

Delextrat, Anne, Hayes, Lawrence, Al Ghannami, Samia S., Ming, Yoeju, Hussein, Izzeldin, Al Oufi, Hamed, Cohen, Daniel D. and Ghebremeskel, Kebreab (2019) Physical fitness characteristics of Omani primary school children according to body mass index. *Journal of Sports Medicine and Physical Fitness*, 59 (3). pp. 440-448.

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1 ORIGINAL ARTICLE

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3 **Physical fitness characteristics of Omani primary school**
4 **children according to body mass index**

5

6 **Running head:** physical fitness in Omani children

7 **Manuscript type:** Original article

8 **Key words:** Body mass index, endurance, strength, obese, overweight.

9

10 **Abstract word count:** 200 words

11

12 **Manuscript word count:**

13

14 **Date of manuscript submission:**

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25 **ABSTRACT**

26 **Background:** There is evidence that children with high cardiorespiratory fitness and normal
27 body mass index (BMI) have less risk of non-communicable diseases (NCDs), however limited
28 research was undertaken in Omani children. Therefore the aims of the present study were to
29 describe body composition and physical fitness of a large cohort of Omani school children of
30 both genders, and to investigate the effects of weight status on physical fitness.

31 **Methods:** Three hundred and fourteen Omani school children aged 9 to 10 years old took part
32 in anthropometric assessments, body composition and fitness tests, including handgrip
33 strength, the basketball chest pass, broad jump, 20-m sprint, four 10-m shuttle agility, 30-s sit-
34 up, and multistage fitness test (MSFT).

35 **Results:** Obese boys and girls performed worse than normal-weight children in sprint, agility
36 and endurance. In addition, fitness measures in the overweight group and underweight groups
37 were not significantly different from other groups, except a better handgrip strength and poorer
38 MSFT in overweight compared to normal weight girls, and poorer agility performance in
39 underweight girls compared to the three other groups.

40 **Conclusions:** Most fitness measures are lower in obese Omani children, which suggests that
41 they will be more at risk of developing NCDs later in life.

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50 INTRODUCTION

51 Non-communicable diseases (NCDs, including cardiovascular diseases, diabetes, cancer, and
52 respiratory diseases) account for more than 60% of the global disease burden and mortality.¹
53 Over 50% of annual deaths in the Arabian countries, including Oman are due to NCDs.² Unlike
54 infectious diseases, NCDs do not start suddenly but develop over a period of time. In particular,
55 atherosclerosis begins in early life and is manifest clinically in adulthood.³ Moreover, there is
56 compelling evidence which indicates that healthy lifestyle habits (healthy eating and
57 maintenance of physical activity) tend to continue from childhood through adolescence, and
58 into adulthood.⁴⁻⁵ Consequently, various national and international committees on NCDs
59 recommend that children and young adults should be an integral part of any action plan for the
60 prevention and control of non-communicable diseases.⁶

61 A sedentary lifestyle is one of the main modifiable risk factors of NCDs⁷ and there is evidence
62 that children with high cardiorespiratory fitness, and normal body mass index (BMI), have less
63 risk of metabolic syndrome.⁸ The World Health Organisation (WHO) recommends that
64 children and adolescents from 2-17 years old take part in >60 minutes of moderate-to-vigorous
65 physical activity every day.⁹ However, a recent investigation reported only 26.1% of Omani
66 adolescents aged 13-15 years met these criteria.¹⁰ The same authors highlighted that Oman is
67 the third most sedentary country in the Gulf area, with 34.7% of adolescents classified as
68 sedentary.¹⁰ In addition, obesity has reached an epidemic proportion in the region, with 36.1%
69 of 20-34 years old Omani classified as overweight or obese in 2000.¹¹ However, despite
70 numerous Arab studies which have investigated obesity and its associated risk factors, the
71 physical fitness of children in Oman has received little attention to date.

72 To our knowledge, there is only study to report physical activity, fitness, and body composition
73 in Omani children.¹² These authors reported that boys aged 9-10 years had a body mass index
74 (BMI) of $18.9 \pm 2.4 \text{ kg} \cdot \text{m}^{-2}$, a sum of five skin folds of 62.5 mm, and waist-to-hip ratio of 0.91.

75 They performed the 1.6 km run/walk in 11.53 minutes (min), and spent 3.2 hours daily
76 watching television or playing video games and engaged in physical activity (defined as at least
77 walking for 40 min) for 6.8 hours weekly.¹² Moreover, significant correlations were observed
78 between 1.6 km run/walk time and BMI ($r=0.69$), and central ($r=0.38$) and peripheral ($r=0.37$)
79 fat, weekly physical activity and 1.6 km run/walk time ($r=-0.40$) and sum of five skin folds ($r=-$
80 0.42).¹² Although these data are interesting, they were obtained exclusively from boys and
81 include only limited fitness results (1.6 km run/walk test). Therefore, additional studies are
82 required to better characterize physical activity, fitness, and body composition in children of
83 both genders, since a recent study highlighted differences between male and female 13-15 year
84 olds in self-reported physical activity and sedentariness.⁹

85 As such, the purpose of this study was 1) to describe body composition and physical fitness of
86 a large cohort of Omani school children of both genders, and 2) to investigate the effects of
87 weight status on physical fitness.

88

89 **METHODS**

90 **Participants**

91 Three hundred and fourteen children (boys: $n=139$, 9.05 ± 0.40 years old; Girls; $n=175$, $9.11 \pm$
92 0.68 years old) accounting for a 4.6% of the school pupils aged between 9 and 10 years from
93 the Muscat Governorate were recruited. A two-stage sampling procedure was used to ensure a
94 representative sample of the target population in the Governorate and to minimise selection
95 bias. In the first stage, three ($n=3$) of 39 schools in the Governorate, and in the second stage
96 three Grade 4 classes from five were randomly selected. The study was approved by the
97 Research Ethics Committee of the Ministry of Health, Sultanate of Oman (Ref.
98 MH/DGP/R&S/Proposal_Aproved/8/2012), and NHS National Research Ethics Committee

99 North West – Haydock, UK (REC reference no. 12/NW/0760) and registered with ISRCTN
100 Register (Reg. No. ISRCTN93233285). Informed and signed consent was obtained from the
101 parent or guardian of the children and the study was conducted in accordance with the
102 principles of the Helsinki Declaration.

