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Assessment of Adipose Tissues as a Risk Factor for Cardiovascular Diseases among Students of a Nigerian Tertiary Institution

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A R T I C L E I N F O

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A B S T R A C T

Introduction: The purpose of this study was to assess adipose tissues distribution. This was with a view of establishing risk for development of CVD among this population.

Method: One hundred and ninety apparently healthy undergraduate students (100 males and 90 females), mean age of 24.29 + 3.54 years participated in the study. The following variables were measured using standard protocols; weight, height, skin fold thickness, waist circumference and hip circumference. Data were analysed using descriptive and inferential statistics.

Result: Result revealed that fewer percentage of participants were obese using body mass index (BMI) (male, 21.0% overweight, 5.0% obese; female, 37.8% overweight); waist to hip ratio, (male 57.0 % overweight, female, 26.7 overweight, 31.1% obese), waist circumference, (male 100% overweight) and waist to height ratio (WHtR), (male,11.0 % overweight, female 4.4% overweight). Male have significant higher weight, BMI, WC, WHR, WHtR than female participants ($p< 0.05$). There was a significant association between age and BMI ($p< 0.01$), and age and WHtR ($p= 0.023$).

Conclusion: It can be concluded from the study that average participants were not obese at the time of the study; hence they may not be at risk of CVD. Body Mass Index of male participants were significantly more than that of female but percent body fat of female were significantly higher than that of male. Age and sex were individually associated with level of adiposity.

INTRODUCTION

Cardiovascular diseases (CVD) have been identified to be the largest world killers claiming 17.1 million of lives annually which amounted to one third of all the deaths worldwide[1]. Report has that over 80% of cardiovascular disease deaths take place in low-and middle-income countries and occur almost equally in men and women[1]. Evidence has also shown that

cardiovascular mortality rates have declined in many high-income countries but have increased at an astonishingly fast rate in low- and middle-income countries in the last two decades[2]. Cardiovascular disease is a growing threat to health in Africa, accounting for 9.2% of deaths in 2001, principally due to hypertension, stroke, cardiomyopathy, and rheumatic valve disease[3, 4]. Adedoyin and Adesoye, reported a high incidence in CVD in Western part of Nigeria between the year 1997 and 2001 in a hospital's based study which was in line with findings of Mucadas and Misbau where a steady increase in the CVD between year 2001 and 2005 at the Northern part of Nigeria was established and hypertension happened to be the most prevalent disease [5,6].

Cardiovascular disease usually affects older adults, but the antecedents of cardiovascular disease, notably atherosclerosis begin in early life, making primary prevention efforts necessary from childhood[7]. During the past two decades, a significant increase in obesity and obesity-related disorders such as type 2 diabetes, hypertension, and dyslipidemia has occurred among people in their teens and 20s [8,9]. Reddy reported that the rate of death due to cardiovascular disease among persons 15 to 59 years of age is 3 to 8 times as high in Tanzania and Nigeria as in England and Wales[10]. It was concluded in his report that death and disability occurring in midlife have disastrous consequences for families who lose wage earners, and the resulting loss of productivity adversely affects national development. Reports suggested that there was a direct relationship between adolescent fatness and increased risk of cardiovascular diseases [11,12]. If no action is taken to improve cardiovascular health and current trends continue, Word health organization (WHO) estimates that 25 per cent more healthy life years will be lost to cardiovascular disease globally by 2020 which will affect developing countries more[13].

The increase in the prevalence of CVD in the developing countries could be attributed to large number and high level of risk factors associated with CVD in the developing countries. Some of the factors include social and economic changes, an increase in westernized diets and physical inactivity which have a profound effect on the lifestyle factors. The trend towards high carbohydrate, high saturated fat, and low nutrient diets have led to increased blood pressures, high blood sugars, and elevated lipid levels[14]. Increase in blood sugar and lipid levels have contributed to the reason why level of obesity has rapidly reached epidemic proportions especially in developing countries. Systematic analysis of population health data revealed that, among the nine risk factors of heart attacks and strokes, six risk factors are modifiable, while three are non-modifiable risk factors; these include increasing age, male gender and family history of cardiovascular disease (CVD)[15,16] .The six modifiable risk factors that are the focus of current research for primary prevention are 1) increased blood cholesterol; 2) increased blood pressure (hypertension); 3) cigarette smoking; 4) lack of regular physical exercise; 5) type 2 diabetes, and 6) obesity. Obesity is accumulation of excess fat in the body. It has been established that obesity is a risk factor for several chronic diseases including hypertension, dyslipidemia, type 2 diabetes mellitus, coronary artery disease, sleep apnea, musculoskeletal problems, gallbladder disease, stroke and some forms of cancer[17,18,19].

