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ASSOCIATION OF SELECTED ANTHROPOMETRIC AND BODY COMPOSITION MEASURES WITH DIET AND LIFE STYLE RELATED FACTORS AMONG PUNJABI ADULT MALES OF INDIA

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ABSTRACT

Occupational level greatly influences the physical activity which, in turn, significantly affects body composition and overall health. Ninety adult male participants in age group of 40-50 years from three occupational categories i.e. field workers, laboratory workers and office workers were selected from PAU, Ludhiana (India). The study revealed that higher income and education were positively and significantly ($p \leq 0.01$) correlated with body weight (r = 0.53; 0.48), BMI (r = 0.4; 70.44), waist circumference (r = 0.65; 0.58) and fat mass (r = 0.37; 0.34), respectively. Of the various activities carried out by participants, cycling and agricultural activities showed a significant but negative relation with body weight (r = -0.41, -0.86), BMI (r = -0.25, -0.38), waist circumference (r = -0.62; -0.37) and fat mass (r = -0.39; -0.27) while positively significant relationship was found with fat free mass (r = 0.31, 0.20). Body fat accumulation was positively and significantly correlated with body weight, BMI, waist circumference and fat mass, however, it was proteins which had significant enhancing effect on fat free mass (r = 0.29). Therefore, it may be concluded that physical activity is a leading factor that influences the anthropometry and body composition.

Key words: Anthropometry body composition, field workers, laboratory workers, office workers

INTRODUCTION

Obesity and four leading causes of death i.e. heart disease, cancer, stroke and type 2 diabetes mellitus are related to lifestyle. Because of drastic changes in lifestyle from an active one to sedentary lifestyle, even young population is fast turning into patients. Sedentary lifestyle and smoking were predisposing risk factors for heart attack (Kishor and Sehgal, 1996). The combination of healthy weight, prudent diet and daily physical activity plays a vital role in primary, secondary and tertiary prevention of other chronic diseases. The recent worldwide increase in prevalence of obesity complicates the relation between weight change, muscle mass and decrease in strength with age. In aging men and women, the percentage of fat mass increases and such change is attributed to accelerated decrease in lean mass. Multivariate analysis suggests that the association between lean mass and fat mass is attributed to hereditary, dietary factors and physical activity levels (Visser *et al.,* 2002). The importance of measuring body composition has increased due to the need to evaluate changes in nutritional status which can affect body reserves differentially. One can gain fat, fat free mass or cellular mass components as a result of overeating and sedentary lifestyle.

These changes can be detected only by using valid body composition techniques. One of the important aspects of individual's health is his/her nutritional status which is defined as the interaction of body composition, energy balance and body functionality. Body composition assessment in terms of lean body mass and fat mass is the best long term indicator of nutritional status (Kaur, 2011).

Occupational level greatly influences the physical activity which, in turn, has significant effect on body composition. Adult males engaged in varied occupations may have different body compositions. Their body composition and anthropometry might be strongly influenced by their diet pattern and activity level. The high prevalence of life style diseases is a serious threat to health and well being of Punjabi community, especially the men. In view of above, the study was aimed to determine the association of anthropometry and body composition of men engaged in varied occupations with their lifestyle, diet and physical activity so as to make healthy life style guidelines to achieve appropriate body composition.