103

104 **Experimental Protocol**

105 Each participant performed two testing sessions separated by one week, for body composition
106 and fitness assessments, respectively. All testing took place between 8 and 11 AM to minimize
107 the influence of circadian rhythms and was conducted indoors (18-20°C; 46-55% relative
108 humidity), except the multi-stage fitness test (MSFT), which was performed outdoors (21-
109 26°C; 46-68% relative humidity).

110

111 ***Body composition***

112 Stature (cm) was assessed to the nearest 0.1 cm using a flatback metal anthropometric tape,
113 with participants' back against the wall, barefoot, and heels of the feet placed against the wall.
114 BMI ($\text{kg}\cdot\text{m}^{-2}$) was then calculated using the following formula:

$$115 \quad \text{BMI (kg}\cdot\text{m}^{-2}\text{)} = \text{body mass (kg)} \div \text{stature (m)}^2$$

116 Subsequently, BMI values were expressed as z scores according to age- and gender-specific
117 norms established in Iranian children.¹³ Participants were then divided into four groups defined
118 by the WHO cut-offs for underweight (value < 2 standard deviations [SD]), overweight
119 (value > +1SD), and obese (value > +2SD).¹⁴ Waist circumference was measured to the nearest
120 0.1 cm at the end of a normal expiration using a non-elastic tape with the child wearing thin
121 clothing and standing erect, abdomen relaxed, arms by their side, and feet together. The waist

122 was identified as the narrowest part of the torso from an anterior view), and the average of two
 123 measurements was recorded. Skinfold thickness was measured for the triceps brachii and
 124 subscapular sites, according to previous recommendations¹⁵ and body fat (BF%, in %) was
 125 calculated based on the following equations:¹⁵

126
$$\text{Boys: } BF (\%) = 1.21 \times (\text{triceps} + \text{subscapular}) - 0.008 \times (\text{triceps} + \text{subscapular})^2 - 1.7$$

127
$$\text{Girls: } BF (\%) = 1.33 \times (\text{triceps} + \text{subscapular}) - 0.013 \times (\text{triceps} + \text{subscapular})^2 - 2.5$$

128 Finally, bioelectrical impedance analysis (Tanita MC-180MA Body Composition Analyzer,
 129 Tanita UK Ltd) was used to give measures of body mass (kg, recorded to the nearest 100 g),
 130 Fat free mass (FFM, kg), muscle mass (kg) and body water content (kg).

131

132 ***Fitness tests***

133 Evaluations of strength, power, speed, agility, trunk muscular endurance, and the MSFT were
 134 conducted in a random order, and the best of two attempts was recorded for each test, except
 135 the MSFT (only one attempt).

136 Handgrip strength was assessed on the dominant (the one used for writing) and non-dominant
 137 limbs using a digital handgrip dynamometer (TKK5101 Grip D, Takei®, Tokyo, Japan),
 138 according to procedures previously described.¹⁶ Verbal encouragement was provided to ensure
 139 they maintained a maximal effort for at least 2 s between 90° and 0°. Excellent test-retest
 140 reliability has been reported for this test (inter-trial difference of 0.3±2.5 and 0.0±1.8,
 141 respectively for boys and girls).¹⁶

142 Lower limb power was assessed by the broad jump.¹⁶ This test is currently the most commonly
 143 administered to assess lower limb explosive power in children and adolescents and is
 144 characterized by very good reliability (mean inter-trial difference [bias] of -0.3±12.9 and

145 0.3±9.0, in boys and girls respectively.¹⁶ Upper limb power was measured by the medicine-
146 ball chest throw. In this test, participants were seated with their head, back, and buttocks against
147 a wall. Their legs rested horizontally on the floor in front of their body. Participants pushed a
148 2 kg ball in the horizontal direction as far as possible using a two-handed chest-pass. Several
149 trials were allowed for participants to become familiar with the movement. Very good test-
150 retest reliability has been reported for this test in children and adolescents (intraclass correlation
151 coefficient [ICC] of 0.93.¹⁷

152 The time to complete 20-m at maximal speed, from a stationary position, was measured by
153 automated photocells adjusted to participants' hip height as per manufacturer's specification
154 (Test centre timing system, Brower, UK). Very good test-retest reliability has been reported
155 for this test in children and adolescents (ICC=0.97).³ Agility was assessed by the 4 x 10-m
156 shuttle run test, described by Ortega et al.¹⁶ Time to completion was recorded with a stop watch
157 to the nearest 0.01 s. This test is characterized by very good reliability (mean inter-trial
158 difference [bias] of 0.1±0.7 and 0.1±0.8, respectively in boys and girls.¹⁶

159 The number of full sit-ups (i.e. touching the knees and returning back to the floor) performed
160 in 30-s is considered as an indicator of abdominal strength and muscular endurance (Lucas et
161 al., 2013). ICC=0.86 for this test.¹⁸

162 The MSFT was used to determine cardiovascular fitness.¹⁹ In the present investigation, the
163 MSFT was completed in groups of up to 15 participants and results are reported as the number
164 of shuttles completed. Leger et al.¹⁹ observed ICC=0.89 for children aged 6-16 years old
165 performing this test. This test has also been validated as a reliable estimate of adolescent
166 maximal oxygen uptake (VO_{2max}).²⁰

167 Finally, during the week preceding testing, participants and their legal guardians were required
168 every day to record the time spent doing moderate-to-vigorous physical activity (defined as

169 football, basketball, tennis, jump rope, running and other activities) as well as the time spent
170 doing quiet activities indoors, such as watching TV, playing video games, using a computer,
171 doing their homework, playing inside the house, reading, drawing and other indoors activities.