The WHO estimated that there were more than 300 million obese people worldwide an increase of 100 million since 1995[20]. Some studies have tracked body fat from childhood to adulthood,[21,22] and emphasized that it is necessary to prevent and treat obesity at an early age in order to prevent its' deadly menace. De Onis and Blosner,[23] reported that adolescence obesity is not limited to the industrialised countries alone, in their review, they reported an increasing prevalence of overweight and obesity among school children in developing countries, such as Nigeria, Ghana, Malawi, Egypt, Argentina, Uzbekistan, Peru, Qatar, South Africa, and Jamaica, the percentage of obesity and overweight children exceeds that of the United States. Obesity will emerge as a dominant cause of cardiovascular disease (CVD) in the future, if the current trend in adolescent's lifestyle continues. The degree of awareness of the health risks caused by obesity is not the same in all countries. In Nigeria, for instance, the image of prosperity and success is associated with weight gain[24]. Among other methods of assessing level of obesity, the use of anthropometric indices have proved to be reliable and simple in assessing body fat distribution.[25,26]

In order to prevent CVD in the later life, it is important to examine one of the major risk factor (obesity) especially among undergraduate students. This study was designed to assess the anthropometric parameters among undergraduate students of Obafemi Awolowo University, Ile Ife, Nigeria. The aim of the study was to assess the level of obesity as a risk of developing cardiovascular diseases among these students.

MATERIAL AND METHODS

A cross sectional research design was used to assess 190 undergraduate (100 males and 90 females) students of Obafemi Awolowo University, Ile Ife. They were selected purposefully. Ethical clearance was obtained from Ethic and Research Committee of Obafemi Awolowo University Teaching Hospitals Complex, Ile Ife. The consent of individual participants was obtained for the study. Lange skin fold callipers manufactured by Cambridge Scientific Industries was used to measure **s**kin fold thickness at triceps, abdomen and suprailliac according to Marfell-Jones[27]. Weight was measured with bathroom scale, height was measured with recalibrated wooding height meter, waist, and hip

circumference were measured using a butterfly brand inextensible tape rule.

The following calculation was carried out:

Body fat for male: (0.39287 x sum of three skinfolds) – (0.00105 x (sum of three skin folds)^2 + (0.15772 x Age)[28]

Body fat for female: (0.41563 x sum of three skinfolds) – (0.00112 x (sum of three skin folds)^2 + (0.03661 x Age) + 4.03653, [28]

Waist to Hip ratio: Waist Circumference ÷ Hip Circumference[29]

BMI: Weight/[Height]^2.

Data Analysis

The data collected was analysed using descriptive statistics of mean, standard deviation. Student-t-test was used to compare the level of adiposity between male and female students. Alpha level of 0.05 was set as level of significance and SPSS 16.0 version was used to analyse data. Chi square was used to analyse the association between age and level of adiposity and between gender and level of adiposity.

RESULT

Presented in table 1 are the physical characteristics of the participants. The mean age of participant was 20.96 + 1.77 years. The mean age was 20.96 +1.77 years while the mean value BMI was 21.19 + 3.99 kg/m^2. The mean value for WHR was 0.83 + 0.06 and the average value for percent body fat was 20.80 + 8.09 %.

Presented in table 2 is the Independent –t-test comparing the mean values of anthropometric parameters male and female participants. There was a significant different between the anthropometric parameters of male and female participants in the study.

Shown in table 3 is the chi-square test of association between gender and level of adiposity. The table revealed that there was a significant level of association at $p < .001$ between gender and BMI, WHR and percent body fat. Presented in table 4 is Chi-square test of association between age and level of adiposity. There was significant association between age and level of adiposity using BMI ($p< .001$), WC ($p < .001$) and percent body fat, ($p < .05$).

