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

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ABSTRACT

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

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

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

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

INTRODUCTION

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

A sedentary lifestyle is one of the main modifiable risk factors of NCDs[7] and there is evidence that children with high cardiorespiratory fitness, and normal body mass index (BMI), have less risk of metabolic syndrome.[8] The World Health Organisation (WHO) recommends that children and adolescents from 2-17 years old take part in >60 minutes of moderate-to-vigorous physical activity every day.[9] However, a recent investigation reported only 26.1% of Omani adolescents aged 13-15 years met these criteria.[10] The same authors highlighted that Oman is the third most sedentary country in the Gulf area, with 34.7% of adolescents classified as sedentary.[10] In addition, obesity has reached an epidemic proportion in the region, with 36.1% of 20-34 years old Omani classified as overweight or obese in 2000.[11] However, despite numerous Arab studies which have investigated obesity and its associated risk factors, the physical fitness of children in Oman has received little attention to date.

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

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

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

METHODS

Participants

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

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

Experimental Protocol

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

Body composition

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

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

Subsequently, BMI values were expressed as z scores according to age- and gender-specific norms established in Iranian children.[13] Participants were then divided into four groups defined by the WHO cut-offs for underweight (value < 2 standard deviations [SD]), overweight (value>+1SD), and obese (value >+2SD).[14] Waist circumference was measured to the nearest 0.1 cm at the end of a normal expiration using a non-elastic tape with the child wearing thin clothing and standing erect, abdomen relaxed, arms by their side, and feet together. The waist was identified as the narrowest part of the torso from an anterior view), and the average of two measurements was recorded. Skinfold thickness was measured for the triceps brachii and subscapular sites, according to previous recommendations[15] and body fat (BF%, in %) was calculated based on the following equations:[15]

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

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

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

Fitness tests

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

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

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

0.3±9.0, in boys and girls respectively.[16] Upper limb power was measured by the medicine-ball chest throw. In this test, participants were seated with their head, back, and buttocks against a wall. Their legs rested horizontally on the floor in front of their body. Participants pushed a 2 kg ball in the horizontal direction as far as possible using a two-handed chest-pass. Several trials were allowed for participants to become familiar with the movement. Very good test-retest reliability has been reported for this test in children and adolescents (intraclass correlation coefficient [ICC] of 0.93.[17]

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

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

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

Finally, during the week preceding testing, participants and their legal guardians were required every day to record the time spent doing moderate-to-vigorous physical activity (defined as football, basketball, tennis, jump rope, running and other activities) as well as the time spent doing quiet activities indoors, such as watching TV, playing video games, using a computer, doing their homework, playing inside the house, reading, drawing and other indoors activities.

Statistical analysis

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

RESULTS

Table 1 shows the body composition, anthropometric characteristics and physical fitness of participants. Our BMI data indicated that 12.5% of boys and 14.4% of girls from our sample were overweight, while 11.0% of boys and 8.0% of girls were obese. A significant gender effect was shown on most fitness variables, with boys characterized by significantly greater handgrip strength of both limbs, significantly greater upper (basketball throw) and lower limb (broad jump) power, and significantly faster speed and agility times. In contrast, no significant effect of gender was observed for the number of sit-ups completed in 30-s.

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

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

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

(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) and overweight (P=0.001, *d*=1.27, 95% CI=0.10-0.43) boys (Figure 2-a).

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

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

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

(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) boys (Figure 4). Normal weight girls performed a significantly greater number of shuttles compared to the overweight (P=0.025, Cohen's *d*=0.72, 95% CI=0.46-9.82) and obese (P=0.002, *d*=1.29, 95% CI=2.56-15.00) girls (Figure 4).