MATERIALS AND METHODS

The three occupational categories namely field workers (doing field jobs like preparation of field, weeding, hoeing, etc.), laboratory workers (doing activities mainly involving standing and sitting) and office workers(mainly performing office work which involved sitting most of the time) were chosen and the selection was based on the level of physical activity of workers. Thirty adult males in age group of 40-50 years from each category were selected from various Departments of PAU, Ludhiana (India) in the year 2014. The age group of 40-50 yr was selected as at this age a person is more prone to develop metabolic disorders. The socio-economic and health status of subject was assessed through a questionnaire. The health status included the information related to common prevailing diseases like diabetes, blood pressure, heart diseases, kidney disorders and digestive disorders. Anthropometric measurements like height, weight, waist and hip circumferences were measured using standard methods (Jelliffe, 1966). Body mass index (BMI) and weight and hip ratio were calculated. The body composition parameters *viz.,* fat mass, muscle mass, fat free mass, total body water and bone mass were determined using bioelectrical impedance method using TANITA Body Composition Analyzer BC-420MA. The information regarding physical activity and dietary pattern was also collected as both these parameters affect anthropometric profile and body composition of an individual. The daily food intake for 3 days including a holiday was assessed by 24 hr recall method. The daily intake of energy, carbohydrates, protein and fat was assessed by MSU Nutri-guide computer program (Song *et al*., 1992). Basal metabolic rate (BMR) and total daily energy expenditure (TDEE) were assessed and physical activity level (PAL) calculated. The lifestyle of subjects was determined on the basis of PAL values. FAO/WHO/UNU (2004) classification was used to categorize the subjects of different age groups. Mean and standard errors for various parameters were computed. Analysis of variance was employed using Microsoft Excel (2003) Statistical Analysis Tool Pack. Coefficients of correlation were derived to determine the relationship of anthropometry and body composition with socio-economic factors, disease incidence, substance use, diet and physical activity in men involved in different occupations.

RESULTS AND DISCUSSION

The average age of participants in the three groups (field-, lab- and office-workers) was 46.0, 45.4 and 45.1 years, respectively. Monthly income and per capita income of office workers was significantly ($p \leq 0.05$) higher than field and lab workers (Table 1). Seven and ten percent laboratory

Table: 1 Information regarding socio-economic status, health status and substance use of the participants

Parameters	Field workers (n = 30)	Lab workers (n = 30)	Office workers (n = 30)	Overall (n = 90)
	Number (values in bracket are show percentage)			
Education level				
Illiterate	9 (30)	0	0	9 (10)
Middle	18 (60)	3 (10)	3 (10)	24 (27)
Matric	2 (7)	20 (67)	4 (13)	26 (29)
Intermediate	1 (3)	4 (13)	6 (20)	11 (12)
Graduate	0	3 (10)	15 (50)	18 (20)
Post-graduate	0	0	2 (7)	2 (2)
Income sources other than regular job (%)				
Agriculture	0	2 (7)	1 (3)	3 (3)
Animal husbandry	0	5 (17)	2 (7)	7 (7)
Others	0	1 (3)	0	1 (1)
Incidence of disease				
Diabetes	1 (3)	2 (7)	3 (10)	6 (7)
Blood pressure	0	3 (10)	4 (13)	7 (8)
Heart diseases	0	1 (3)	1 (3)	2 (2)
Kidney disorders	0	1 (3)	2 (7)	3 (3)
Digestive disorders	0	6 (20)	4 (13)	10 (11)
Substance use				
Smoking	6 (20)	1 (3)	0	7 (8)
Alcohol	13 (43)	13 (43)	8 (23)	34 (38)
Tobacco	9 (30)	0	0	9 (8)
Any other*	7 (27)	0	0	7 (8)
	Mean ± S.D			
Age (years)	46.0 ± 3.4	45.4±3.5	45.1 ±2.9	45.5 ± 3.28
Family size (No.)	5.0 ± 1.3	4.8±1.9	4.6 ±0.7	4.85 ± 1.48
Time spent on regular job (hr day^{-1})	8 ± 0	8±0	8 ± 0	8 ± 0
Time spent on job other than regular job (hr day^{-1})	0 ± 0	2±0	2 ± 0	2 ± 0
Family income (₹ month^{-1})	9,533 ± 6,888	24,033 ± 23,967	29,566 ± 8,269	21,000 ± 11307
Per capita income (₹ month^{-1})	2,066± 1,594	5,726 ± 5,700	6,767 ± 2,450	4,831 ± 3228

Values in parenthesis are percentages; *Opium, weeds, etc.

