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Current Prospectus on Obesity in Bahrain and Determination of Percentage Body Fat Range

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Background: Obesity and its related disorders are becoming an overburden on healthcare systems worldwide.

Objective: To evaluate the current status of obesity in Bahrain and predict percentage body fat.

Setting: Shopping mall in Bahrain.

Design: Prospective cross-sectional study.

Method: Four hundred fourteen volunteers were recruited; each provided informed consent. A range of physical measurements were collected from each individual and used to calculate the parameters obtained.

Result: The average body mass index (BMI) for males was 28.2 kg/m^2 and for females was 28.6 kg/m^2. This increased with age, showing a biphasic increase for females. Linear transformation of BMI data showed greater significance in correlating BMI versus percent body fat. However, prediction equations for calculation of percent body fat were more accurate without linear transformation of data. Percent body fat ranges for Bahrain, corresponding to BMI categories were derived.

Conclusion: Prevalence rates for obesity in Bahrain are higher than predicted and are increasing at a higher rate than the global average. This mirrors the alarming increase in the prevalence of Type 2 Diabetes Mellitus in Bahrain.

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Obesity is a medical disorder usually defined as a condition of abnormal or excessive fat accumulation in adipose tissue[1]. This accumulation may be deleterious to the individual's health, leading to numerous co-morbidities, such as dyslipidemia, coronary artery disease and strokes, hypertension, non-insulin-dependent diabetes mellitus, sleep apnea and osteoarthritis[2]. The World Health Organization (WHO) suggests that obesity is significant threat to public health, but it remains one of the most neglected public-health issues[1]. Obesity is considered a risk factor and financial burden worldwide[3].

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Assessing the degree of obesity in an individual is achieved by using the body mass index (BMI), a crude method for population-based measurement of obesity[4]. BMI of 25.0 kg/m^2 or higher is considered overweight; obesity defined as BMI greater than 30.0 kg/m^2 or more. Further subdivisions could be applied to the obese category; BMI of 30.0-34.9 kg/m^2 is Class I Obese, BMI of 35.0-39.9 kg/m^2 is Class II Obese and BMI of greater than 40.0 kg/m^2 is Class III Obese[1].

BMI is often distorted for athletes and the elderly and can diverge across age, sex, race and severity of obesity[5-7]. One of the simplest non-invasive techniques is the use of bioelectrical impedance analysis (BIA); a measure of a two-compartment model of fat mass and fat-free mass, measuring the impedance to a small electrical current as transmitted through the body's water pool. This method provides a more sensitive and accurate measure of body composition than BMI[8].

The association between obesity and Type 2 diabetes mellitus is strong, it has led to the adoption of the term Diabesity to describe it[9]. One of the key mediators in its pathogenesis is a class of metabolically-active molecules termed adipokines[10]. These cytokines derived from adipose tissue, they have the ability to interfere with insulin actions, either by increasing resistance to or by altering the sensitivity to insulin. A low-grade chronic inflammation also accompanies obesity, accompanied with a release of cytokines such as Tumor Necrosis Factor-α and Interleukin-6 contributing to increased insulin resistance[10].

The Middle Eastern region has one of the highest prevalence of both obesity and diabetes in the world[11]. In Bahrain, a study by Musaiger et al showed that BMI $\geq$ 25.0 kg/m^2 in males was 56.4% and in females was 79.7%; it was attributed to changes in dietary habits, lifestyle and a lack of physical activity[12]. Studies on diabetes in Bahrain indicate prevalence rates of 25.8% in males and 36.4% in females, mirroring a trend in obesity rates[11,13]. Although recent studies show that the awareness of the risk of complications due to diabetes in Bahrain is high, the personal risk related to diabetes and perception of body composition remain under-estimated[14].

The aim of the study is to evaluate the current status of obesity in Bahrain, predict percentage body fat and determine whether the use of BIA would be more accurate in representing body composition or not.

METHOD

Four hundred fourteen Participants were recruited voluntarily and informed consent was obtained from each. Gender, age, marital status and nationality were obtained. Height and weight measurements were obtained in order to calculate body mass index.

The research ethics committee at the Royal College of Surgeons in Ireland-Medical University of Bahrain approved the study.

Subjects' age, weight, gender and height, obtained from the survey, were entered into an OMRON HF-306 Body Fat Analyzer (OMRON Corporation, Kyoto, Japan). Based on these measurements, the percentage body fat was obtained by electrical impedance analysis. An average of three readings per person was taken to increase the accuracy of reading and to avoid measurement error.

Body mass index of subjects was calculated based on the original formula (weight in kilograms/height in m^2). Categorization of subjects based on their body mass index was done according to the World Health Organization Expert Committee Guidelines on body mass index ranges. Ranges for the percentage of body fat were determined based on Gallagher et al[15].

