ORIGINAL ARTICLE

# Body composition analysis and estimation of physical fitness by scoring grades in Saudi adults

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## Abstract

**Objective:** To determine the prevalence of different categories of body composition in healthy Saudi adults and its relationship with fitness scoring.

**Methods:** The cross-sectional study was conducted on 428 healthy adult Saudi subjects over 18 years of age conducted at the department of Physiology, College of Medicine, King Khalid University Hospital, King Saud University, Saudia Arabia from April 2010 to September 2011. All participants underwent body composition analysis assessed by bioelectrical impendence analysis. Measurements included body weight, body mass index, protein mass, fat mass, percent body fat, and fitness scoring based on the target values. SPSS 10 was used for statistical analysis.

**Results:** The mean age of the participants was 36.90±15.22 years, ranging from 18 to 72 years. There were 318(74.3%) males and 110(25.7%) females. The mean body mass index and fitness scores were 27.22±5.65 and 69.3±8.48 respectively. The per cent prevalence of underweight, normal weight, overweight, obesity class I, obesity class II and obesity class III was 2.91 (n=13), 33.81 (n=139), 35.27 (n=145), 19.46 (n=80), 6.32 (n=26) and 2.18 (n=9) respectively. Of the total, 57 (13.4%) individuals had poor fitness, while 123(28.7%) had fair fitness scores. Good fitness score was seen in 218 (50.9%). Only 33(7.8%) subjects had normal body fats and 46(10.7%) showed lesser body fats than required. While the percentage of subjects with extra body fats ranging from <2kg, 2-4.9, 5.0-9.9, 10.0-14.9,15-19.9 and ≥20kg was 12.1(n=52), 19.4(n=83), 15.6(n=67), 15.2(n=65), 9.0(n=38) and 10.3(n=44) respectively. Significant gender differences were observed in body mass index, fitness score, per cent body fat and other parametres of body composition.

**Conclusions:** The prevalence of obesity, per cent body fat and poor fitness was high in the study population with significant gender differences. Public awareness programmes, including exercise and diet teaching, are required at mass scale to cope up with the growing burden of obesity.


**Keywords:** Body composition, Obesity, Fitness score, Body mass index, Percent body fat, Lean body mass.
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## Introduction

Obesity, understood as a condition of excessive fat accumulation, is a global problem now reaching epidemic proportions. It is a major, yet largely preventable, risk factor for a number of chronic diseases, including coronary artery disease and type 2 diabetes mellitus. Body mass index (BMI), because of its simplicity and hence general applicability, is a widely used surrogate measure of obesity.[1] However, there are limitations of BMI as an indicator of cardiovascular risk complications. Body weight is not a suitable measure for assessing ideal body composition related fitness because an increase in weight due to an increase in fat-free mass (FFM) can be misinterpreted as an increase in body fatness. BMI measure cannot be valid for all people; hence, we should be cautious when this index is applied to the extremes of physical types such as elite athletes, the physical frail, pregnant women, and children.[2,3]

Body composition analysis is important for understanding proportional changes in fat and lean mass for healthy individuals as well as individuals with various health conditions. Traditionally, assessing body composition relied upon the principle of underwater weighing, regarded as the 'gold standard. However, with improved technology various devices have been introduced to evaluate body composition. Dual-energy X-ray absorptiometry (DEXA) and bioelectrical impedance analysis (BIA) have become the preferred methods for measuring body composition because of accuracy and precision.[4,5] DEXA is often used as a criterion method for the assessment of body composition, justified by successful validation against multi-component models.[6] Unfortunately, the use of DEXA is limited in many environments due to inaccessibility, exposure to low-dose

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radiation and the high cost of the scanner. Another safe and practical method to assess body composition is near-infra red (IR) interactance (NIA) that uses wavelengths of harmless low-intensity near-IR light to calculate %BF. Alternatively, it is also possible to calculate %BF using. BIA which has been widely used in athletics and health clinics because of its relative low cost and ease of use. Over the past several years, there has been an increase in the marketing and sales of economical body composition analysers (i.e. bioelectrical impedance analysis devices). Studies have claimed that there are ethnic-specific muscularity, fat distribution, bone mass and leg length, characteristics that may contribute to the ethnic differences in the relationships between BMI and %BF.[7]

Therefore, a greater need has developed to evaluate the accuracy of these body composition devices. In addition, practical indicators of %BF for different age ranges and gender are needed for epidemiological and clinical studies. Moreover, segmental BIA, such as the InBody, has great potential to accurately assess total and appendicular body composition estimates.[8] Discrepancies may exist due to differences in sample size, ethnicity, fitness level and hydration status. In general, BIA devices are safe, quick and easy to use with little or no training.[9]

There is scanty data on body composition analysis as indicator of physical health and no such report is available in Saudi population. Therefore, the present study was planned to determine the prevalence of different categories of body composition distribution in healthy Saudi adults of both genders and its relationship with fitness scoring.