and office workers were suffering from diabetes; and 10 and 13% had hypertension. Substance use namely alcohol, smoking, tobacco and opium, weeds, etc. was high in field workers. Alcohol was consumed high amongst all all intoxicants. The alcohol consumption was 43% each in field and lab workers and only 23% in office workers. The average BMI of field workers was 21.3 while lab and field workers had higher BMI of 25.3 and 27.6 kg m^{-2}, respectively (Table 2). About 17% field workers were underweight. Overweight prevalence was high in office workers (80%) followed by lab workers (53%). The fat mass was high in office workers (25.8%) followed by lab workers (22.6%) with least value in field workers (18.2%). The fat mass index of field workers was lesser (4.0) than lab (5.8) or office (7.4) workers in comparison to the reference value of 4.8 which revealed that less physical activity contributed to higher fat mass. The fat free mass (FFM) was high in field workers (81.2%) followed by lab workers (78.1%) and office workers (73.7%). Higher physical activity by field workers contributed to lesser fat mass and more fat free mass which is considered desirable for optimum health. Schutz *et al.* (2002) reported that Caucasian men in age group of 35-55 yr had fat mass of 15.2 kg and FFM of 59.9 kg. Miglani *et al.* (2014) reported a total fat mass of 24.9% in office workers which was closer to the values of FM observed in the present study. A total

Table 2: Anthropometric measurements and body composition parameters of the participants

Parameters	Field workers (n = 30)	Lab workers (n = 30)	Office workers (n = 30)	Overall (n = 90)	$CD_{0.05}$	Normal values
Basic						
Height (cm)	164.2 ± 6.8	165.8 ±7.6	171.8 ± 5.3	167.3 ± 7.4	3.96	-
Weight (kg)	57.5 ± 9.5	69.8 ± 13.6	81.8 ± 10.2	69.7 ± 15.0	6.7	62[a]
Waist circumference (cm)	76.0 ± 3.9	88.4 ± 9.2	94.0 ± 7.0	88.8 ± 13.0	4.2	102[a]
Hip circumference (cm)	80.2 ± 6.4	91.6 ± 11.9	100.0 ± 7.2	99.1 ± 21.3	5.3	-
Derived						
Body mass index (kg m^{-2})	21.29 ± 3.18	25.31 ± 4.03	27.63 ±2.52	24.74±4.19	1.41	20-25[b]
Waist hip ratio	1.05 ± 0.05	1.03 ± 1.29	1.06 ± 0.02	1.05 ± 0.05	0.03	<1.02[c]
Body composition parameters						
Fat mass (kg)	10.9 ± 5.1	16.1 ± 7.2	21.8 ±6.5	16.3 ±7.7	3.8	-
Fat mass (%)	18.2 ± 6.2	22.6 ± 6.5	25.8 ±5.5	22.2 ±6.8	3.6	< 27[d]
Fat mass index	4.01 ± 3.18	5.8± 2.4	7.4± 2.1	5.7 ± 2.5	0.22	4.8[d]
Fat free mass (kg)	46.1 ± 5.2	53.9± 7.7	59.8 ±5.5	53.3 ± 8.4	3.7	-
Fat free mass (%)	81.2 ± 6.71	78.1 ± 6.5	73.7 ±5.6	77.7 ± 6.9	3.74	<73[d]
Muscle mass (kg)	43.9 ± 4.8	51.2 ± 7.3	56.9 ±5.3	50.7 ± 8.0	3.5	-
Muscle mass (%)	77.2 ± 6.19	74.2 ± 6.14	70± 5.3	73.8 ± 6.5	3.52	-
Total body water (kg)	33.5 ± 3.3	38.4 ± 5.0	42.5 ± 3.3	38.2 ± 5.4	2.4	-
Total body water (%)	59.3 ± 5.16	55.6 ± 4.2	52.2 ±3.3	55.7 ± 5.1	2.5	-
Bone mass (kg)	2.41 ± 0.23	2.7 ± 0.34	2.9 ± 0.25	2.7 ± 0.4	0.17	-

Values are mean±SD; [a]NCEP (2004); [b]WHO (2004); [c]Ghafoorunissa and Krishnaswamy(2000); [d]Schutz *et al.* (2002)

FFM of 56.9% was observed in office workers which was lower than the values of FFM observed in present study.