Basic statistical analysis was calculated using Excel. All other statistical analysis was performed using SPSS version 16.0 R^2 linear values and R^2 quadratic values for the comparison of BMI versus the percentage of body fat were determined by using the Spearman's Rho coefficient test.

RESULT

Four hundred fourteen individuals were recruited on a voluntary basis over a period of two weeks in June 2009. Of these, 295 were males and 119 were females. The Mean age for the subjects was 34.2 years, with a standard deviation of 11.7 years. Males mean age was 34.0 years and females mean age was 33.3 years. Males had an average height of 1.71 m ± 0.07 m and an average weight of 83.5 kg ± 18.0 kg. The average male percentage body fat was 23.7% ± 8.0%. Females mean height was 1.57 m ± 0.07 m with an average weight of 70.9 kg ± 18.2 kg. The female percentage body fat had a mean of 34.3 ± 8.5%, see tables 1and 2.

Table 1: Predicted Percentage Body Fat by Gender and Age[4]. BMI Scales Were According to the WHO Guidelines

Men	**Ages 18-24**	**25-34**	**35-44**	**45-54**	**55-64**
BMI ≤ 18.5	10.6	12.9	15.2	17.5	19.8
BMI ≥ 25	18.4	20.7	23	25.3	27.6
BMI ≥ 30	24.4	26.7	29	31.3	33.6
BMI ≥ 35	30.4	32.7	35	37.3	39.6
BMI ≥ 40	36.4	38.7	41	43.3	45.6
Women	**18-24**	**25-34**	**35-44**	**45-54**	**55-64**
BMI ≤ 18.5	21.4	23.7	26	28.3	30.6
BMI ≥ 25	29.2	31.5	33.8	36.1	38.4
BMI ≥ 30	35.2	37.5	39.8	42.1	44.4
BMI ≥ 35	41.2	43.5	45.8	48.1	50.4
BMI ≥ 40	47.2	49.5	51.8	54.1	56.4

Table 2: Personal Characteristics and Sample Size. Mean Values for Age, Weight, Height, Body Mass Index (BMI) and Percentage Body Fat Were Calculated and Represented as Mean ± Standard Deviation ($\bar{x}$ ± SD)

	Male	Female
Sample size (n)	295	119
Age (y)	34.0 ± 11.9	33.3 ± 11.3
Weight (kg)	83.5 ± 18.0	70.9 ± 18.2
Height (m)	1.71 ± 0.07	1.57 ± 0.07
BMI (kg/m^2)	28.2 ± 5.5	28.6 ± 6.9
Body fat (%)	23.7 ± 8.0	34.3 ± 8.5

The average BMI was 28.4 ± 5.8 kg/m^2, see table 3. Males' BMI average was 28.2 ± 5.5 kg/m^2. According to BMI, 75 (25.4%) males were in the normal range (18.5 - 24.9 kg/m^2), only 3 (0.7%) of the population were underweight. The majority of the male population, 128 (43.4%), was overweight (25.0 - 29.9 kg/m^2). Eighty-nine (30.2%) males were obese, 54 (18.3%) were class I obese (30.0 – 34.9 kg/m^2), 28 (9.5%) were class II obese (35.0 – 39.9 kg/m^2) and 7 (2.4%) were class III obese (>40 kg/m^2), a total percentage overweight of 74%.

The average female BMI was 28.6 ± 6.9 kg/m^2. Compared to male population, 39 (32.8%) females were in the normal range. Thirty-two (26.9%) females were overweight, 44 (37%) females were determined as being obese, class I obese was 19 (16%), class II obese was 17 (14.3%) and class III obese was 8 (6.7%).

Table 3: Distribution of BMI Ranges for Populations of Men and Women

BMI Category	BMI Range (kg/M^2)	Male Percentage	Female Percentage
Underweight	<18.5	0.6	3.3
Normal	18.5 – 24.9	25.1	32.8
Overweight	25.0 – 29.9	44.1	26.9
Obese I	30.0 – 34.9	18.3	16.0
Obese II	35.0 – 39.9	9.5	14.3
Obese III	>40.0	2.4	6.7

The mean BMI was determined for each decade in both males and females, see figure 1A. Univariate ANOVA analysis determined no significant differences in the mean BMI across the age groups in males. However, ANOVA determined that women in their twenties had a significantly higher BMI.

In order to determine visually the outliers, the data for BMI and percentage of body fat was represented by box plots. The greatest variation in the Interquartile range (IQR) for males was seen in the 30-39 age range, see figure 1B. The data in this range was tailed towards a higher BMI value. Several subjects in the male population could be found outside the 1.5 IQR. All these subjects had BMI values more than 1.5 IQR for that age category. These

values ranged from BMI of 40.5 to BMI of 49.6. For the female population, the greatest variation in BMI values was found in the 20-29 age group. These data showed vast degree of variation from the mean, the data skewed towards a heavier BMI value. Outliers were found in the upper age groups, one outlier showed very low BMI.