Table 1: Physical Characteristics of Participants with independent -t- test comparing mean values of male and female (n = 190)

Variables	Male Mean+ SD	Female Mean + SD	Total Mean + SD
Age/years	21.88 +1.61	20.14+1.49	20.96+ 1.77
Height/m	1.63+ 0.07	1.74+ 0.06	1.69+ 0.09
Weight/Kg	61.97+ 7.92	57.34 +8.12	59.53+ 8.34
BMI/Kg/m^2	23.46+ 3.62	19.14+ 3.11	21.19+ 3.99
WC/cm	75.37+4.96	73.34 + 6.04	74.30+ 5.63
HC/cm	87.97+4.83	91.04+ 5.30	89.59+ 5.30
WHR	0.86+3.28	0.81+0.05	0.83+ 0.06
WHtR	46.30+3.28	42.31+3.71	44.20+ 4.04
PBF	13.14+1.90	27.70+4.50	20.80+ 8.09

Key: BMI = Body Mass Index; WC= Waist circumference; HC= Hip circumference; WHR= Waist- to- Hip ratio; WHTR= Waist –to – Height ratio; PBF= Percentage Body Fat

Table 2: Summary of independent -t- test comparing mean values of male and female participants (n = 190)

Variables	Male Mean+ SD	Female Mean + SD	Total Mean + SD	T value	P value
Age/years	21.88 +1.61	20.14+1.49	20.96+ 1.77	7.716	0.001**
Height/m	1.63+ 0.07	1.74+ 0.06	1.69+ 0.09	-10.844	0.001**
Weight/Kg	61.97+ 7.92	57.34 +8.12	59.53+ 8.34	3.966	0.001**
BMI/Kg/m^2	23.46+ 3.62	19.14+ 3.11	21.19+ 3.99	8.840	0.001**
WC/cm	75.37+4.96	73.34 + 6.04	74.30+ 5.63	2.511	0.013*
HC/cm	87.97+4.83	91.04+ 5.30	89.59+ 5.30	-4.154	0.001**
WHR	0.86+3.28	0.81+0.05	0.83+ 0.06	7.031	0.001**
WHtR	46.30+3.28	42.31+3.71	44.20+ 4.04	7.805	0.001**
PBF	13.14+1.90	27.70+4.50	20.80+ 8.09	-28.477	0.001**

*Significant at $p <.05$, ** significant at $p < .001$

Key: BMI = Body Mass Index; WC= Waist circumference; HC= Hip circumference; WHR= Waist- to- Hip ratio; WHTR= Waist –to – Height ratio; PBF= Percentage Body Fat.

Table 3: Chi – square test of association between gender and level of adiposity

Variables	Male (n=100) (%)	Female (n-90) (%)	x^2 value	P value
BMI				
Normal	64 (64.0)	56 (62.2)	46.534	0.001**
Over weight	31 (31.0)	34 (37.8)		
Obese	5 (5.0)	0 (0)		
WHR				
Normal	43 (43.0)	38 (42.2)		
Overweight	57 (57.0)	24 (26.7)	43.817	0.001**
Obese	0 (0)	28 (31.1)		
WC				
Normal	0 (0)	90 (100)	1.900	0.001**
Overweight	100 (100)	0 (0)		
WHtR				
Normal	89 (89.0)	86 (95.5)	4.404	0.036*
Overweight	11 (11.0)	4 (4.4)		
PBF				
Lean	25 (25.00)	40 (44.4)	17.642	0.001**
Acceptable	75 (75.00)	46 (51.1)		
Moderate	0 (0)	4 (4.4)		

*Significant at p<.05, ** Significant at p < .001
Key: BMI = Body Mass Index; WC= Waist circumference; HC= Hip circumference; WHR= Waist- to- Hip ratio; WHTR= Waist –to – Height ratio; PBF= Percentage Body Fat.

Table 4: Chi-square test of association between age and level of adiposity

Variables	<20Years (n=46) (%)	>20 Years (n=144) (%)	x^2 value	P value
BMI				
Normal	5 (10.87)	115 (79.86)	47.545	0.001**
Over weight	41 (89.13)	24 (16.67)		
Obese	0 (0)	5 (3.47)		
WHR				
Normal	21 (45.65)	60 (41.67)	0.273	0.872
Overweight	19 (41.3)	62 (43.06)		
Obese	6 (13.04)	22 (15.28)		
WC				
Normal	38 (82.61)	62 (43.06)	21.87	0.001**
Overweight	8 (17.39)	82 (56.94)		
WHtR				
Normal	46 (100)	129 (89.58)	5.202	0.02*
Overweight	0 (0)	15 (10.42)		
PBF				
Lean	20 (43.48)	35 (24.31)	8.354	0.015
Acceptable	24 (52.17)	107 (74.31)		
Moderate	2 (4.35)	2 (1.39)		