The effect of high-soy-protein diet on weight loss without losing muscle mass in pre-obese and obese subjects was assessed. The changes in weight, body composition, metabolic and hormonal parameters were determined using different intervention protocols. The 3 interventions comprising of the lifestyle education or a substitutional diet containing a high-soy-protein low-fat-diet with or without a guided physical activity program were designed. A total of 83 subjects completed a six month study. The study revealed that high-soy-protein and low-fat diet improves body composition in overweight and obese people, losing fat but preserving muscle mass (Deibert, 2004). In present study the diet profile of participants was also assessed. The cereal intake was adequate in all the groups, the percent adequacy being 163.7, 134.0 and 115.2%, respectively, in comparison to the suggested values of 225 g. Batra (2014) reported the cereal intake of 395 and 434 g in low and middle income group men. Consumption of pulses in all groups was lesser than the suggested intake of 60 g, the percent adequacy being 50.5, 43.3 and 39.5%, respectively. There was an inadequate consumption of green leafy vegetables in all the 3 groups studied. The lower intake of green leafy vegetables was attributed to lesser availability of greens during summer season when the survey was carried out. There was a significant difference in the consumption of roots and tubers among the three groups. The consumption of root and tubers was more than adequate in all the groups. The consumption of other vegetables was much lower than the suggested intake of 200 g, the adequacy being 45, 21.8 and 47.5%, respectively. Further, the fruit consumption was inadequate in the participants as compared to the suggested intake of 100 g. The daily consumption of milk and milk products was adequate in all the groups, the adequacy being 126.7, 147.0 and 163.6%, respectively. The daily intake of fats and oils by field workers was adequate (100.3%) as against the suggested intake of 20 g. More intake of fats and oils was in both lab and field workers, the adequacy being 116.0 and 132.5%, respectively. More than adequate consumption of fats and oils by Punjabi men has also been reported by Batra (2014) and Miglani *et al.* (2014). Sugar consumption was significantly low in field workers than in office workers.

Table 3: Nutrient intake, total daily energy expenditure, basal metabolic rate and physical activity level in the participants

Parameters	Field workers (n = 30)	Lab workers (n = 30)	Office workers (n = 30)	Overall (n = 90)	$CD_{0.05}$
Energy (k cal)					
Range	1195 – 2232	1205 - 2295	1331 - 3399	1195 - 3399	ns
Mean ±SD	1803 ± 271	1835 ± 266	1889 ± 367	1842 ± 303	
Carbohydrates (g)					
Range	203 – 310	192 - 332	215 - 625	192 - 625	ns
Mean ±SD	258.3 ± 27.6	258.6 ± 35.79	280.6 ± 78.5	265.8 ± 52.8	
Protein (g)					
Range	31 – 81	28 - 69	37 - 74	28 - 74	ns
Mean ±SD	48.2 ± 10.8	48.5 ± 9.9	51.9 ± 9.5	49.7 ± 10.2	
Fat (g)					
Range	19 – 60	18 - 97	30 - 130	18 - 130	6.4
Mean ±SD	35.4 ± 10.7	53.3 ± 18.3	55.0 ± 14.7	47.9 ± 17.2	
Total daily energy expenditure (k cal)					
Range	1991 – 2679	1840 - 2855	1826 - 4126	1826 - 4126	ns
Mean ±SD	2352 ± 183	2287 ± 250.3	2356 ± 408	2330 ± 294	
Basal metabolic rate (k cal)					
Range	1134 – 1676	1212 - 2033	1338 - 2033	1134 - 2033	86.38
Mean ±SD	1366 ± 153	1571 ± 229	1776 ± 170	1571 ± 250	
Physical activity level (PAL)					
Range	1.35 - 2.22	1.38 - 1.46	1.38 - 1.57	1.35 - 2.22	0.08
Mean ±SD	1.73 ± 0.21	1.43 ± 0.01	1.43 ± 0.03	1.53 ±0.18	

ns: non-significant

Diets were inadequate for energy and protein but adequate for fat in all the three categories. No significant change in energy, protein and carbohydrates was observed in all the groups of workers; however, daily fat intake was least in field workers (35.4 g) and higher in lab workers (53.3 g) and office workers (55.0 g). Significantly less fat were consumed by field workers. The contribution of fats to total energy was higher i.e. >20% in case of lab workers and office workers which was undesirable as it may lead to obesity and other degenerative disorders (Table 3).