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

DISCUSSION

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

We reported BMI values of 16.8±7.8 kg.m^{-2} and 16.9±3.4 kg.m^{-2}, respectively for boys and girls. These values are greater than children of the same age from Bahrain (15.6±2.0 kg.m^{-2} and 15.5±3.1 kg.m^{-2}, respectively for boys and girls)[34], but much lower than 9-year-old Omani boys (18.9±2.4 kg.m^{-2})[20]. In addition, our BMI values are only slightly lower that the ones reported in a large European cohort study for children of the same age (17.2±2.4 kg.m^{-2} and 17.3±2.4 kg.m^{-2}, respectively for boys and girls)[35]. A similar trend was shown for BF% and FFM, with our BF% marginally lower and FFM higher than results obtained on 9-year old children in Bahrain (boys: 12.5±2.6% and 22.8±3.5 kg of FFM; girls: 13.6±3.1% and 21.7±4.8 kg of FFM)[34]. We reported waist circumference values of 60.0±8.3 cm, for boys and 60.0±8.9 cm for girls, which is comparable with data obtained on European children of the same age (60.7±6.0 cm and 60.2±6.1 cm for boys and girls respectively)[35]. Waist circumference is considered as an accurate marker of abdominal fat accumulation and visceral adiposity in young people, and higher BMI have been associated to increased risk for metabolic disease.[36-37] Therefore, our data indicated that Omani children do not seem more at risk of metabolic disease than European children of the same age.

BMI is commonly used to characterize overweight and obesity amongst children,[38] and our data on 9-year old Omani children revealed that 12.5% of boys and 14.4% of girls were overweight, while 11.0% of boys and 8% of girls were obese, according to WHO thresholds.[22] These values are very similar to those reported on 9-year old Iranian children (12.6% and 14.3% of overweight boys and girls, and 13.4% and 8.1% of obese boys and girls)[39], and much lower than those reported in Kuwati children aged 10 to 13 years old (22.5-22.7% overweight, and 16.8-17.7% of obese).[40] Comparisons with European children of the same age (9 years old) showed that the proportion of overweight and obese Omani children is similar to countries from Northern and Eastern Europe (11.2% and 8% of obese boys and girls in Ireland, for example), and lower than children from Southern Europe (21.9% and 13% of obese boys and girls in Italy).[41] Finally our data are lower than children from the United States of America aged 6 to11 years old (34.2% of obese and 17.7% of overweight children).[42] One reason that could explain lower obesity and overweight figures in Oman compared to other countries is the observation that Oman has the highest prevalence of physical activity amongst all the Gulf countries.[18] In favour of this hypothesis, children from the present study reported relatively high levels of moderate-to-vigorous physical activity, that are greater than European children (220 min and 183 min)[35]. A greater wealth has been proposed as an explanatory factor for higher physical activity, but no significant effects of countries' gross national income (GNI) on physical activity were shown in the above-mentioned study, suggesting other factors are manifest.[18]

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

On average, fitness performances of our participants appear comparable to those reported in younger European children by one year (handgrip strength: 13.5 and 12.3 kg; broad jump: 1.28 and 1.18 m; MSFT: 23 and 19 shuttles completed, for boys and girls respectively in children aged 8.5-9 years old)[46], and lower than Northern European children of the same age (handgrip strength: 14.4±3.7 kg and 12.8±3.4 kg, respectively for boys and girls; broad jump: 1.39±0.23 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, respectively for boys and girls)[47]. The comparison of fitness performances according to BMI groups in the present study showed that obese children performed worse than normal-weight children in tests that require acceleration of one's own mass. This is similar to the findings of Castro-Pinero et al.[43], showing poorer broad jump distance in obese compared to normal-weight children. However, Moura Dos-Santos et al.[48] did not find any significant correlation between BMI and 20 m sprint in children aged 7-10 years old. It should be noted however, that correlations might not be appropriate when a bell-shaped relationship between variables is expected. The main explanation for poorer power and speed performances observed in the present study is the difficulty for obese individuals to carry their extra body weight in tasks involving propulsion or lifting their body.[43] Indeed, body fat can be considered an extra load, which, unlike muscle does not contribute to power or speed production. These results may suggest that poor performances could discourage obese children from taking part in sporting activities, which lead to further weight gain in adolescence and adulthood. Indeed, several authors refer to the discomfort associated with locomotor tasks in obese individuals, characterised by greater perceived effort for a given energy expenditure, or greater musculo-skeletal pain, compared to non-obese individuals.[49-50] Therefore we suggest that participation in physical activity should be encouraged from a younger age to avoid this vicious circle.