172

173 **Statistical analysis**

174 Data are presented as mean \pm standard deviation (SD). Analyses were carried out with SPSS
175 version 22 (IBM SPSS, IBM Corporation, Armonk, NY, USA). Following confirmation of
176 parametricity by a Shapiro-Wilk test of normality and Levene's test for homogeneity of
177 variance, an unpaired *t*-test was used to assess gender differences for outcomes variables.
178 Subsequently, a one-way ANOVA was undertaken to assess the effects of BMI group
179 (underweight, normal weight, overweight, obese) on fitness measures. A post-hoc Tukey test
180 was then performed to identify where significant differences lay. Estimates are shown as 95%
181 confidence intervals (CI) with corresponding P values. The level of significance was set *a*
182 *priori* at $P < 0.05$. Effect sizes were calculated using eta squared (η^2 , for one-way ANOVA) and
183 Cohen's *d* (*d*, for pairwise comparisons), and interpreted as small (< 0.1), medium (< 0.3) and
184 large (> 0.5), respectively.³³

185

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187

188 **RESULTS**

189 Table 1 shows the body composition, anthropometric characteristics and physical fitness of
190 participants. Our BMI data indicated that 12.5% of boys and 14.4% of girls from our sample
191 were overweight, while 11.0% of boys and 8.0% of girls were obese. A significant gender
192 effect was shown on most fitness variables, with boys characterized by significantly greater

193 handgrip strength of both limbs, significantly greater upper (basketball throw) and lower limb
194 (broad jump) power, and significantly faster speed and agility times. In contrast, no significant
195 effect of gender was observed for the number of sit-ups completed in 30-s.

196

197 Daily moderate-to-vigorous physical activity was 278 ± 36 min and 236 ± 28 min, respectively
198 in boys and girls, while sedentary indoor activities were 419 ± 53 min (including 219 ± 41 min
199 of TV and video games) and 482 ± 45 min (including 194 ± 38 min of TV and video games),
200 respectively in boys and girls.

201

202 The ANOVA showed no significant effect of BMI on handgrip strength in boys ($P=0.225$,
203 $\eta^2=0.033$ and $P=0.346$, $\eta^2=0.025$, respectively for the dominant and non-dominant limbs),
204 whilst a significant effect of BMI on handgrip strength was found in girls on both limbs
205 ($P=0.001$ for both limbs, $\eta^2=0.093-0.166$). Post-hoc comparisons in the dominant limb revealed
206 significantly greater strength in the overweight and obese girls compared to the two other BMI
207 groups ($P=0.001-0.009$, $d=0.86-1.03$, 95% CI=0.60-6.69, Figure 1-a). In the non-dominant
208 limb, significantly greater strength values were observed in obese girls compared to
209 underweight ($P=0.048$, $d=0.86$, 95% CI=0.01-6.00) and normal weight girls ($P=0.006$,
210 Cohen's $d=0.82$, 95% CI=0.59-4.76), as well as in overweight girls compared to normal weight
211 girls ($P=0.047$, $d=0.55$, 95% CI=0.01-3.16, Figure 1-b).

212 Regarding power measures, no significant difference was shown between BMI groups on upper
213 body power assessed by the basketball chest throw in both genders ($P=0.136$, $\eta^2=0.042$ in boys
214 and $P=0.793$, $\eta^2=0.007$ in girls, Figure 2-a), and on lower body power measured by the broad
215 jump in girls ($P=0.119$, $\eta^2=0.035$). However, significant differences in broad jump distance
216 between BMI groups were reported in boys ($P=0.001$, $\eta^2=0.230$, Figure 2-b). Further analyses
217 demonstrated significant lower broad jump distance in obese boys compared to underweight

218 (P=0.001, $d=1.98$, 95% CI=0.09-0.48), normal weight (P=0.001, $d=1.88$, 95% CI=0.19-0.46)
219 and overweight (P=0.001, $d=1.27$, 95% CI=0.10-0.43) boys (Figure 2-a).

220 Significant effects of BMI were found on speed and agility performances in boys (P=0.020,
221 $\eta^2=0.298$ for speed and P=0.001, $\eta^2=0.142$ for agility) and girls (P=0.001, $\eta^2=0.220$ for speed
222 and P=0.001, $\eta^2=0.107$ for agility). Post-hoc analyses showed significantly slower 20-m sprint
223 time in obese boys compared to the three other BMI groups (P=0.001, $d= 1.11-1.63$, 95%
224 CI=0.27-1.29, Figure 3-a) and in obese girls compared to underweight and normal weight girls
225 (P=0.001, $d=1.38-1.70$, 95% CI=0.23-1.02 in girls). In addition, overweight girls showed
226 significantly slower sprint times compared to normal weight girls (P=0.043, $d=0.66$, 95%
227 CI=0.005-0.419, Figure 3-a). A main BMI effect was shown by the ANOVA on the 4x10-m
228 shuttle test. Post-hoc analyses showed obese boys were significantly slower than underweight
229 (P=0.032, $d=0.62$, 95% CI=0.108-3.46), normal weight (P=0.001, $d=0.75$, 95% CI=0.933-
230 03.216) and overweight (P=0.026, $d=0.57$, 95% CI=0.136-3.04) boys (Figure 3-b).
231 Significantly better performance was observed for normal weight girls compared to
232 underweight girls (P=0.009, $d=0.93$, 95% CI=0.270-2.572) and obese girls (P=0.01, $d=0.70$,
233 95% CI=0.227-2.27, Figure 3-b).