Total daily energy expenditure (TDEE) of field, lab and office workers was 2352, 2287 and 2356 k cal, respectively. No significant difference in TDEE was observed within the groups. The basal metabolic rate (BMR) calculated on the basis of body weight of field workers was least (1336 k cal) followed by lab workers (1571 k cal) and office workers (1776 k cal). The differences in BMR within groups were significant. The body composition represents an unbreakable unity of human body, basic structure elements and involves relative representation of various constituent elements of human total body weight. It is well known that the body composition changes under the influence of continuous physical activity and is, therefore, one of the major components of fitness and general health (Mazic *et al.*, 2014).

The physical activity level (PAL) was highest (1.73) in field workers. The average value of PAL for field workers revealed them in category of moderate workers (1.70 to 1.99). The mean PAL value of lab and office workers was 1.43 each, both the groups fall in the category of sedentary workers having PAL values in the range of 1.40-1.69 as prescribed by FAO/WHO/ UNU (2004). Field workers were engaged in strenuous physical activity in their occupation, hence expectedly had higher PAL than other groups. Milgani *et al.* (2014) observed high PAL (1.51) in office workers. Du *et al.* (2013) reported that physical activity was 1/3rd lower in professionals than in factory workers. Field workers had maximum physical activity in the form of agricultural work as a part of their occupation and bicycling for an average 107.5 min day^{-1}. Forty six and 33% of office and lab workers were engaged in walk and spent 47.5 and 40.3 min. in walking daily. TV viewing was a leisure time activity carried out by all the lab and office workers for an average of 95 and 72 min. day^{-1} and none of the field workers reported regular television viewing.

The correlation coefficients (r) were derived to find the relation of anthropometry and body composition with socio-economic factors, disease incidence, substance use, diet and physical activity in men involved in different occupations (Table 4). No significant effect of age, family size and family type was found on anthropometry composition. However, income and education were positively and significantly correlated with body weight, BMI, waist circumference and fat mass, thus indicating that as the income increases the level of obesity related parameters also rise. Education showed positive relation with obesity because education was higher in high income groups. The reported incidence of diseases namely diabetes, hypertension, heart disease, kidney diseases and digestive system disorders was insignificantly related to anthropometry and body composition in the studied groups. Batra (2014) found a positive and a significant correlation of cardiovascular diseases with BMI and waist circumference. The participants were frequent consumers of intoxicants like alcohol, smoking, tobacco, opium, weeds, etc. Surprisingly, none of the intoxicant affected waist circumference, fat mass or fat free mass. Alcohol showed a positive and significant correlation with only body weight and BMI. Coulson *et al.* (2013) reported higher alcohol intake was associated with greater total and central obesity. Alcohol is a source of empty calories and can turn into fat, adding weight to the body (Ghafoornissa and Krishnaswamy, 2000).

BMI, waist circumference and fat mass were negatively correlated with fat free mass. Similarly, higher consumption of fat/oils and sugar were highly correlated ($p \leq 0.01$) with body weight, BMI, waist circumference and total body fat but negatively correlated ($p \leq 0.05$) with fat free mass. Other foods such as vegetables, fruits and milk and milk products showed no relationship with anthropometry and body composition. Carbohydrates, protein and fats, all the three showed a positively significant ($p \leq 0.01$, 0.05, 0.10) correlation with body weight, BMI, waist circumference and fat mass; however, proteins had a significantly ($p \leq 0.01$) enhancing effect on fat free mass. The consumption of cereals and pulses was positively correlated with body weight.

The PAL showed highly significant negative correlation with body weight (r = -0.63), BMI (r= -0.59), waist circumference (r= -0.57) and fat mass (r= -0.47) but significant positive relationship with fat free mass (r = 0.45). The results indicated that active life style helps to prevent obesity and improve fat free mass. According to Takata *et al.* (2014) BMI was negatively correlated with moderate intensity exercise whereas body fat was negatively correlated with TDEE and PAL in Japanese adult males. Out of the various activities carried out by participants, cycling and agricultural activities showed a significant but negative correlation with body weight, BMI, waist circumference and fat mass; while significant but positive correlation was found with fat free mass.