## Subjects and Methods

The cross-sectional study was conducted at the department of physiology, college of medicine and King Khalid University hospital, King Saud University, from April 2010 to September 2011. A total of 428 healthy adult Saudi subjects were recruited. The study was approved by the ethical review board of the College of Medicine, King Saud University. All participants underwent body composition analysis. Body composition was assessed by BIA, with a commercially available body analyser (InBody 3.0, Biospace, seoul, Korea). Measurements included body weight, BMI, protein mass, fat mass, %BF and fitness scoring based on the target values for ideal body fitness. Body fitness depends on specific criteria for body composition based on age and gender. The BIA analyzer has specific standardised criteria for fitness scoring which is automatically calculated by the machine.

The analyses works on the principal of bioelectrical impedance. Different tissues of the body have varying degrees of electrical resistance.[10-12] The analyser calculates the amount of each tissue with the difference in electrical impedance. The analyzer used was a segmental impedance device measuring the voltage drop in the upper and lower body. The participant stood on the device while it measured body weight, and age, height and gender were entered on the touch screen. The device uses eight points of tactile electrodes (contact at the hands and feet). This detects the amount of segmental body water. The technique uses multiple frequencies to measure intracellular and extracellular water separately. The frequency of 50kHz measures extracellular water while frequencies above 200kHz measure intracellular water. Segmental analysis can calculate slight differences by gender, age and race without using empirical estimation.

The subject is asked to first wipe the sole of the feet with a wet tissue. Then he stands over the electrodes of the machine. Demographic data is entered into the machine and then the subject holds the palm electrodes in hands and the machine is started. Within 3-5 minutes, results are in hand. On the basis of BMI, subjects were categorised into 6 groups: (kg/m$^2$) Underweight (BMI < 18.5), Normal (BMI 18.5-24.9), Overweight (BMI 25.0-29.9), Obesity class I (BMI 30.0-34.9), Obesity class II (BMI 35.0-39.9) and Extreme Obesity class III (BMI 40.0 +).[1]

The data was analysed through SPSS version 10. Descriptive characteristics were calculated as Mean ± SD (Standard Deviation) for continuous variables, and as frequencies and percentages for categorical variables. The test applied for statistical analysis was Student's t test and post hoc power analysis with an alpha error of 5%. A p value of $\leq$0.05 was taken as statistically significant.

## Results

Of the 428 subjects, 318(74.3%) were males and 110(25.7%) were females. The mean age of the participants was 36.90±15.22 years, ranging from 18 to 72 years (Table-1). The mean BMI of the study population was 27.22±5.65 (median= 26.80; range= 15.6-55.4). Significant gender differences were observed in different body indices and composition (Table-2). The mean height (p<0.0001), body surface area (p<0.0001), weight (p<0.0001), BMI (p<0.0249) and protein mass (p<0.0001) was significantly higher in males compared with females. However, the difference in body fat mass was non-significant. Females had significantly higher levels of %BF (p<0.0001). The mean fitness score was also significantly lower in females (p<0.0010).

The percent prevalence of underweight, normal weight, overweight, obesity class I, obesity class II and obesity class III was 2.91(n=13), 33.81(n=139), 35.27(n=145), 19.46(n=80), 6.32(n=26) and 2.18(n=9) respectively (Figure-1). Besides, 33(7.8%) subjects had normal body fats and 46(10.7%) showed lesser body fats than required. While the percentage of subjects with extra body fats ranging from <2kg, 2-4.9, 5.0-9.9, 10.0-14.9, 15-19.9 and $\geq$20kg was 12.1(n=52), 19.4(n=83), 15.6(n=67), 15.2(n=65), 9.0(n=38) and 10.3(n=44) percent respectively (Figure-2).

Table-1: Demographic data.

| Variables | All Mean ± SD | Minimum | Maximum | Median |
|---|---|---|---|---|
| Age years | 36.90 ± 15.22 | 18.00 | 72.00 | 33.00 |
| Height | 167.92±8.52 | 147.00 | 187.00 | 169.00 |
| Body Surface Area | 2.83±0.29 | 2.16 | 3.50 | 2.86 |
| Weight kg | 76.73±17.47 | 38.30 | 140.00 | 75.80 |
| Obesity Degree | 127.61±26.83 | 74.00 | 268.00 | 125.00 |
| BMI | 27.22±5.65 | 15.60 | 55.40 | 26.80 |
| Protein Mass kg | 10.74±2.13 | 5.60 | 15.80 | 11.00 |
| Fat Mass kg | 23.08±10.77 | 2.20 | 81.60 | 21.20 |
| %BF | 29.13±8.88 | 4.00 | 58.20 | 29.60 |
| Fitness Score | 69.32±8.48 | 29.00 | 99.00 | 71.00 |

SD: Standard deviation.
BMI: Body mass index.
%BF: Percent body fat.

