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DETERMINANTS OF ABDOMINAL OBESITY AMONG PUNJABI ADULT MALES OF INDIA

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ABSTRACT

The purpose of this study was to highlight the determinants of abdominal obesity among Punjabi adult males. A total of 102 volunteer male subjects (40-60 yr) belonging to a group of people who regularly visited the Punjab Agricultural University campus, Ludhiana (India) for either morning or evening walk were enrolled for a study to identify dominant factors associated with abdominal obesity (AO) among the subjects. The subjects were divided into three groups as per their AO grade. The anthropometric parameters, food intake, physical activity and substance use were recorded using standardized procedures. All the anthropometric parameters of the studied group were higher than the reference values. The daily protein intake of subjects with grade II AO was significantly ($p \leq 0.001$) lower than the subjects with either no AO or grade I AO. The maximum number of subjects as regular alcohol drinkers was highest in grade II of AO. Physical activity like walking, jogging etc. was more prevalent in groups with lower abdominal obesity. Physical activities were inversely and significantly ($p \leq 0.01, 0.05$) correlated with body weight and BMI. Animal protein to plant protein ratio had a positive and significant ($p \leq 0.10, 0.05$) relationship with body weight and BMI. The results concluded that the waist hip ratio, waist-height ratio, conicity index and abdominal volume index are more reliable parameters for determining abdominal obesity and physical activity is more prominent determinant of abdominal obesity in comparison to dietary factors.

Keywords: Abdominal obesity, animal: plant protein ratio, males, protein, waist circumference

INTRODUCTION

Obesity is emerging as one of the most significant health concerns of this century. Abdominal obesity (AO) which is characterized by deposition of excessive body fat in the upper body especially waist and trunk as compared to hips and thighs is more closely associated with degenerative diseases (Hu *et al.*, 2016). Body mass index (BMI) is not considered as an appropriate estimate of obesity in Asian Indians due to very peculiar obesity phenotype characterized by prominent central obesity but with lower BMI in this group. Asian Indians have a greater tendency to accumulate abdominal fat and this has been termed as "Asian Indian phenotype or paradox" (Joshi, 2003). They reveal distinctive features of obesity such as excess in total body fat, abdominal adiposity, increased subcutaneous adipose tissue, intra-abdominal adipose tissue and deposition of fat in ectopic sites. Many studies revealed that for any given BMI, Indians have increased waist circumference which leads to abdominal and truncal adiposity (Pradeepa *et al.*, 2015). Most of the Indians have been characterized as metabolically obese but normal weight individuals. This depicts that though adult Indians have lean BMI, they have more chances of having AO. The proportion of body fat percentage of an Indian is much more than his Western counterpart with similar BMI and blood glucose level. The fat distributed in the abdominal region especially the visceral fat is more metabolically important in comparison to the one present in other fat depots (Deshmukh *et al.,* 2006). Excessive visceral fat is damaging because it is located closer to portal vein that carries the blood from the intestinal region to the liver. Some vital substances such as free fatty acids released by visceral fat enter the portal vein and travel to the liver where they significantly influence the production of blood lipids (Harvard Medical School, 2015). Visceral fat is related to higher total cholesterol and LDL cholesterol (Ludwig, 2000). Hence, abdominal fat accumulation determines cardiovascular risk profile and increases the vulnerability to ischaemic heart disease and arterial hypertension (Mathieu *et al.*, 2008). Visceral obesity is an integral part of metabolic syndrome and the extent of obesity is directly related to the progression of this condition (Ritchie and Connell, 2007). Therefore, abdominal adiposity assessment through waist circumference measurement is more appropriate to predict metabolic disorders than the determination of general obesity through BMI. This isolated use of BMI runs the risk of missing those who despite of having a normal BMI, are at the risk of developing metabolic disorders in their later lives (Poobalan and Aucott, 2016).

Several factors including genetic, metabolic, social, cultural and environmental factors are associated with obesity but a strong association between macronutrient intake and weight change has been demonstrated. The macronutrient composition of the diet has been observed as an important contributing factor in obesity (Crowe *et al.*, 2004). In addition to decreased physical activity, the intake of energy dense and high calorie foods mainly sugars and fats are found to be the major causative factors of obesity. In a state of energy imbalance, excess of energy is stored in the body in the form of fat. A positive association is found between waist circumference and energy, cabohydrates and fats. In order to control and prevent abdominal obesity and related chronic diseases, it is important to avoid high fat or high carbohydrate diet (Nikbazm *et al.,* 2013).