234 No significant effects of BMI were observed for the number of sit-ups completed in 30-s
235 (P=0.701 and 0.169, for boys and girls respectively). Boys' performance was 15 ± 2 , 14 ± 5 ,
236 13 ± 5 , and 13 ± 4 , respectively for underweight, normal weight, overweight and obese groups.
237 Girls' performance was 9 ± 4 , 12 ± 3 , 12 ± 5 , and 10 ± 5 for underweight, normal weight,
238 overweight and obese groups, respectively.

239 A significant BMI effect was observed on the number of shuttles completed in the MSFT
240 (P=0.001, $\eta^2=0.120$ in boys and P=0.001, $\eta^2=0.107$ in girls). Post-hoc analyses showed that
241 obese boys completed a significantly lower number of shuttles compared to underweight

242 (P=0.008, $d=1.35$, 95% CI=3.6-32.1) and normal weight (P=0.002, $d=1.25$, 95% CI=3.9-23.4)
243 boys (Figure 4). Normal weight girls performed a significantly greater number of shuttles
244 compared to the overweight (P=0.025, Cohen's $d=0.72$, 95% CI=0.46-9.82) and obese
245 (P=0.002, $d=1.29$, 95% CI=2.56-15.00) girls (Figure 4).

246 Finally, significant differences in BF and FFM in each of our BMI groups were shown
247 ($8.8\pm 2.2\%$ and $20.3\pm 2.3\text{kg}$, $15.2\pm 4.1\%$ and $22.8\pm 2.8\text{kg}$, $33.9\pm 5.1\%$, and $33.9\pm 5.1\%$ and
248 $27.5\pm 3.2\text{kg}$, and $31.2\pm 3.7\text{kg}$, respectively in underweight, normal weight, overweight and
249 obese children, P=0.001).

250

251 **DISCUSSION**

252 The present study was the first to describe relationships between body composition and fitness
253 characteristics in a large sample of Omani school children of both genders. We report that obese
254 boys and girls performed worse than normal-weight children in sprint, agility and endurance.
255 Other fitness variables were gender-specific, with obese boys performing significantly worse
256 compared to normal weight boys in lower limb power, and obese girls characterized by
257 significantly greater handgrip strength compared to normal weight girls. Fitness measures in
258 the overweight group were not significantly different from normal weight participants, except
259 a better handgrip strength and poorer MSFT in girls. Similarly, no significant difference was
260 observed between underweight children and other groups, except poorer agility performance
261 in girls only.

262

263 We reported BMI values of $16.8\pm 7.8 \text{ kg}\cdot\text{m}^{-2}$ and $16.9\pm 3.4 \text{ kg}\cdot\text{m}^{-2}$, respectively for boys and
264 girls. These values are greater than children of the same age from Bahrain ($15.6\pm 2.0 \text{ kg}\cdot\text{m}^{-2}$
265 and $15.5\pm 3.1 \text{ kg}\cdot\text{m}^{-2}$, respectively for boys and girls)³⁴, but much lower than 9-year-old Omani
266 boys ($18.9\pm 2.4 \text{ kg}\cdot\text{m}^{-2}$)²⁰. In addition, our BMI values are only slightly lower than the ones

267 reported in a large European cohort study for children of the same age ($17.2 \pm 2.4 \text{ kg.m}^{-2}$ and
268 $17.3 \pm 2.4 \text{ kg.m}^{-2}$, respectively for boys and girls)³⁵. A similar trend was shown for BF% and
269 FFM, with our BF% marginally lower and FFM higher than results obtained on 9-year old
270 children in Bahrain (boys: $12.5 \pm 2.6\%$ and $22.8 \pm 3.5 \text{ kg}$ of FFM; girls: $13.6 \pm 3.1\%$ and 21.7 ± 4.8
271 kg of FFM)³⁴. We reported waist circumference values of $60.0 \pm 8.3 \text{ cm}$, for boys and 60.0 ± 8.9
272 cm for girls, which is comparable with data obtained on European children of the same age
273 ($60.7 \pm 6.0 \text{ cm}$ and $60.2 \pm 6.1 \text{ cm}$ for boys and girls respectively)³⁵. Waist circumference is
274 considered as an accurate marker of abdominal fat accumulation and visceral adiposity in
275 young people, and higher BMI have been associated to increased risk for metabolic disease.³⁶⁻
276 ³⁷ Therefore, our data indicated that Omani children do not seem more at risk of metabolic
277 disease than European children of the same age.

278 BMI is commonly used to characterize overweight and obesity amongst children,³⁸ and
279 our data on 9-year old Omani children revealed that 12.5% of boys and 14.4% of girls were
280 overweight, while 11.0% of boys and 8% of girls were obese, according to WHO thresholds.²²
281 These values are very similar to those reported on 9-year old Iranian children (12.6% and
282 14.3% of overweight boys and girls, and 13.4% and 8.1% of obese boys and girls)³⁹, and much
283 lower than those reported in Kuwaiti children aged 10 to 13 years old (22.5-22.7% overweight,
284 and 16.8-17.7% of obese).⁴⁰ Comparisons with European children of the same age (9 years old)
285 showed that the proportion of overweight and obese Omani children is similar to countries
286 from Northern and Eastern Europe (11.2% and 8% of obese boys and girls in Ireland, for
287 example), and lower than children from Southern Europe (21.9% and 13% of obese boys and
288 girls in Italy).⁴¹ Finally our data are lower than children from the United States of America
289 aged 6 to 11 years old (34.2% of obese and 17.7% of overweight children).⁴² One reason that
290 could explain lower obesity and overweight figures in Oman compared to other countries is the
291 observation that Oman has the highest prevalence of physical activity amongst all the Gulf