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

Gender-specific results were found in the present study for the other fitness variables considered. Indeed, obese boys, but not girls, were characterised by poorer performance than normal-weight boys in the broad jump. This is in contrast with findings from Castro-Pinero et al.,[43] where obese children of both genders performed worse than their normal bodyweight counterparts. The main difference between this study and ours is participants' age, with age ranging from 6-17.5 years old, compared to 9-10 years old in our study. Therefore, different rates of maturity and growth between genders may explain the lack of significant differences in girls' broad jump performance. Significant correlations between handgrip strength and BMI have been demonstrated previously.[51] This greater strength can be explained by the commonly observed greater FFM in obese and overweight individuals, compared to people of normal weight.[52] An interesting result of our study is the absence of decreased performance in overweight compared to normal weight children, except on the MSFT in girls only. This is in contract with the study of Castro-Pinero et al.[43] who reported lower broad jump in overweight compared to normal weight children. Despite the significantly greater BF% in the overweight children of our study, it seems that it did not impair their speed, power, strength or endurance in boys. An explanation could be that overweight Omani adolescents (13-15 years old) are reportedly more physically active compared to normal weight adolescents in Oman, which is different to other countries in the Middle East.[18] While this study was based on self-reported activity and data from adolescents cannot be extrapolated to 9 year olds, this suggests there is a different physical activity pattern in Omani school children, which may protect overweight but not obese children from decreased fitness. Finally, our results showed that underweight children did not perform worse than normal weight children, except in the agility test in girls only. These results are in accordance with previous studies showing no significant differences between underweight and normal weight children and teenagers on broad jump and sit-up tests, as well as other tests of muscle strength or muscular endurance.[43,53] The authors explained these results by the fact that underweight children have both lower body fat levels and higher relative muscle mass compared to normal weight counterparts.

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

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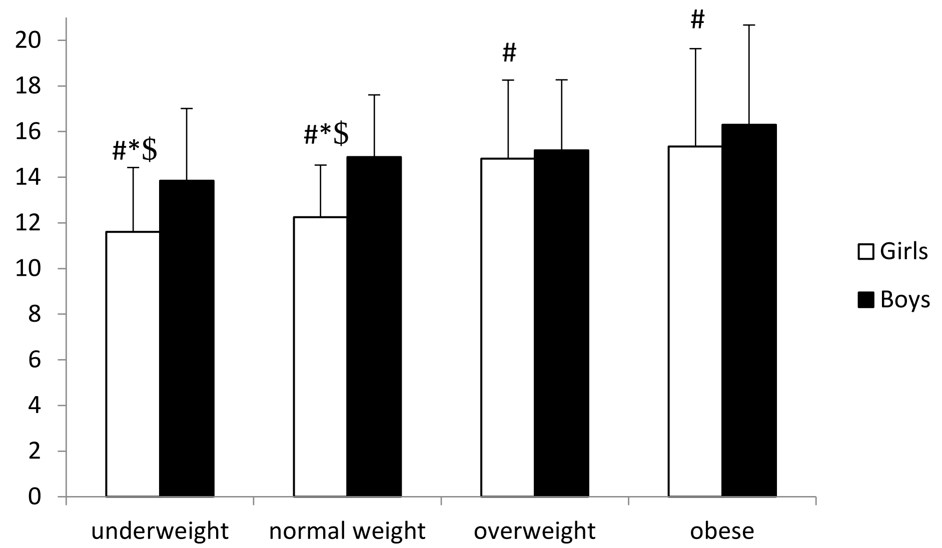
Table 1: Baseline anthropometry, body composition and physical fitness of Omani school children aged 9 and 10 years. Data are presented as mean ± SD. (BMI = body mass index; D: dominant; ND: non-dominant; MSFT (*n*) = number of shuttles completed in the multi-stage fitness test; 95% CL: 95% confidence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