Sedentary lifestyle along with poor dietary habits, negative effects of globalization, urbanization and increasing age of the adult population contribute to a gradual increase in BMI over the years (Hosseinpoor *et al.*, 2012). The macronutrient composition of diet has been observed as an important contributing factor in obesity. In addition to decreased physical activity, the intake of energy dense and high calorie foods mainly sugars and fats are found to be the major causative factors of obesity. The foods with high glycemic index, high insulin response and fast glucose decline may cause an increase in hunger and lipogenesis, therefore, leads to obesity and a sudden increase in blood sugar. A positive association between glycemic index and weight/waist-circumference has been reported (Larsen *et al.*, 2010). Increasing the proportion of proteins from 15-18% to 20-35% at the expense of carbohydrates and fat can diminish the problem of obesity in sedentary workers. In comparison to ordinary high-carbohydrate diets, protein rich diets are proved to increase insulin sensitivity, which is corelated with higher energy expenditure (Kitabchi *et al.*, 2013). The high incidence of lifestyle diseases such as cardiovascular diseases, diabetes etc. have been found related with abdominal fat among Punjabi males (Kaur and Bains, 2005), however, the association of quality and quantity of macronutrients with AO among Punjabi males need to be studied to draw appropriate dietary guidelines for them in order to overcome AO and its negative health outcomes. The study aimed to highlight the determinants of AO among Punjabi adult males of India.

MATERIALS AND METHODS

A total of 102 male volunteer subjects in the age group of 40 to 60 yrs, free from any major illness, who regularly visited PAU, Ludhiana (India) for morning or evening walks were enrolled for the study. The subjects were divided into 3 groups on the basis of their AO assessed through their waist circumference measurements (WHO, 2008). A questionnaire was developed to gather information about their anthropometric profile, food consumption pattern, type and duration of activities. Daily food intake was recorded for three consecutive days using '24 h recall method'. Qualitative and quantitative consumption of macro- and micro-nutrients was assessed by a dietary software 'DietCal' (Kaur, 2018). The contribution of vegetarian food sources like cereals and pulses and animal sources namely milk and milk products, egg and chicken, meat and fish to total daily protein intake of each subject was assessed. Similarly, ratio of saturated, monounsaturated and poly-unsaturated fatty acids (SFA: MUFA: PUFA) was assessed (Ghafoorunissa and Krishnanurthy, 2000). Daily intake of available carbohydrates and dietary fibre was also determined (Merchant *et al.*, 2009).

The anthropometric measurements *viz.*, height, weight, waist circumference and hip circumference were taken using standard methods (Jelliffe, 1966). BMI as a derived indicator of general obesity was calculated and the derived indicators of AO i.e. weight/hip circumference (WHR), waist/height circumference (WHtR), conicity index (CI) and abdominal volume index (AVI) were calculated using the given formulas:

Waist and hip ratio = Waist circumference (cm) / hip circumference (cm)

A reference value of ≥0.90 for waist and hip ratio was taken (WHO 2008).

Waist and height ratio = Waist (cm) / height (cm).

A cut off point of >0.5 for waist and height ratio was taken as reference value (Browning *et al.*, 2010).

$$\text{Conicity index} = \text{waist (m)} / [0.109 \times \sqrt{(\text{weight (kg)} / \text{height (m)})}\,]$$

A cut off point of 1.21 for Conicity index was considered to assess AO (Wang et *al.*, 2017).

$$\text{Abdominal volume index} = \{2\text{x waist (cm)}^2 + 0.7 \text{ x [waist (cm)} - \text{hip (cm)]}\}^2 / 1000.$$

A cut off value of > 14.25 for abdominal volume index was taken as reference value (Wang *et al.*, 2017).

RESULTS AND DISCUSSION

The subjects were divided into three grades of AO on the basis of their waist circumference (WC) i.e. grade 0 with no AO (WC: < 94 cm); grade I with increased AO (WC: 94.1 to 101.9 cm) and grade II with substantially increased AO (WC: >102 cm) as prescribed by WHO (2008). The average age of the subjects ranged from 49.1 to 51.4 yrs. The monthly family income of subjects ranged from Rs. 43,083 to 56,637. Majority of the subjects (62%) were engaged in government sector jobs, followed by business (31%) and private sector jobs (7%).