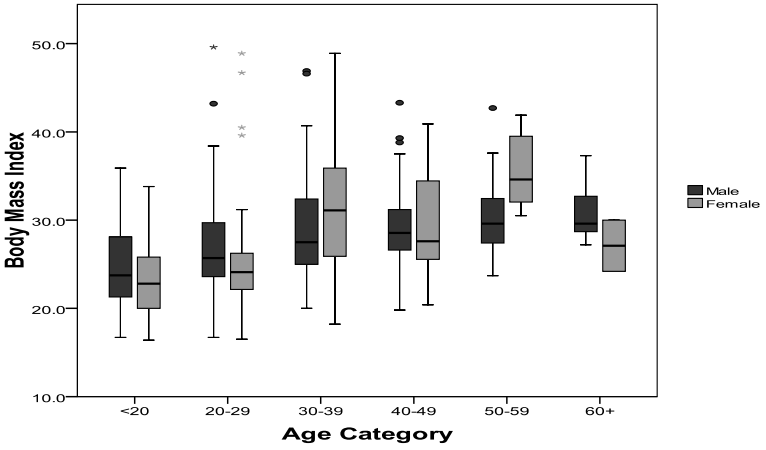

Figure 1 (A): BMI Distribution per Decade. Medians (Horizontal Black Lines) and Interquartile Range (IQR) are Indicated by Boxes. Whiskers Represent 1.5 IQR. Outliers Are Indicated by Dots

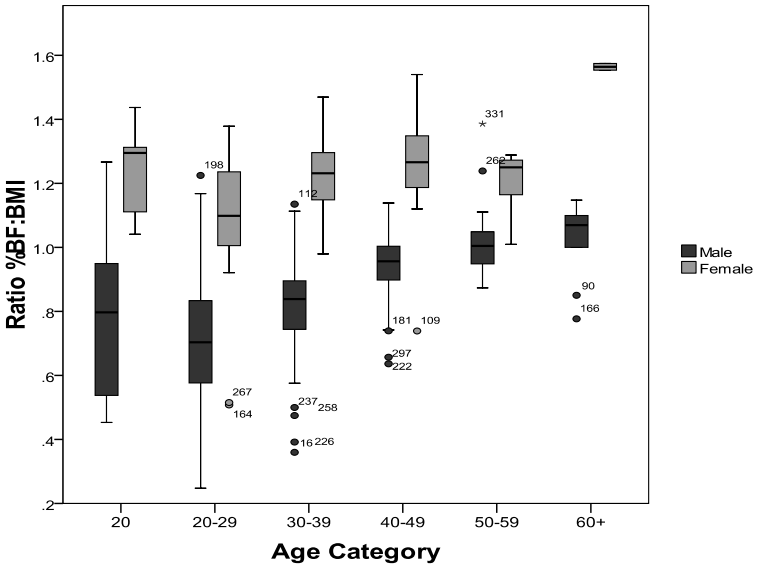

Figure 1 (B): Distribution by Decade of Percentage Body Fat. Medians (Horizontal Black Lines) and Interquartile Range (IQR) Are Indicated by Boxes. Whiskers Represent 1.5 IQR. Outliers Are Indicated by Dots

A steady linear increase in the ratio of percentage of body fat to BMI was observed in males, an average increase of 2.35% per decade up to the sixth decade. A slight decrease in the ratio is observed in the seventh decade according to the mean of the age category. However, calculation of the median value for this category and representation of the 1.5 interquartile range would suggest that there is less decrease as indicated by the mean value.

An increase in the ratio of percentage of body fat to BMI is observed from the third to the 5th decade in females. This equated to an average of 1.95% per decade. Statistical analysis of the

data for the sixth decade indicated a large decrease in the ratio, indicating an increase in BMI versus percentage of body fat at this stage.

A direct correlation analysis of BMI versus the percentage of body fat did not show any significance for either male (-0.022) or female data (0.074). However, linear transformation of BMI, as it is not a single value, is suggested to produce accurate results. Following data transformation the correlation analysis was repeated. A correlation coefficient of 0.866 for males and 0.889 for females was achieved by inversion of BMI values (1/BMI). This increased in significance for logarithmical transformation of the BMI data (logBMI), producing a correlation coefficient of 0.865 for males and 0.890 for females. This suggests that there is a high level of correlation between percentage body fat and BMI.

Non-linear transformation of the data using the equation of Deurenberg et al was used to calculate age-related body fat ranges for the sample population[4]. These ranges are given in Table 1.