*Significant at p <0.05, **

DISCUSSION

The purpose of this work was to assess the anthropometric parameters of students of university students with a view of screening them for risk of obesity related cardiovascular diseases. The physical characteristics of the participants of this study indicated that the BMI of an average participant of this study was normal as the mean BMI was 23.46 kg /m^2 + 3.62 male and 19.14+ 3.11 kg/m^2 for female. World health organization[30,31], considered BMI of 18.5 – 24.9 kg/m^2 to be normal, 25.0 kg/m^2-29.9kg/m^2 to be overweight and above 30 to be obese for an average male and female. Body Mass Index is a simple index of weight-for-height that is commonly used to classify underweight, overweight and obesity in adults. Body mass index values are age-independent and the same for both sexes and may not correspond to the same degree of fatness in different populations which is partially due to different body proportions. Based on this, the interpretation of BMI grading in relation to health risk may differ for different populations[32]. There was no cut off point of BMI for Nigeria population yet, but in the expert consultation meeting of WHO[33], in Singapore it was agreed that the recommended WHO BMI cut-off points should be retained as the international

classification. Therefore an average student in the study population at the time of this study was not at health risk based on BMI. One hundred percent of male participants were overweight using the waist circumference, but were not at level of obesity. This inferred that waist circumference of male participant of this study may be tending towards the health risk but not at health risk based on the mean waist circumference (75.59 cm) which was below 100cm which would have been indicative of a strong health risk especially for insulin resistance[25,33,34]. Waist circumference assesses fat located at the abdominal region, and studies[35,36,37,38,39] have shown that the fat located at the abdominal region is associated with greater health risk than that in peripheral regions.

Considering waist to hip ratio, 31.1% of female participants in this study were categorised to be at obese an indication that their waist to hip ratio was more than 0.85 for female which is at risk of cardiovascular diseases[40]. More so, according to American Council on Exercise (ACE)[41], the percent body fat of participants of this study was at athletes level for male (13.14 + 1.90) and optimal level for female (27.70 + 4.50) therefore they were not at any risk of cardiovascular diseases based on percent body fat. The reason for the level of adiposity found in the participants could be deduced to the period when the study was conducted. The finding of this study was similar to the findings of Ai-Kilani et al [42] where they conducted a cross-sectional study of 202 Omani students (101 males and 101 females) from Sultan Qaboos University in Oman. Participants were classified according to BMI and total body fat. The result revealed that 2.48% were underweight, 69.31% were normal weight, 26.73% were overweight and 1.49% was obese. According to total body fat, 32.67% of students had low body fat scores, 26.73% high and 22.28% very high body fat score. A different result might be obtained in our own study if the study was conducted at the beginning of first semester. In addition the study does not assess the socioeconomic status of the students which is a strong factor, for the feeding may be an additional factor for the level of adiposity.

The significant association between level of adiposity in all measurements and age in this study could be deduced to the finding of Van Harmelen et al[42] that BMI correlated positively to age, mature fat cell size and total number of adipocytes and stromal cells per body. They concluded in their study that there seems to be a constant ratio between the number of adipose tissue stromal cells and adipocytes independently of BMI and age in humans. During adipose tissue expansion, there seems to be both a continuous increase in fat cell size, and in stromal cell and adipocyte number, but the increase in fat cell size apparently precedes the increase in fat cell number. As the average age of individuals within a society increase, the rate of obesity also increases. In addition Brook et al[44] and Heywood [45] documented a different percent body fat for different age group, an indication that percent body fat differ in different age group. These were in support of the findings of this study. There was a significant association between the values of percent body fat and gender in this study. The percentage body fat for women has been documented to be greater than that of men, due to the demands of childbearing and other hormonal functions. Studies have shown that there are tremendous amount of variation in the body fat of different groups of people. In athletes, the percent body fat can range from 5 to 20% in males and from 10 to 20% in females[46]. American Council on Exercise[41] and WHO[47] also recommended separate values of percent body fat for male and female athletes. Wilmore and Costill [48] reported that as fat is added to the body, existing fat cells in the body continue to fill with fat to a certain critical volume. Once these cells are filled to this point, new fat cells are formed. When girls reach puberty, which is applicable in this study, their estrogen levels increases which promotes the deposition of body fat, therefore, a female at puberty have a greater tendency to have increase body adiposity than her male counterpart. This may be responsible for the significant association between gender and body adiposity found in this study.

