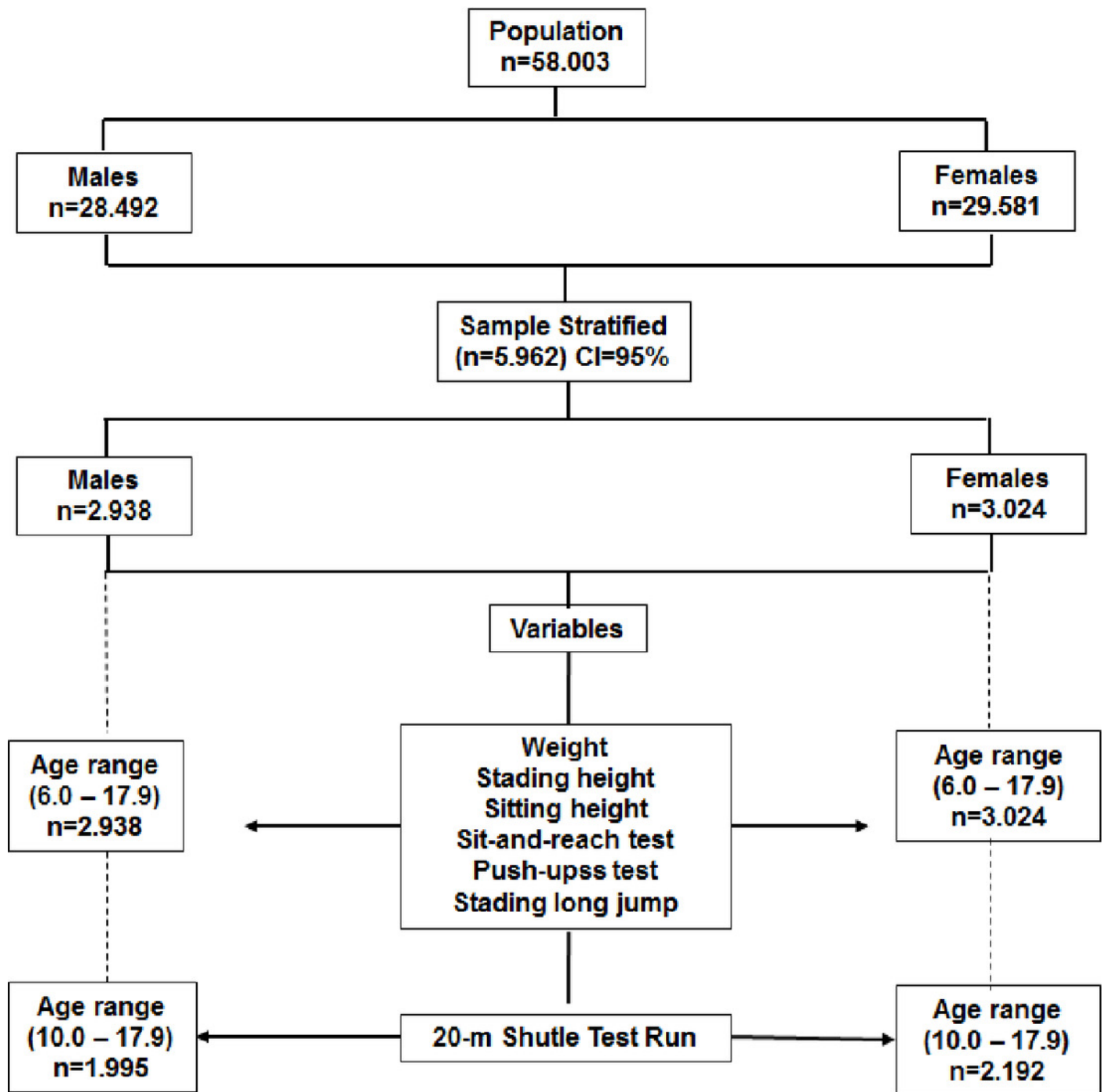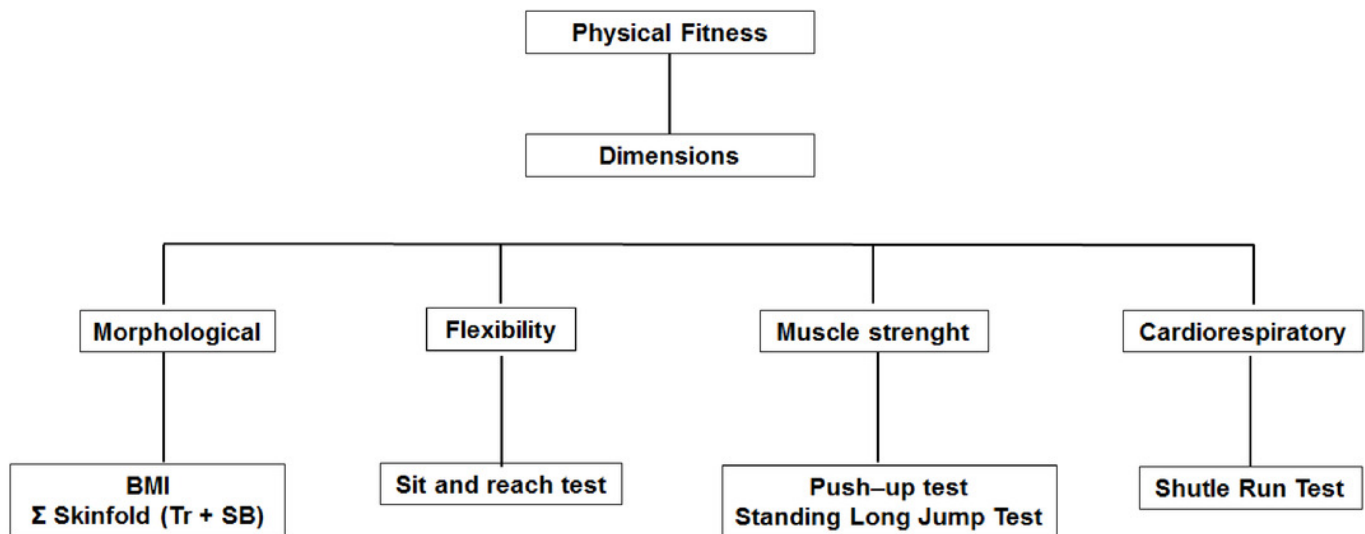Figure 1. Flowchart outlined to select the study sample.