292 countries.¹⁸ In favour of this hypothesis, children from the present study reported relatively
293 high levels of moderate-to-vigorous physical activity, that are greater than European children
294 (220 min and 183 min)³⁵. A greater wealth has been proposed as an explanatory factor for
295 higher physical activity, but no significant effects of countries' gross national income (GNI)
296 on physical activity were shown in the above-mentioned study, suggesting other factors are
297 manifest.¹⁸

298

299 No significant gender effect was shown in anthropometrical measures, except a significantly
300 greater FFM in boys compared to girls. The absence of a gender effect on anthropometrics was
301 also observed in 9 year old European boys and girls.²⁷ Conversely, we reported a significant
302 gender effect on all our fitness measures, with boys outperforming girls. This is not surprising,
303 as several authors reported greater strength, power and endurance in boys compared to girls of
304 similar age as our study.⁴³⁻⁴⁴ Factors explaining the greater strength and power in boys are
305 linked to physical development, such as differences in lean body mass and body fat, bone
306 length, and hormonal changes, in particular increased testosterone production in boys.⁴⁵ In
307 favour of this hypothesis, significantly greater FFM as well as a trend ($P=0.068$) for lower body
308 fat were recorded in boys compared to girls in the present study. However, we did not report
309 maturation status, which limits the interpretation of these variables.

310 On average, fitness performances of our participants appear comparable to those reported in
311 younger European children by one year (handgrip strength: 13.5 and 12.3 kg; broad jump: 1.28
312 and 1.18 m; MSFT: 23 and 19 shuttles completed, for boys and girls respectively in children
313 aged 8.5-9 years old)⁴⁶, and lower than Northern European children of the same age (handgrip
314 strength: 14.4 ± 3.7 kg and 12.8 ± 3.4 kg, respectively for boys and girls; broad jump: 1.39 ± 0.23
315 m and 1.29 ± 0.22 m, respectively for boys and girls; sit-ups in 30-s: 18.7 ± 4.9 and 17.0 ± 4.7 ,
316 respectively for boys and girls)⁴⁷. The comparison of fitness performances according to BMI

317 groups in the present study showed that obese children performed worse than normal-weight
318 children in tests that require acceleration of one's own mass. This is similar to the findings of
319 Castro-Pinero et al.⁴³, showing poorer broad jump distance in obese compared to normal-
320 weight children. However, Moura Dos-Santos et al.⁴⁸ did not find any significant correlation
321 between BMI and 20 m sprint in children aged 7-10 years old. It should be noted however, that
322 correlations might not be appropriate when a bell-shaped relationship between variables is
323 expected. The main explanation for poorer power and speed performances observed in the
324 present study is the difficulty for obese individuals to carry their extra body weight in tasks
325 involving propulsion or lifting their body.⁴³ Indeed, body fat can be considered an extra load,
326 which, unlike muscle does not contribute to power or speed production. These results may
327 suggest that poor performances could discourage obese children from taking part in sporting
328 activities, which lead to further weight gain in adolescence and adulthood. Indeed, several
329 authors refer to the discomfort associated with locomotor tasks in obese individuals,
330 characterised by greater perceived effort for a given energy expenditure, or greater musculo-
331 skeletal pain, compared to non-obese individuals.⁴⁹⁻⁵⁰ Therefore we suggest that participation
332 in physical activity should be encouraged from a younger age to avoid this vicious circle.

333

334 Poorer performance in the MSFT was observed in the present study in obese children compared
335 to other groups, in accordance with previous literature.^{35,48,51} The same factors as previously
336 described may explain these poorer performances. On the other hand, obesity did not affect
337 upper-body power and abdominal muscular endurance in both genders, which is in contrast
338 with the results from Castro-Pinero et al.⁴³. Our results can be explained by the fact that these
339 exercises are not weight-bearing. Another explanation is due to the fact that the basketball
340 throw is quite difficult to perform technically, and hence inter-individual differences in
341 coordination may have biased our results.

342

343 Gender-specific results were found in the present study for the other fitness variables
344 considered. Indeed, obese boys, but not girls, were characterised by poorer performance than
345 normal-weight boys in the broad jump. This is in contrast with findings from Castro-Pinero et
346 al.,⁴³ where obese children of both genders performed worse than their normal bodyweight
347 counterparts. The main difference between this study and ours is participants' age, with age
348 ranging from 6-17.5 years old, compared to 9-10 years old in our study. Therefore, different
349 rates of maturity and growth between genders may explain the lack of significant differences
350 in girls' broad jump performance. Significant correlations between handgrip strength and BMI
351 have been demonstrated previously.⁵¹ This greater strength can be explained by the commonly
352 observed greater FFM in obese and overweight individuals, compared to people of normal
353 weight.⁵² An interesting result of our study is the absence of decreased performance in
354 overweight compared to normal weight children, except on the MSFT in girls only. This is in
355 contract with the study of Castro-Pinero et al.⁴³ who reported lower broad jump in overweight
356 compared to normal weight children. Despite the significantly greater BF% in the overweight
357 children of our study, it seems that it did not impair their speed, power, strength or endurance
358 in boys. An explanation could be that overweight Omani adolescents (13-15 years old) are
359 reportedly more physically active compared to normal weight adolescents in Oman, which is
360 different to other countries in the Middle East.¹⁸ While this study was based on self-reported
361 activity and data from adolescents cannot be extrapolated to 9 year olds, this suggests there is
362 a different physical activity pattern in Omani school children, which may protect overweight
363 but not obese children from decreased fitness. Finally, our results showed that underweight
364 children did not perform worse than normal weight children, except in the agility test in girls
365 only. These results are in accordance with previous studies showing no significant differences
366 between underweight and normal weight children and teenagers on broad jump and sit-up tests,

367 as well as other tests of muscle strength or muscular endurance.^{43,53} The authors explained these
368 results by the fact that underweight children have both lower body fat levels and higher relative
369 muscle mass compared to normal weight counterparts.