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

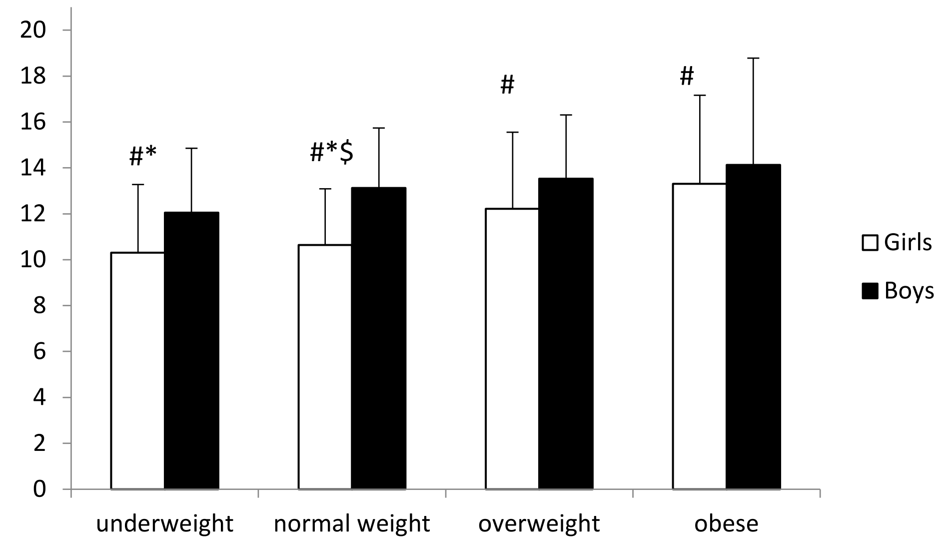
Handgrip D (kg)	15.00 ± 3.04	12.80 ± 2.93	0.001	0.74	1.48-2.84
Handgrip ND (kg)	13.21 ± 2.94	11.06 ± 2.86	0.001	0.74	1.48-2.81
Standing long jump (m)	1.36 ± 0.21	1.19 ± 0.20	0.001	0.84	0.12-0.21
Chest throw (m)	2.69 ± 0.61	2.43 ± 0.46	0.001	0.47	0.13-0.379
Agility test (s)	13.58 ± 1.66	14.48 ± 1.40	0.001	0.58	0.55-1.25
Sit-ups (*n*)	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 (*n*)	23± 14	18 ± 9	0.001	0.43	2.4-7.7

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

a-Handgrip strength (kg) of the dominant arm



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



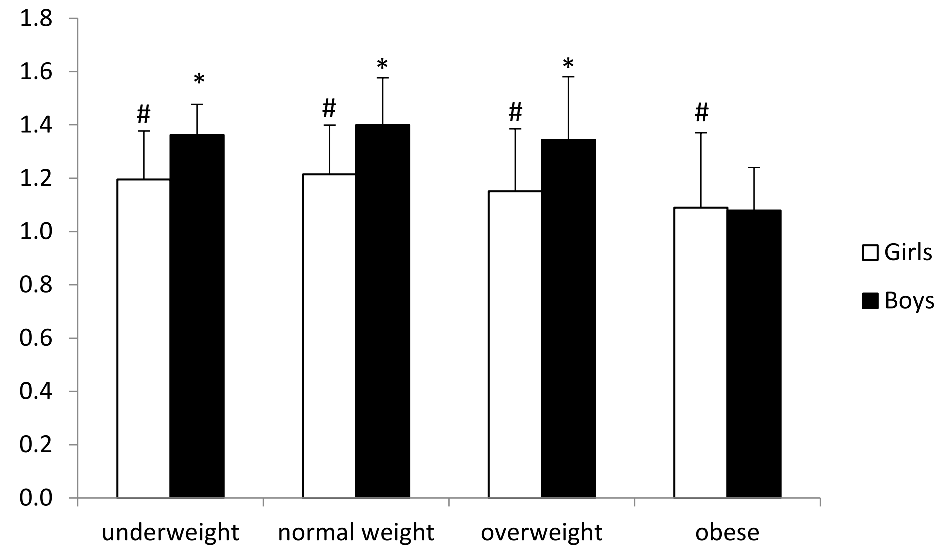
#: significantly different from boys, P<0.05.