Anthropometric parameters

The average weight of male subjects in grade 0, I and II of AO was 70.44, 77.05 and 92.31 kg, respectively (Table 1). A significantly ($p \leq 0.001$) higher body weight was observed in the subjects with grade II AO as compared to their counterparts with no AO or grade I AO. The higher body weight among the subjects with grade II of AO could be attributed to more deposition of visceral fat among them. The mean values of the waist circumference of grade 0 were within the reference value while that of grade I and II of AO were above the reference value of WHO (2008). The subjects with higher waist circumference may be at a higher risk to degenerative diseases as Després (2006) showed that large waist circumference increases the future risk of cardiovascular diseases (CVD) and diabetes by 2- to 3-folds for a given BMI. A statistically significant association between AO represented by waist circumference and the presence of colonic polyps and atrial fibrillation has been shown by Morales *et al.* (2014) and Baek *et al.* (2017). BMI, derived from weight and height of the subjects was significantly ($p \leq 0.05$) higher in subjects with grade II (31.11 kg m^{-2}) in comparison to the with grade 0 (24.09 kg m^{-2}) and grade I (26.18 kg m^{-2}). All the subjects in present study had BMI higher than the

Table 1: Basic and derived anthropometric measurements of the selected male subjects with different grades of abdominal obesity (N = 102)

Anthropometric measurements	Grade 0 (n = 32)	Grade I (n = 34)	Grade II (n = 36)	P value	$LSD_{0.05}$	Cut-off values
Basic						
Height (cm)	171.31 ± 5.76	171.41 ± 6.86	172.14 ± 6.11	0.84	ns	-
Weight (kg)	70.44 ± 7.57	77.05 ± 7.36	92.31 ± 16.33	≤ 0.001	10.48	-
Waist circumference (cm)	87.15 ± 4.40	96.89 ±2.06	111.51 ± 10.14	≤ 0.001	4.55	94 cm[a]
Hip circumference (cm)	92.15± 8.49	100.85 ±3.40	107.35 ± 7.24	≤ 0.001	4.60	-
Derived						
BMI (kg m^{-2})	24.09 ± 2.83	26.18 ± 1.93	31.11 ± 4.88	≤0.001	2.39	23.0[b]/25.0[c]
Waist-hip ratio	0.95 ± 0.08	0.96 ± 0.03	1.04 ± 0.05	≤0.001	0.04	0.90[d]
Waist-height ratio	0.51 ± 0.03	0.57 ± 0.02	0.65 ± 0.06	≤0.001	0.03	5[e]
Conicity index	1.25 ± 0.08	1.33 ± 0.05	75.07 ± 12.99	≤0.001	5.31	1.21[f]
Abdominal volume index	15.28 ± 1.51	18.80 ± 0.79	25.10 ± 4.94	≤0.001	2.12	14.25[f]

The values are mean ± SD; AO Abdominal Obesity; Grade 0 of AO: Waist circumference: <94 cm; Grade I of AO: Waist circumference: 94.1 to 101.9 cm, Grade II of AO: Waist Circumference: >102 cm;
Cut-off values: [a,b,d] WHO (2008), [c]Garrow (1981), [e]Browning *et al.* (2010), and [f]Wang *et al.* (2017)

reference value of 23.0 kg m^{-2} given by WHO (2008) for Asians. Similarly, a calculated value of waist-hip ratio was also significantly ($p \leq 0.001$) higher in the subjects in grade II (1.04) of AO when compared to the subjects with grade 0 (0.95) and grade I (0.96) of AO. The results clearly indicated that weight, BMI and waist circumference were much higher in males with WC >102 cm when compared to males with WC either <94 cm or between 94.1 to 101.9 cm.

According to WHO (2008), waist-hip ratio (WHR) > 0.9 represents a substantial increased risk of metabolic diseases. The subjects in all the three categories had WHR >0.90. The presence of AO i.e. high WC and WHR correlates with insulin resistance, diabetes mellitus (Hu *et al.*, 2016), hypertension, dyslipidemia and coronary artery diseases (Prasad *et al.*, 2011). Therefore, indicated a high risk for developing metabolic complications among all the three groups. Waist to height ratio (WHtR) is a proxy for central adipose tissue of the subjects with different grades of AO and is used as an indicator of central obesity to enable adjustment for various body frame sizes. The conicity index (CI) and the abdominal volume index (AVI) which reflect adipose in viscera and abdominal organs were also evaluated.