On the other hand, animal care activities exhibited significant correlation with waist circumference (r = -0.37) and fat mass (r = -0.27). However, animal care activities depicted significant negative correlation with fat free mass. Further, bicycling, agricultural and animal care activities reduced body fats but increased

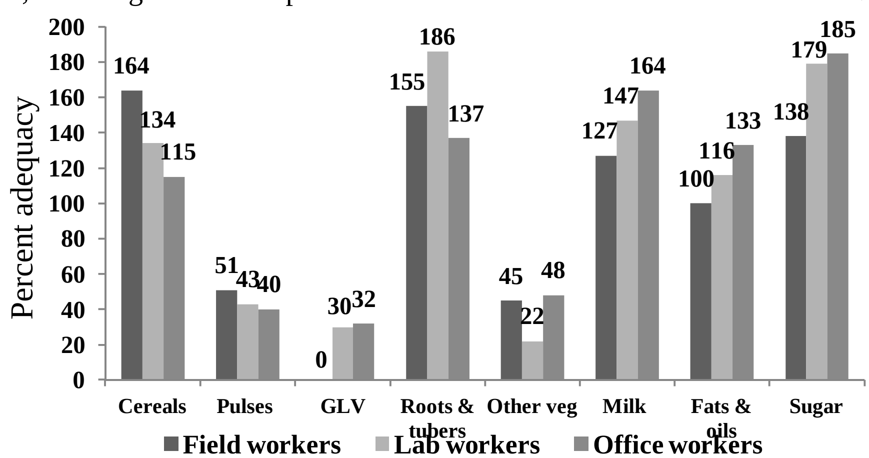

Fig. 1: Percent adequacy of food groups among the participants

Table 4: Relationship of socio-economic factors, disease incidence, substance use, diet and physical activity with anthropometry and body composition

Parameters	Correlation coefficients (r)				
	Body weight	BMI	Waist circumference	Fat mass	Fat free mass
Socio-economic factors					
Education	0.48***	0.44***	0.58***	0.34***	-0.30***
Income	0.53***	0.47***	0.65***	0.37***	-0.28***
Disease incidence	ns	ns	ns	ns	ns
Substance use					
Alcohol	0.28***	0.20**	ns	ns	ns
Smoking	ns	ns	ns	ns	ns
Tobacco etc.	ns	ns	ns	ns	ns
Foods					
Cereals	0.67***	0.61***	0.69***	0.50***	-049***
Pulses	0.35***	0.31***	0.44***	0.38***	-0.38***
Fats and oils	0.55***	0.55****	0.50***	0.44***	-0.45***
Sugar	0.28***	0.30***	0.39***	0.21**	-0.29***
Other foods	ns	ns	ns	ns	ns
Nutrients					
Carbohydrates	0.22**	0.23**	0.18*	0.23**	ns
Protein	0.25**	0.20*	0.18*	0.27***	0.29***
Fat	0.24**	0.19*	0.23**	0.28***	ns
Physical activity					
Walking	ns	ns	ns	ns	ns
Bicycling	-0.41***	-0.25***	-0.39***	-0.40***	0.31***
Agricultural activities	-0.86***	-0.38***	-0.62***	-0.39***	0.20*
Animal care activities	ns	ns	-0.37***	-0.27***	0.28***
PAL	-0.63***	-0.59***	-0.57***	-0.47***	0.45***

N = 90; ns: = non-significant; *Significant at 10%; **Significant at 5%; ***Significant at 1% probability level

fat free mass. Gudmundsdottir *et al.* (2004) reported that obesity risk is halved among in persons who exercised at least 5 days per week than those who exercised less frequently.

The derived correlation coefficients revealed that in adult males occupation and physical activities were leading factors influencing the anthropometry and body composition. Higher education and more income were positively correlated with body fat accumulation. Of the various activities, bicycling and agricultural activities were related to less body weight, body mass index, waist circumference, fat mass and higher fat free mass. Excessive food consumption, especially cereals, pulses, sugar, fats and oils, resulted in total body fat gain and fat accumulation in waist area which exposes individuals to increased risk of degenerative diseases. Body fat accumulation was found related to higher intake of carbohydrates, protein and fats; however proteins boosted fat free mass gain. Hence, it is recommended that awareness of adequate physical activities and optimum nutrition needs to be promoted through various educational programmes, so that people strive to achieve optimum body composition and body weight to prevent chronic degenerative diseases.

REFERENCES

Batra, A. 2014. *Dietary Fat Intake and Risk of Cardiovascular Diseases in Young Adult Males.* M.Sc. thesis, Punjab Agricultural University, Ludhiana, India.