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

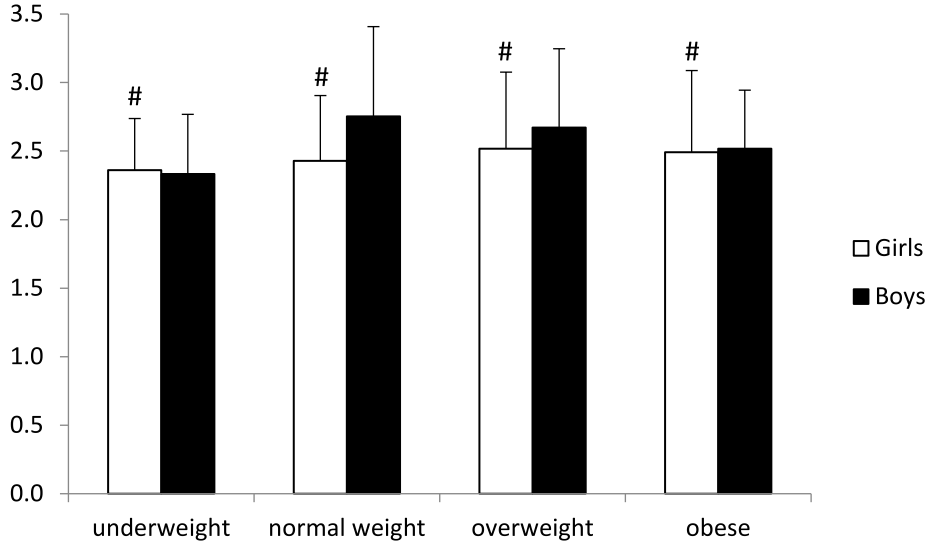
$: significantly different from the overweight group, P<0.05.

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

a-Broad jump distance (m)



b-Basketball chest throw distance (m)

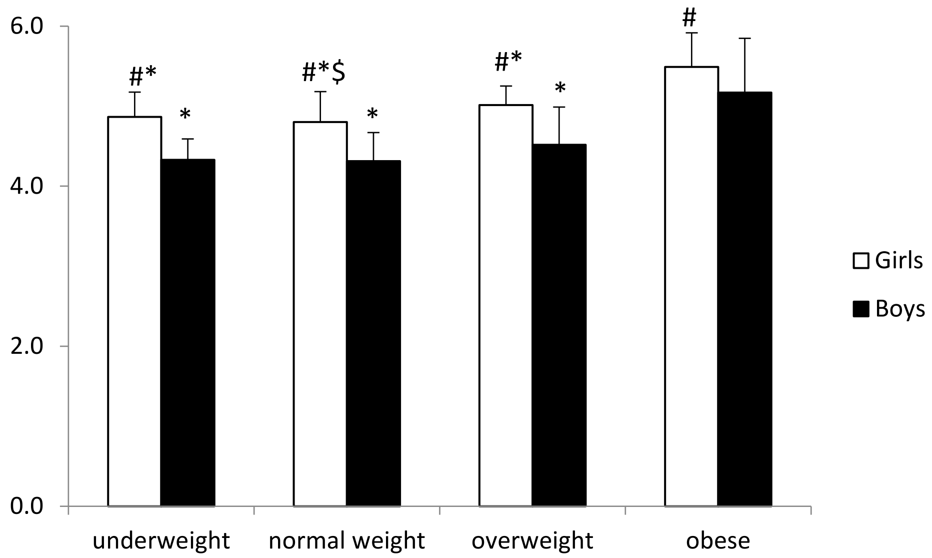


#: significantly different from boys, P<0.05.