CONCLUSION

It could be concluded from this study that an average university students at the time of this study may not at risk of obesity related chronic disease. Body mass index of male participants were significantly more than that of female but percent body fat of female were significantly higher than that of male. Age and sex were individually associated with level of adiposity.

REFERENCES

1. WHO 2002. The world health report- reducing risks, promoting healthy lifestyles. Geneva;
2. Mendis, S.; Puska, P.; Norrving, B.(editors) (2011), *Global Atlas of cardiovascular disease prevention and control*, ISBN 978-92-4-156437-3
3. Kadiri S. Tackling cardiovascular diseases in Africa. British Medical Journal, 2005. 331; 711-712. doi; 10: 11361/bmj .7519.711.
4. Opie LH, Mayosi BM. Cardiovascular disease in sub-Saharan Africa. Circulation 2005;112:3536–40. PubMed
5. Adedoyin R. A., and Adesoye AT. Incidence and pattern of cardiovascular disease in a Nigerian hospital. Tropical Doctor 2005; 35: 104-106
6. Mukadas AO, Misbau U. Incidence and patterns of cardiovascular disease in north western Nigeria. Niger Med J 2009;50:55-7
7. McGill HC, McMahan CA, Gidding SS . "Preventing heart disease in the 21st century: implications of the Pathobiological Determinants of Atherosclerosis in Youth (PDAY) study". *Circulation* 2008, **117** (9): 1216–27.
8. U.S. Department of Health and Human Services. The Surgeon General's call to action to prevent and decrease overweight

and obesity. Rockville (MD): U.S. Department of Health and Human Services, Public Health Service, Office of the Surgeon General; 2001. Available from: http://www.surgeongeneral.gov/topics/obesity