DISCUSSION

Obesity is rapidly becoming one of the leading pandemics in the world today. Rates of obesity are increasing worldwide; the incidence of childhood obesity is growing at an alarming rate. There has been rapid increase in the prevalence of metabolic disorders, such as coronary artery disease and strokes, hypertension, certain types of cancer and osteoarthritis[2].

In this study, the mean weight was 83.5 kg for males and 70.9 kg for females. In 1982, it was reported that the mean weight for males was 62.8 kg and for females 56 kg[16]. This suggests a large increase in the mean weight for Bahraini adults, 20.7 kg for males and 14.9 kg for females. A similar increase was also seen in the mean BMI figures. The prevalence of overweight and obesity in Bahraini males was 44.1% and 30.2% respectively and 26.9% and 37.0% in females. Compared to figures of 2001, the prevalence of individuals with BMI $\geq$ 25.0 kg/m^2 had increased in males from 56.4% to 74.3% over the preceding ten years, female Bahrainis declined from 79.7% to 63.9%[12].

In this study, the mean BMI was 28.4 $\pm$ 5.8 kg/m^2, for males, the mean BMI was 28.2 $\pm$ 5.5 kg/m^2, which would rank Bahrain as 10th in the WHO's global comparable estimates[17]. However, in the WHO Global Estimates Bahrain was ranked joint 36th with a mean BMI of 26.4 kg/m^2. This resulted in an overall discrepancy of 1.8 kg/m^2 in BMI estimates. The prevalence of males with BMI $\geq$ 25.0 kg/m^2 was underestimated by 13.4%, while discrepancy of 9% was observed for males in the obese category. According to WHO's global comparable estimates, females in our study ranked 21st globally with an average BMI of 28.6 kg/m^2.

Previous studies have demonstrated an increase in the mean BMI in both males and females from the second to the seventh decade[18]. In this study, an increase in mean BMI between the third and fourth decades for both males and females populations was demonstrated. Similar biphasic increases in BMI amongst the female population over 40 years old had also been previously observed[12,19]. This was attributed to metabolic and hormonal changes that occur during the menopause[20].

The muscle mass and lean body tissue normally declines with an increasing age, it is replaced by abdominal fat[4]. This might distort the determination of an individual's body composition, the BMI falsely lowering the estimation of body fat[4]. Consequently, measurement of body

weight alone may mask important increases in age-related adiposity. Determination of the percentage of body fat might be a better indicator of body composition. A consistent increase in the ratio of the percentage of body fat compared to BMI for males was observed in our study, an average ratio of 0.1 per decade; this correlated to percentage increase of 2.4% per decade for mean BMI of 23 kg/m^2. This is higher than that predicted for Caucasians and African-Americans, which increases at a rate of 1% per decade, suggesting a more rapid weight-gain per decade in our study population[21,22]. Similarly, in the female population, an individual with mean BMI of 23 kg/m^2 demonstrated cubic polynomial distribution in the ratio of the percentage of body fat versus BMI.

This suggests that females undergo a larger increase in their average BMI, compared to the increase in the percentage of body fat. This finding contradicts the suggestions of other authors who report greater increases in percentage body fat over time.

This might be attributed to a slower accumulation of visceral fat compared to their male counterparts[23]. The observed massive increase of over 8% body fat over 60 years of age may be attributed to an increase in subcutaneous fat post-menopause[24].

A major assumption of BMI is representation of adiposity independent of age, sex and ethnicity. Construction of graphs of the percentage of body fat versus BMI showed quadratic, non-linear curves, consistent with the observations of Jackson et al[6]. This is most likely due to the non-linearity of data in the upper obese category (35-50 kg/m^2), common to both the male and female data sets. Multiple regression analysis of the data indicated that 1/BMI gave optimal linearization in both study populations. However, prediction of the percentage of body fat by established methods that use inversion did not correlate well with the data obtained, This equation under-estimated the percentage of body fat in the lower body fat ranges[15]. By application of the equation of Deurenberg et al, we created a more accurate prediction of the percentage of body fat ranges for age, gender and BMI category, specific for the Bahraini population studied[4]. Suggested percentage of body fat ranges were higher than those for Caucasians and African-Americans[15], especially in the lower percentage of body fat range. The values obtained were more comparable to those obtained for the Asian population. This concurs with the suggestion that a single universal set of percentage of body fat ranges for all ethnic groups seems unlikely[15].

CONCLUSION

In this study, obesity is well above the estimates by the WHO for males and it showed a rapid increase in adiposity, which exceeded other ethnic groups. High correlation between BMI and the percentage of body fat was found. This would suggest that further measurements of body composition other than BMI would be unnecessary. This would also imply that the use of BMI would be sufficient for reporting of adiposity-related markers such as adiposity-induced adipokine concentrations.

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