Table-2: Gender differences in demographic data and fitness score.

| Variables | Males (N=318) | Females (N=110) | P value |
|---|---|---|---|
| Age years | 39.14 ± 16.07 | 37.63 ± 9.91 | 0.2543 |
| Height | 170.8 ± 2 7.32 | 159.35 ± 5.56 | 0.0001 |
| Body Surface Area | 2.91 ± 0.30 | 2.54 ± 0.18 | 0.0001 |
| Weight kg | 80.29 ± 16.80 | 66.22 ± 15.05 | 0.0001 |
| Obesity Degree | 127.91 ± 25.48 | 126.75 ± 30.59 | 0.7047 |
| BMI | 27.58 ± 5.44 | 26.15 ± 6.15 | 0.0249 |
| Protein Mass kg | 11.54 ± 1.72 | 8.38 ± 1.33 | 0.0001 |
| Fat Mass kg | 22.77 ± 10.63 | 24.00 ± 11.20 | 0.3163 |
| %BF | 27.28 ± 8.07 | 34.61 ± 9.01 | 0.0001 |
| Fitness Score | 70.94 ± 7.03 | 68.13 ± 8.51 | 0.0010 |

BMI: Body Mass Index.
%BF: Per cent body fat.

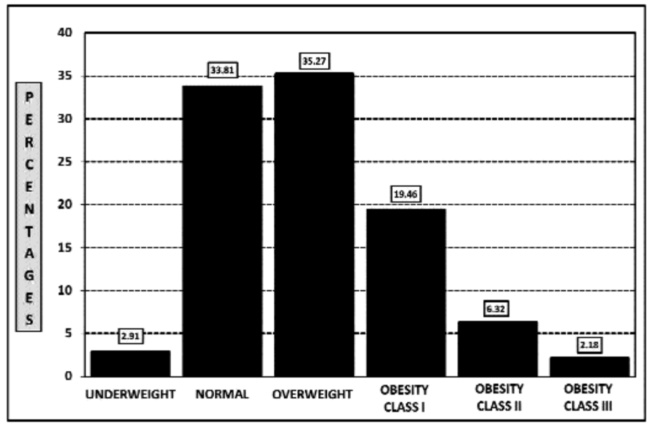


**Figure-1:** Prevalence of weight distribution in Saudi adults according to BMI classification of World Health Organization (WHO).

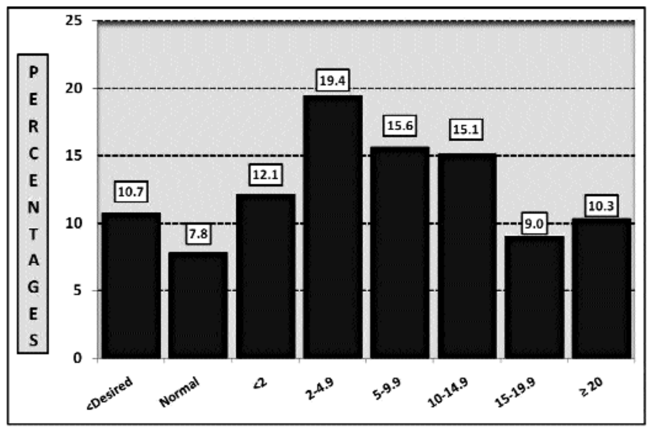


**Figure-2:** Percent distribution of Saudi adults according to the amount of fat content in the body.

We categorized various degrees of fitness score into different classes into grades like A, B, C, D and E or also into excellent, very good, good, fair, poor and very poor categories. There were 57 about 57(13.4%) individuals in poor and very poor categories, while 123(28.7%) had fair fitness scores; had excellent (ideal) body fitness (Table-3). Secondly, most of the subjects had good fitness scores

Table-3: Cumulative percent and absolute percentage of fitness score categories.

| Fitness Scores | Frequency | Cumulative Frequency | Percent Prevalence | Cumulative Percent | Severity Categories | Grades Category |
|---|---|---|---|---|---|---|
| <50 | 12 | 12 | 2.9 | 2.9 | V Poor | E |
| 50-59.9 | 45 | 57 | 10.5 | 13.4 | Poor | D |
| 60-69.9 | 123 | 180 | 28.7 | 42.1 | Fair | C |
| 70-79.9 | 218 | 398 | 50.8 | 93.0 | Good | B |
| 80-89.9 | 27 | 425 | 6.4 | 99.3 | V Good | A |
| 90-99.9 | 3 | 428 | 0.7 | 100 | Excellent | A+ |

(n=218; 50.9%). These data also show that 180(42.1%) had fitness below 70, and 398 (93.0%) had fitness scores<80. Using alpha error of 5% post hoc power analysis was performed based on gender differences in body composition characteristics and it was observed that the statistical power of our study was 87%.