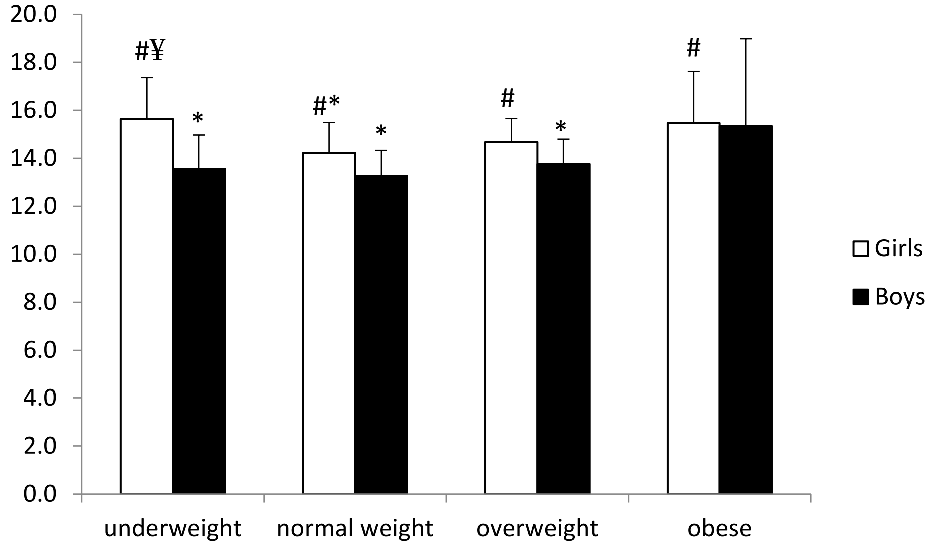
*: significantly different from the obese group, P<0.05.

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

a-20-m time (s)



b-4x10-m shuttle time (s)



#: significantly different from boys, P<0.05.

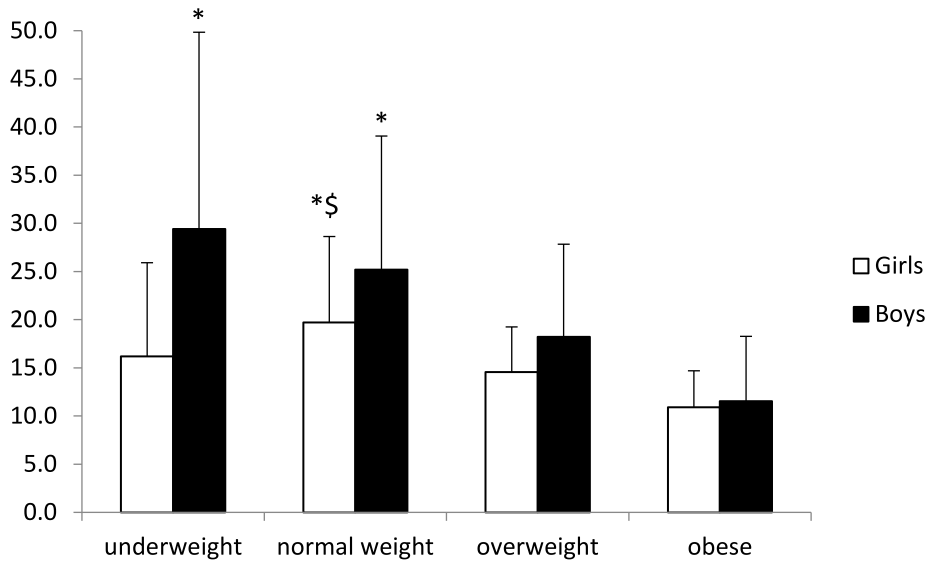
*: significantly different from the obese group, P<0.05.

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

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

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

Number of shuttles completed



#: significantly different from boys, P<0.05.

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

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