Figure 2

Figure 2. Organization of physical fitness dimensions: BMI: Body Mass Index, TR: Triceps SE: Subscapular.

Legend: BMI: Body Mass Index, TR: Triceps, SB: Subscapular.

Figure 3

Figure 3. Smoothed centile curves for BMI and Skinfolds (P10, P50 and P85) and physical fitness tests (P15, P50 and P85) by chronological age in males.
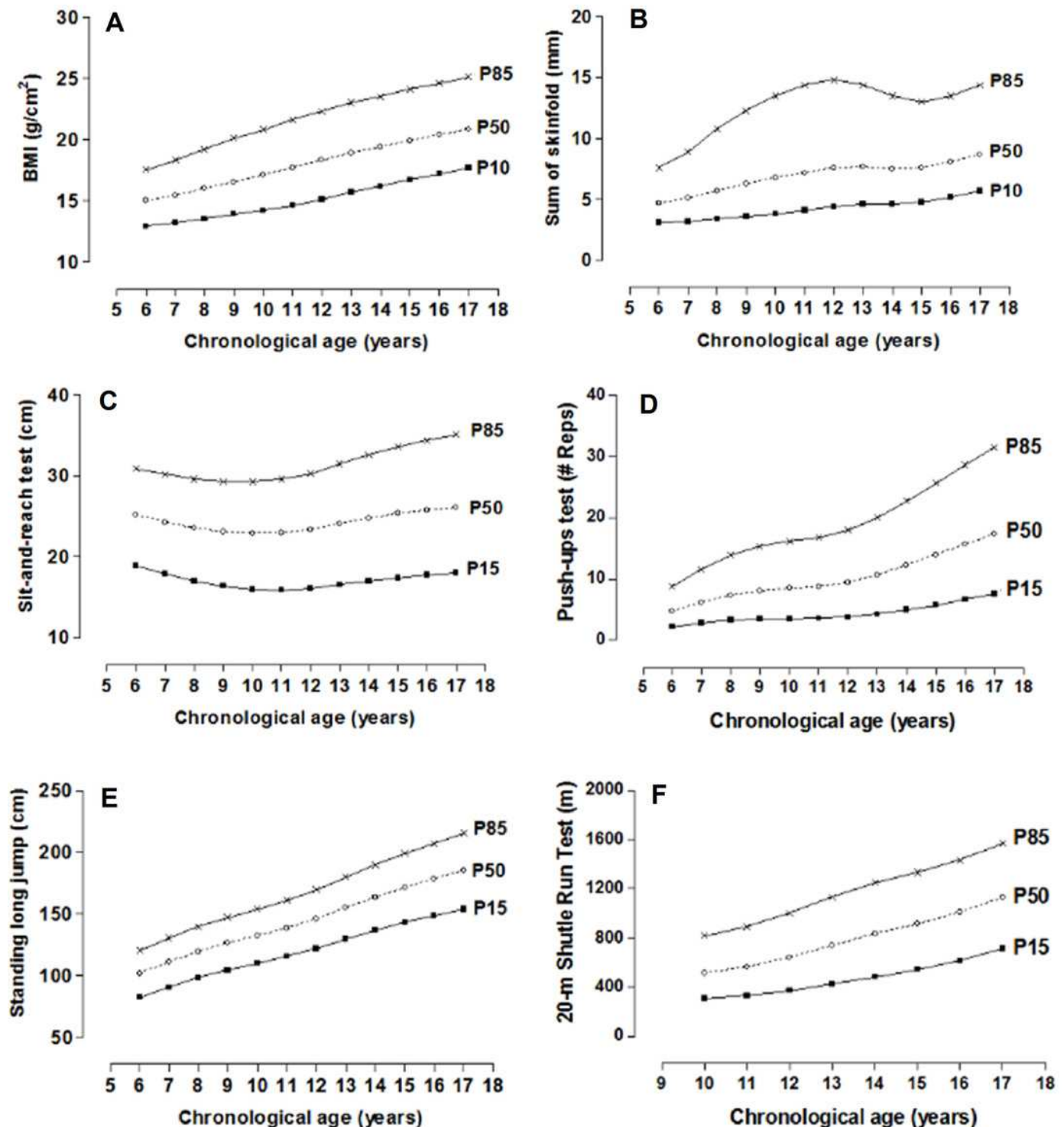
Figure 4

Figure 4. Smoothed centile curves for BMI and Skinfolds (P10, P50 and P85) and physical fitness tests (P15, P50 and P85) by chronological age in females.