## Discussion

A very high prevalence of obesity and poor fitness scoring was observed in Saudi adult population. Moreover, significant gender differences were observed in BMI, fitness score, %BF and other parameters of body composition. Body anthropometric data is frequently collected in clinics, sports medicine, nutrition and other health-related fields, but the routine parameters of body fitness like BMI and waist hip ratio (WHR) do not give a true picture of physical fitness. Using parameters of body fat analysis, lean body mass and muscle fat ratio would encourage people to initiate an active lifestyle early in their lives, thus preventing the occurrence of non-communicable diseases. Investigators working in this field have looked into body composition and physical fitness from different aspects. The results of these studies are interesting. The reason for very high prevalence of obesity and poor fitness scoring in Saudi adult population may be physical inactivity and high caloric intake. A clear association has been reported between low physical activity or age and height-normalised body composition parameters like body fat mass index (BFMI) and fat free mass index (FFMI) derived from BIA.[13]

A study in Korean adult population reported the association between the ratio of visceral fat to thigh muscle area and metabolic syndrome. It observed that the ratio was significantly increased in subjects with metabolic syndrome and independently associated with it.[14] Another study analysed associations between health-related physical fitness and the anthropometric and demographic indicators of children at elementary schools. It reported that unhealthy physical fitness levels were related to female gender, obesity and excessive abdominal adiposity. Our study also showed poor fitness in females. Implementation of effective programmes to change lifestyle for achieving physical fitness and healthy nutrition in schools are needed. A published report from India, related regional body composition to anthropometric indices and reproductive events in low-income population. It observed that the women had a 'high fat muscle poor' phenotype.[16] In our study, females had significantly lower fitness compared with the males, but the Saudi community has no income problems, therefore, poor muscle type was not observed in our female subjects.

Also, BMI and %BF are generally well correlated. There is increasing evidence of wide ethnic variations in the relationship between these two frequently tested variables.[17] Therefore it is appropriate to study it in different ethnic groups. For example in a study involving both men and women, the percentage of total fat as abdominal fat was significantly higher in Maori, Pacific and Asian Indians than the Europeans.[18] This may explain, in part, the higher prevalence of hypertension and type 2 diabetes found in these ethnic groups compared with the Europeans.[19-21]

A wide disparity is seen in the %BF and BMI relationship between, Pacific people, who could, argueably, be the largest population segment in the world,[22] and, Asian Indians, who appear to have the most fat.[23] For example, at a fixed %BF corresponding to a BMI of 30kg/m$^2$ for Europeans (29 %BF for men, 43 %BF for women), Pacific BMI values were up to 5 units higher and Asian Indian up to 6 units lower: a span of 11 BMI units. For a BMI of 30kg/m$^2$, BF in Pacific men was 25% and in Asian Indian men 37%, while in women these fat levels were 38% and 47%, respectively. The second main finding of this study was that Asian Indians had higher fat levels, both total and in the abdominal region, with lower lean mass, skeletal muscle and bone mineral levels than all other ethnic groups.[18] Moreover, with increasing age, while the %BF in Asian Indians showed little change, there was a shift in the distribution of this fat to the abdominal area. In other ethnic groups, and particularly in women, increasing levels of abdominal fat with age were coupled with increasing %BF.

We categorised various degrees of fitness score into different classes either according to grades like A, B, C, D and E or into excellent, very good, good, fair, poor and very poor. This division would enable individuals to know more about their physical fitness scores rather than just knowing about their weight and BMI. Our study revealed that about 13.4% (n=57) individuals had poor and very poor categories, while 28.7% (n=123) had fair fitness scores. About 0.7% (n=3) individuals had excellent (ideal) body fitness. Secondly most of the population had good fitness scores (50.9%; n=218). Besides, 42.1% (n=180) population had fitness below 70, and about 93.0% (n=398) had fitness scores<80. Approximately 95% of Pacific men and 100% Pacific women have been reported to be 'overweight or obese'. This problem requires the adoption of a total Pacific population 'environmental change' approach rather than dietary or physical activity interventions targeted at overweight individuals.[24]

National surveys, including large samples of healthy people, are needed to generate reference data for body composition parameters that describe differences expected by gender and age during adulthood, with specific reference to fat and muscle mass, to develop ranges of normal values and thus promote health.

## Conclusions

The prevalence of obesity, %BF and poor fitness was high in the study population with significantly lower fitness scores in females. Weight reduction can be achieved through structured and community-tailored training programmes that would optimise body composition and fitness level both in young and elderly people to initiate an active lifestyle early in their lives, thus preventing diseases related to obesity and physical inactivity. .

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