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371 In conclusion, our findings showed that the proportion of obese and overweight 9-year old
372 Omani children is lower than most countries from the Middle East, and comparable to
373 European children. In addition, their fitness is slightly worse than European children of the
374 same age. Obese children performed worse than normal-weight children in fitness components
375 that require weight-bearing tasks, and differences between BMI groups were gender-dependant
376 in the broad jump and hand grip strength tests. Finally, not many differences were observed
377 between overweight and underweight children, compared to their normal-weight counterparts.
378 Further studies using large cohorts of children of both genders in the Middle East should be
379 undertaken to better understand and intervene on childhood obesity in this area of the world.

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382 **ACKNOWLEDGEMENTS**

383 Very sincere thanks are due to the children, parents, teachers and headmistresses of the schools
384 for their participation and support, staffs and management of the Ministries of Agriculture and
385 Fisheries Wealth, Health and Education who helped with the design, implementation and
386 monitoring of the study, and to Sheikh Saif Sultan Mohammed Al Habsi for providing
387 transport.

388

389 **FUNDING SOURCES/TRIAL REGISTRATION**

390 This clinical trial was registered with ISRCTN register (Reg No. ISRCTN93233285).

391 The study was funded by the Ministry of Agriculture and Fisheries Wealth of the Sultanate of
392 Oman.

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533 **Table 1:** Baseline anthropometry, body composition and physical fitness of Omani school
534 children aged 9 and 10 years. Data are presented as mean \pm SD. (BMI = body mass index; D:
535 dominant; ND: non-dominant; MSFT (*n*) = number of shuttles completed in the multi-stage
536 fitness test; 95% CL: 95% confidence intervals for the difference; *d*: Cohen's *d*)

	Boys (n=139)	Girls (n=175)	P	<i>d</i>	95% CL
Body mass (kg)	30.1 \pm 7.9	29.9 \pm 8.2	0.598	0.03	-1.61-2.02
Stature (cm)	133.1 \pm 6.4	133.1 \pm 6.6	0.669	0.01	-1.45-1.48
BMI (kg·m ²)	16.8 \pm 7.8	16.9 \pm 3.5	0.733	0.035	-6.35-0.90
BMI (z scores)	0.93 \pm 1.7	-0.03 \pm 1.0	0.001	0.68	0.655-1.27
Body fat (%)	16.5 \pm 8.0	18.9 \pm 6.2	0.001	0.209	-1.92-0.90
Fat free mass (kg)	24.7 \pm 4.22	23.6 \pm 4.0	0.16	0.244	0.21-2.04
Waist circumference (cm)	60.0 \pm 8.3	60.0 \pm 8.9	0.998	0.256	-1.95-1.94

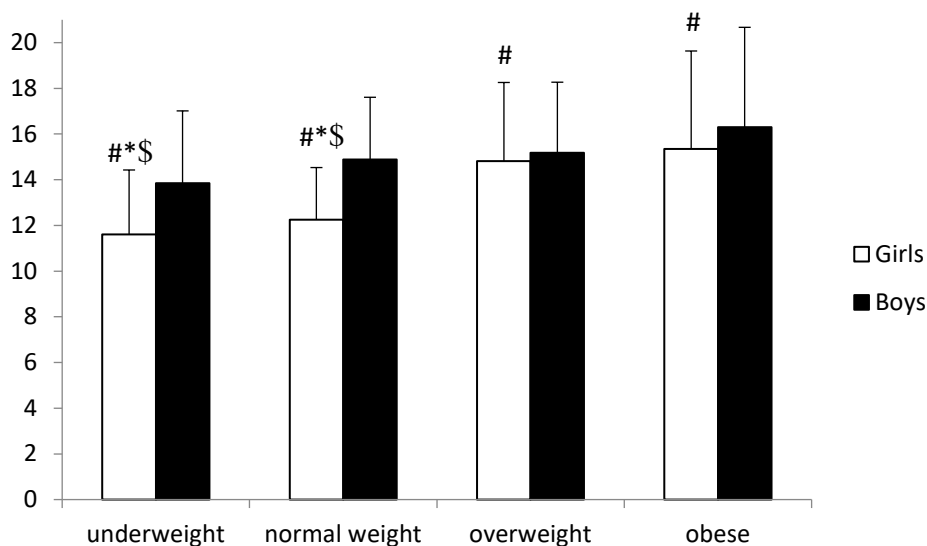
Handgrip D (kg)	15.00 ± 3.04	12.80 ± 2.93	0.001	0.74	1.48-2.84
Handgrip ND (kg)	13.21 ± 2.94	11.06 ± 2.86	0.001	0.74	1.48-2.81
Standing long jump (m)	1.36 ± 0.21	1.19 ± 0.20	0.001	0.84	0.12-0.21
Chest throw (m)	2.69 ± 0.61	2.43 ± 0.46	0.001	0.47	0.13-0.379
Agility test (s)	13.58 ± 1.66	14.48 ± 1.40	0.001	0.58	0.55-1.25
Sit-ups (<i>n</i>)	14 ± 4	11 ± 4	0.001	0.59	1.48-3.33
Sprint (s)	4.43 ± 0.48	4.90 ± 0.42	0.001	1.05	0.06-0.36
MSFT (<i>n</i>)	23 ± 14	18 ± 9	0.001	0.43	2.4-7.7

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539 **Figure 1. Effect of BMI status on handgrip strength of the dominant (a) and non-**
 540 **dominant (b) limbs in Omani 9-year old school children.**