9. Overweight and obesity [Internet] Atlanta (GA): Centers for Disease Control and Prevention; [cited 2006 Oct 16]. Available from: http://www.cdc.gov/nccdphp/dnpa/obesity
10. Reddy, K. Srinath, and Yusuf, Salim. Emerging epidemic of cardiovascular disease in developing countries. *Circulation.* 1998; 97: 596-601.
11. Eisenmann JC, Wickel EE, Welk GJ, Blair SN. Relationship between adolescent fitness and fatness and cardiovascular disease risk factors in adulthood: The Aerobics Center Longitudinal Study (ACLS) Am Heart J. 2005;149:46–53.
12. Jürimäe T, Jürimäe J. Anthropometric and health-related fitness characteristics in middle-aged obese women. Coll Antropol. 1998;22:97–106
13. WHO. www. WHO | Cardiovascular death and disability can be reduced more . 2010
14. Sankaran Sujatha and Shetty Rahul. Cardiovascular disease in developing world. www cardiovascular diseases.com, 2010
15. Lopez A, Mathers C, Ezzati M, Jamison D, Murray C. Global and regional burden of disease and risk factors, systematic analysis of population health data. Lancet. 2001;360:1747–57.
16. Mokdad AH, Ford ES, Bowman BA, Dietz WH, Vinicor F, Bales VS, Marks JS. Prevalence of obesity, diabetes, and obesity-related health risk factors. JAMA. 2003;289:76–9.
17. Rodgers Ellie. Calculating waist circumference. http: // www health. yahoo. com/ ency/ healthwise/ aa128700. 2005
18. Reuters Health. Thick waist predicts blood pressure risk study. http://www.Waist circumference. 2005
19. George A. and Bray M.D. Evaluation of Obesity. Postgraduate Medicine. 2003. On line. 14. 6. 1-12.
20. World Health Organization, Controlling the global obesity epidemic. Geneva: World Health Organization; 2003.
21. Serdula MK, Ivery D, Coates RJ, Freedman DS, Williamson DF, Byers T. Do obese children become obese adults? A review of the literature. Prev Med 1993; 22:167-77.
22. Freedman, DS, Secular increases in relative weight and adiposity among adolescents over two decades. The Bogalusa Heart study Pediatrics; 1997. 99: 420-426.
23. De Onis, M, Blossner, M (2000): Prevalence and trends of overweight among adolescents in developing countries. Am j clin Nutri; 72: 1032-1039.
24. Ojofeitimi EO, Adeyeye AO, Fadiora AO, Kuteyi AO, Faborode TG, Adegbenro CA, Bakare OE, Setiloane K, Towobola KS: Awareness of obesity and its health hazard among women in a university community. Pakistan Journal of Nutrition, 2007, 6(5):502-505.
25. Aronne, LJ. Classification of Obesity and Assessment of Obesity-Related Health Risks. Obesity Res 2002. 10:105-115.
26. Wahrenberg H, Hertel K. Use of waist circumference to predict insulin resistance: retrospective study. BMJ. 2005; 11: 330:1363-1364
27. Marfell-Jones M. Tim Olds, Arthur Stewart and Lindsay Carter. Skinfolds measurements and Girth circumference, in International Standard for Anthropometric Assessment. International Society for the Advancement of Kinanthropometry (ISAK) publication 2006. South Africa. Pg 67&80.
28. Jackson A.S, and Pollock M.L. Practical assessment of body composition. Physician and Medicine 1985. 12(5) : 76- 90.
29. Bray G.A and Gray DS;. Obesity Part I: Pathogenesis: Breadth as a frame size standard on nutritional assessment. Western Medical Journal 1988, 149.429 – 441.
30. WHO. Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee. WHO Technical Report Series 854. Geneva: World Health Organization, 1995.
31. WHO. Obesity: preventing and managing the global epidemic. Report of a WHO Consultation. WHO Technical Report Series 894. Geneva: World Health Organization, 2000.
32. WHO expert consultation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. The Lancet, 2004; 157-163
33. Shankuan Z. and Steven B. Race-ethnicity-specific waist circumference cut-offs for identifying cardiovascular disease risk factors. Am J Clin Nutr. 2005 81:409-415
34. Klein Samuel, David B. Allison, Steven B. Heymsfield, David E. Kelley, Rudolph L. Leibel, Cathy Nonas, Richard Kahn, Waist circumference and cardiometabolic risk. a consensus statement from shaping America's health: *Diabetes Care* 2007. June vol. 30 no. 6 1647-1652
35. Barclay (2002): Childhood Physical Fitness May BE Linked With Less Obesity, Hypertension in Early Adulthood. 99: 420-426.
36. Björntorp P. Obesity and adipose tissue distribution as risk factors for the development of disease. A review. Infusionstherapie. 1990;17(1):24–7.
37. Seidell J, Björntorp P, Sjöström L, Kvist H, Sannerstedt R. Visceral fat accumulation in men is positively associated with insulin, glucose, and C-peptide levels, but negatively with testosterone levels. Metabolism. 1990;39 (9):897–901.
38. Wang Y, Rimm EB, Stampfer MJ, Willett WC, Hu FB. Comparison of abdominal adiposity and overall obesity in predicting risk of type 2 diabetes among men. Am J Clin Nutr. 2005;81(3):555–63.
39. Janssen I, Katzmarzyk PT, Ross R, Leon AS, Skinner JS, Rao DC, Wilmore JH, Rankinen T, Bouchard C. Fitness alters the associations of BMI and waist circumference with total and abdominal fat. Obes Res. 2004;12(3):525–37.
40. Bray G.A and Gray DS;. Obesity Part I: Pathogenesis: Breadth as a frame size standard on nutritional assessment Western Medical Journal 1988, 149.429 – 441.
41. ACE. American Council on Exercise. **2007** http://www.scientificpsychic.com/fitness/diet.html
42. Al-Kilani H, Waly M, Yousef R. Trends of Obesity and Overweight among College Students in Oman: A cross sectional study. Sultan Qaboos Univ Med J. 2012 Feb;12(1):69-76.
43. Van Harmelen V, Skurk T, Röhrig K, Lee YM, Halbleib M, Aprath-Husmann I, Hauner H (2003). Effect of BMI and age on adipose tissue cellularity and differentiation capacity in women. Int J Obes Relat Metab Disord. 2003 Aug; 27(8):889-95.
44. Brooks G.A., Fahey T.D. White T.P. and Baldwin K.M; Obesity, body composition and exercise. Exercise physiology. Human bioenergetics and its application, 2000. 3rd Edition. Library of Congress cataloguing – in – publication data. New York. USA. 578-579.
45. Heywood V.H., Evaluation of body composition . Sports Med. 1996, 22. 146 – 156.
46. BFC. Body Fat Calculator 2010. www. Body fat calculator. com. Download June 2010.
47. WHO. Obesity: Preventing and managing the global epidemics In report of a WHO consultation in obesity ,1998. (Geneva: WHO).
48. Wilmore J.H and Costil D.C. Body composition, In Physiology of Sport and Exercise 2004. Human kinetic publisher campaign. 3rd Edition pp.517 - 537