Coulson, C.E., Williams, L.J., Brennan, S.L., Berk, M., Kotowicz, M.A., Lubman, D.I. and Pasco, J.A. 2013. Alcohol consumption and body composition in a population-based sample of elderly Australian men. *Aging Clinical and Experimental Research,* **25**: 183-192.

Deibert, P., König, D., Schmidt, T.A., Zaenker, K.S., Frey, I., Landmann, U. and Berg, A. 2004. Weight loss without losing muscle mass in pre-obese and obese subjects induced by a high-soy-protein diet. *International Journal of Obesity and Metabolic Disorders,* **28:** 1349-1352.

Du, H. Bennett, D., Li, L., Whitlock, G., Guo, Y., Collins, R., Chen, J., Bian, Z., Hong, L.S., Feng, S., Chen, X., Chen, L., Zhou, R., Mao, E., Peto, R. and Chen, Z. 2013. Physical activity and sedentary leisure time and their associations with BMI, waist circumference and percentage body fat in 0.5 million adults: The China Kadoorie Biobank study. *American Journal of Clinical Nutrition,* **97**: 487-496.

FAO/WHO/UNU. 2004. Energy costs of activities. pp. 92-96. **In**: *Human Energy Requirements: Report of a Joint FAO/WHO/UNU Expert Consultation*. FAO Food and Nutrition Technical Report Series No. 1, FAO, Rome, Italy.

Ghafoorunissa and Krishnaswamy, K. 2000. *Diet and Heart Disease*. National Institutes of Health, Hyderabad, India.

Gudmundsdottir, S.L., Oskarsdottir, D., Franzson, L., Indridason, O.S. and Sigurosson, G. 2004. The relationship between physical activity, body mass index, body composition and grip strength in an Icelandic population. *Laeknabladid,* **90**: 479-486.

Jelliffe, D.B. 1966. *The Assessment of Nutritional Status of the Community*. Monograph series No 53. WHO, Geneva, Switzerland.

Kaur, G. 2011. *Relationship of Lean Body Mass with Dietary Factors and Physical Activity Level of Women*. M.Sc. Thesis, Punjab Agricultural University, Ludhiana, India.

Kishore, M. and Seghal, S. 1996. Dietary habits and nutritional status of heart patients and related risk factors (abstract). **In**: *24th Annual National Conference of Indian Dietetic Association*, Ludhiana, Punjab, India.

Mazic, S., Lazovic, B., Delic, M., Lazic, J.S., Acimovic, T. and Brkic, P. 2014. Body composition assessment in athletes: A systematic review. *Medicinski Pregled,* **67**: 255-260.

Miglani, N., Bains, K. and Singh, P. 2014. Diet and physical activity in relation to metabolic syndrome among urban Indian men and women. *Ecology of Food and Nutrition,* **54**: 43-56.

NCEP. 2004. *Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) Update.* NIH Publication No. 02-5215, National Heart, Lung and Blood Institute. National Institutes of Health, Hyderabad, India.

Schutz, Y., Kyle, U.G. and Pichard, C. 2002. Fat Free mass index and fat mass index percentiles in Caucasians aged 18-98 y. *International Journal of Obesity,* **26**: 953-960.

Song, W.O., Mann, S.K., Sehgal, S., Devi, P.R., Guradu, S. and Kaharala, M. 1992. *Nutriguide, Asian Indian Foods.* Nutritional Analysis Computer Programme, Michigan State University, Michigan, USA.

Takata, I.K., Park, J., Tanaka, S., Hikihara, Y., Ohkawara, K., Watanabe, S., Miyachi, M., Morita, A., Aiba, N. and Tabata, I. 2014. The relationship of body composition to daily physical activity in free-living Japanese adult men. *British Journal of Nutrition,* **111**: 182-188.

Visser, M., Kritchevsky, S.B. and Goodpaster, B.H. 2002. Leg muscle mass and composition in relation to lower extremity performance in men and women aged 70 to 79 years: The health, aging and body composition study. *Journal of American Geriatric Society,* **50**: 897-904

WHO. 2004. Appropriate body mass index for Asian populations and its implications for policy and interventions strategies. *The Lancet,* **3**: 157-163.