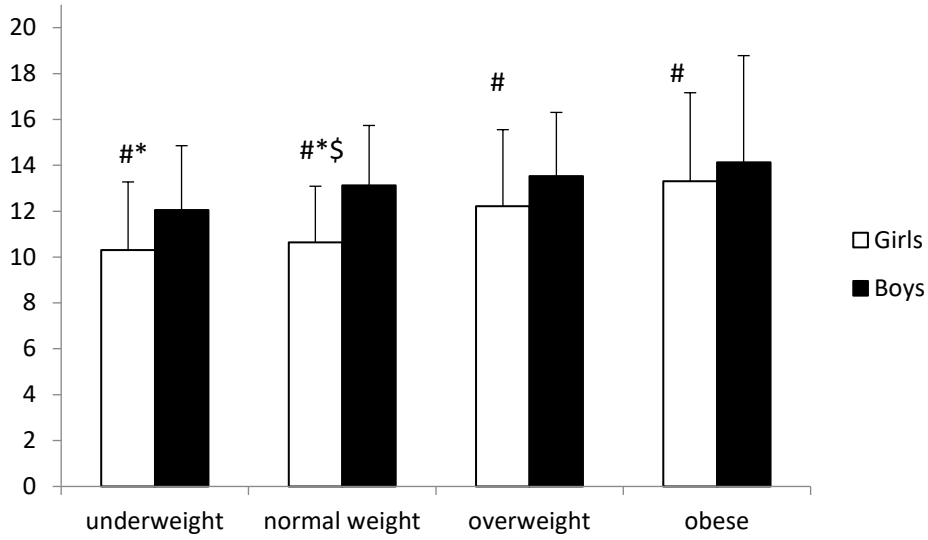
541 **a-Handgrip strength (kg) of the dominant arm**



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544 **b-Handgrip strength (kg) of the non-dominant limb.**



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546 #: significantly different from boys, $P < 0.05$.

547 *: significantly different from the obese group, $P < 0.05$.

548 \$: significantly different from the overweight group, $P < 0.05$.

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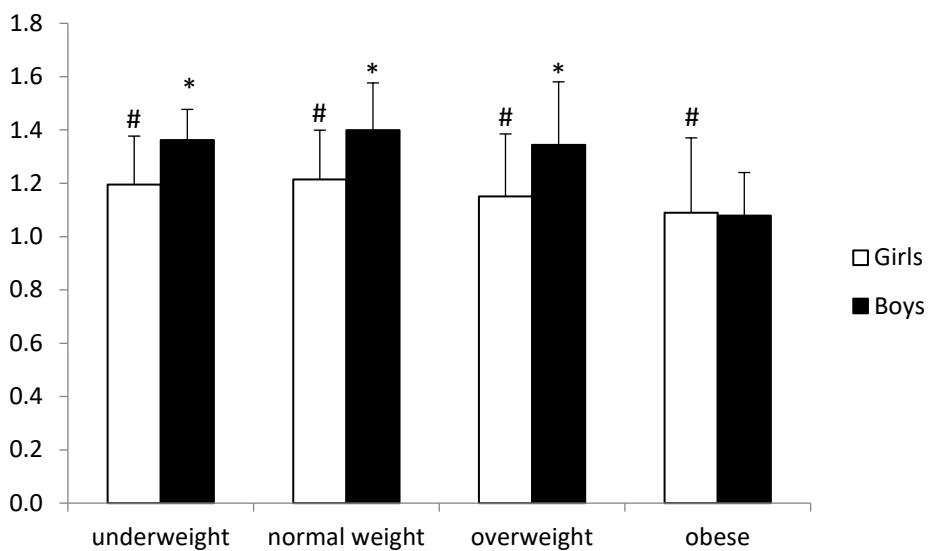
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552 **Figure 2. Effect of BMI status on lower limb power (a-broad jump) and upper limb**
 553 **power (b-basketball throw) in Omani 9-year old school children.**

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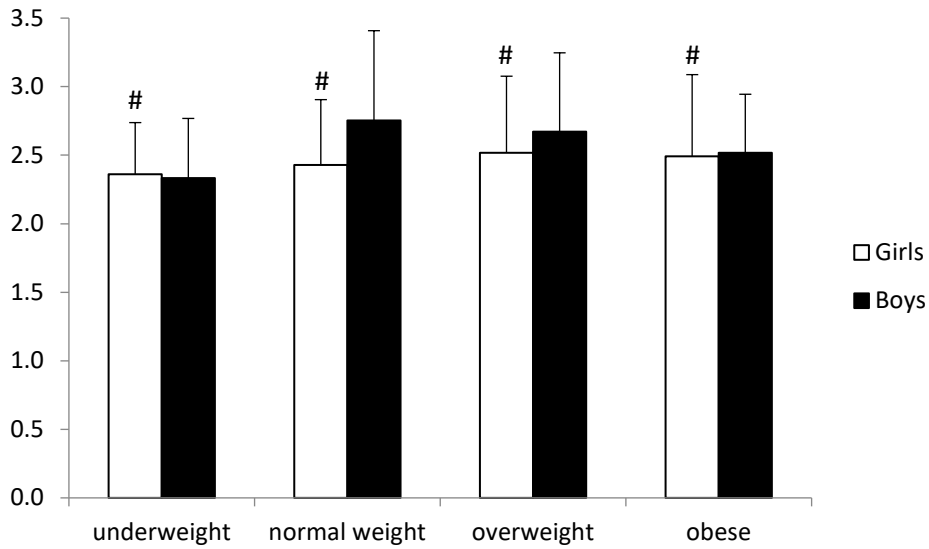
555 **a-Broad jump distance (m)**



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558 **b-Basketball chest throw distance (m)**



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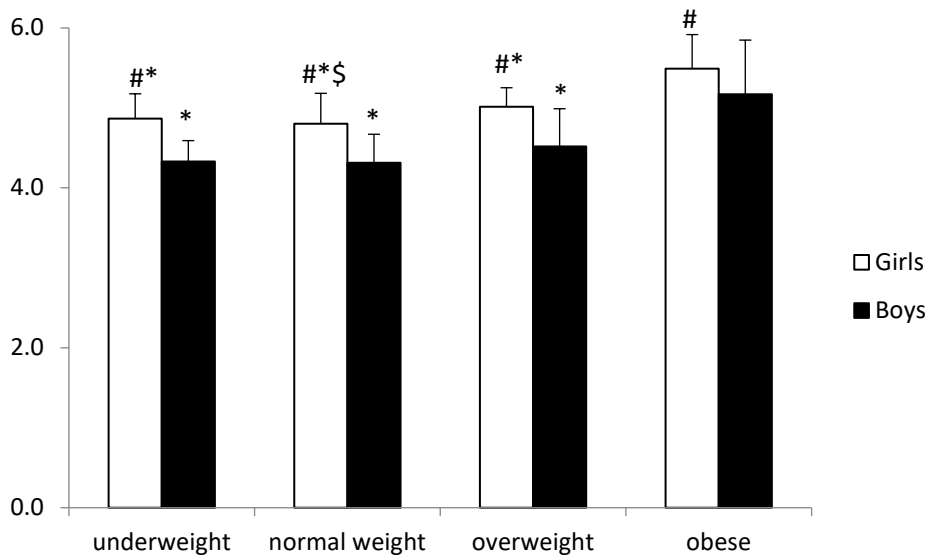
561 #: significantly different from boys, $P < 0.05$.

562 *: significantly different from the obese group, $P < 0.05$.

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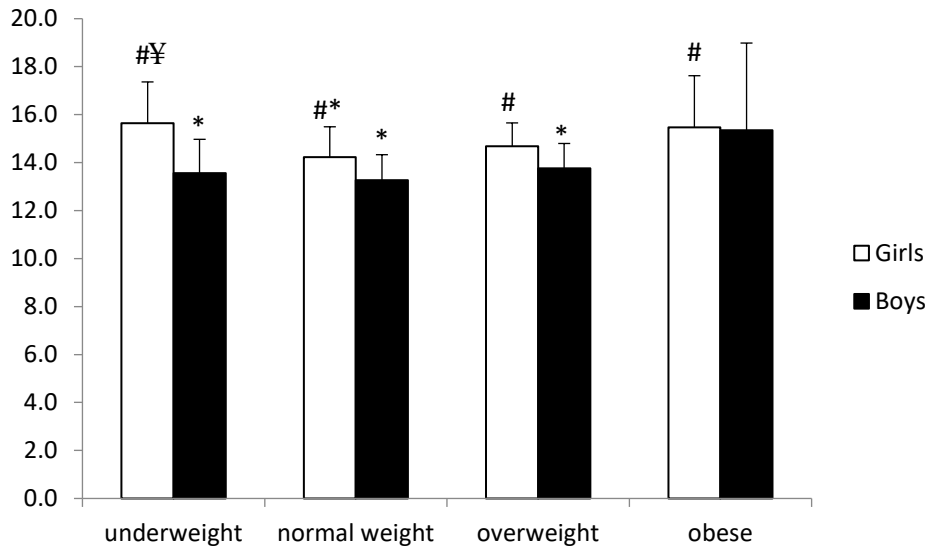
564 **Figure 3. Effect of BMI status on speed (a, 20-m sprint) and agility (b, 4x10-m shuttle)**
 565 **in Omani 9-year old school children.**

566 **a-20-m time (s)**



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568 **b-4x10-m shuttle time (s)**



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570

571 #: significantly different from boys, $P < 0.05$.

572 *: significantly different from the obese group, $P < 0.05$.

573 \$: significantly different from the overweight group, $P < 0.05$.

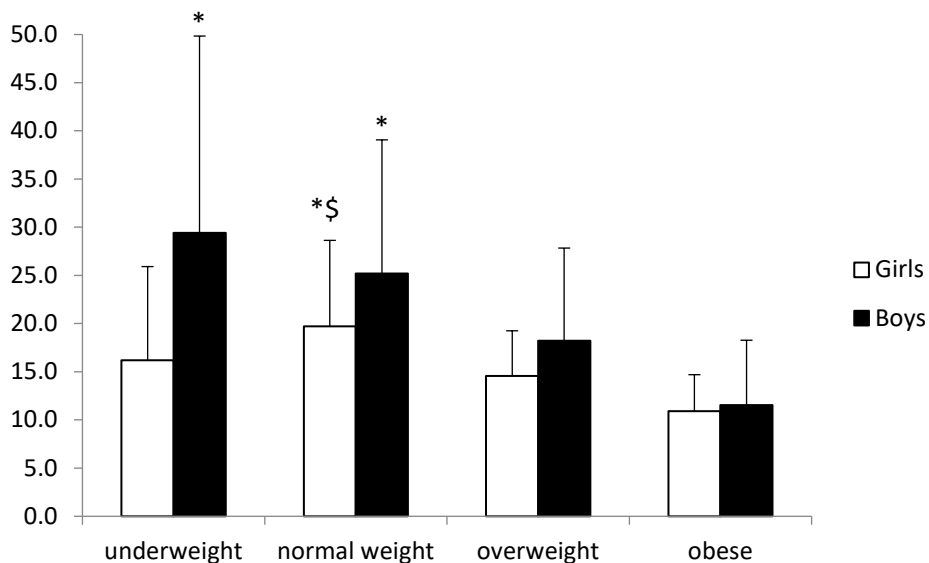
574 ¥: significantly different from the normal weight group, $P < 0.05$.

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577 **Figure 4. Effect of BMI status on cardiovascular fitness (multistage fitness test, MSFT)**
 578 **in Omani 9-year old school children.**

579 **Number of shuttles completed**



580

581 #: significantly different from boys, $P < 0.05$.

582 *: significantly different from the obese group, $P < 0.05$.

583 \$: significantly different from the overweight group, $P < 0.05$.

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