The values of CI were the highest for grade II (75.07), followed by grade I (1.33) and grade 0 (1.25) of AO. Similar trend was observed in abdominal volume index (AVI) values where the corresponding values being 15.28, 18.80 and 25.10, respectively. There was a significant ($p \leq 0.001$) difference in CI and AVI values of grade 0, I and II of AO. It has been proved that these central obesity indices have discriminatory power to estimate the risk of cardiovascular diseases as reported by Motamed *et al.* (2015). Various studies have confirmed the association between obesity measures and cardiovascular diseases and the incidence of metabolic syndrome patients had higher baseline visceral fat area compared with non-metabolic syndrome patients and abdominal visceral fat can be excellent indicator for metabolic syndrome and the indicators are cost effective and safe to use as observed by Whitlock *et al.* (2009), Dudina *et al.* (2011) and Wang *et al.* (2017).

Daily quantitative intake of macronutrients

The daily consumption of protein by the subjects in grade 0, I and II was 89.98, 93.51 and 95.85 g, respectively (Table 2). On calculating the daily protein intake per kg body weight of the subjects, the subjects with grade II AO (WC: >102 cm) had significantly ($p \leq 0.05$) lower protein intake kg^{-1} body weight than the subjects with no AO or grade I AO. The daily carbohydrate intake of the subject in grade 0, I and II of AO varied between 313.05 to 340.96 g with carbohydrate: protein ratio varying in a narrow range of 3.48 to 3.69 among the three groups (Fig. 1). Carbohydrate: protein ratio higher than 2.5 indicates a high carbohydrate diet and the subjects in all the three groups in present study

Table 2: Daily intake of macronutrients of the selected male subjects with different grades of abdominal obesity (N = 102)

Nutrients	Grade 0 (n = 32)	Grade I (n = 34)	Grade II (n = 36)	P value
Protein (g)	89.98 ± 32.32	93.51 ± 29.26	95.85 ± 25.26	0.71^{ns}
Protein kg^{-1} body weight (g)	1.28 ± 0.42	1.21 ± 0.34	1.04 ± 0.29	0.03**
Carbohydrates (g)	313.05 ± 71.97	311.14 ± 64.68	340.96 ± 79.94	0.16^{ns}
Total fat (g)	117.03 ± 42.68	138.32 ± 41.24	124.70 ± 33.28	0.08^{ns}
Energy (kcal)	2878 ± 1169	2912 ± 576	2981 ± 611	0.86^{ns}

Values are mean ± SD; Values in parenthesis are percentages; ns: Non-significant; ** Significant at 5%; AO: Abdominal Obesity; Grade 0 of AO: Waist Circumference: <94 cm; Grade I of AO: Waist Circumference: 94.1 to 101.9 cm; Grade II of AO: Waist Circumference: >102 cm.

were consuming high carbohydrate diets. Feng *et al. (*2015) found that high total carbohydrate and carbohydrates from starchy foods intake were associated with hyperlipidemia and metabolic syndrome. The carbohydrate cut-off value being 220 g from starchy foods. Kitabchi *et al.* (2013) showed that the subjects on high protein–low carbohydrate diet exhibited greater improvement in markers of insulin sensitivity and β-cell function, oxidative stress, lipid peroxidation and inflammatory cytokines than high carbohydrate–low protein diet. Jung and Choi (2017) suggested that low-carbohydrate diets help in significant weight loss and a reduction in plasma glucose, HbA1c and low-density lipoprotein-cholesterol (LDL-C). Campos-Nonato *et al.* (2017) reported that the group on high protein diet lost significantly more weight than those consuming standard protein diet. In present study, carbohydrate intake of subjects was higher than all other related studies.

Daily qualitative intake of macronutrients

Protein: The total intake of proteins from both cereals and pulses by the subjects of grade 0, I and II AO varied in a narrow range of 36.59 to 37.71 g. The corresponding intake of protein from animal sources i.e. milk and milk products ranged from 26.96 to 30.71 g. The ratio of animal: plant protein ranged from 0.74 to 0.89 among the subjects belonging to different groups (Table 3). There have been inconsistent results on whether the source of protein i.e. plant or animal has different effects on obesity. Lin *et al.* (2011) reported that plant protein intake was inversely correlated with BMI and WC in Belgian adults while Alkerwi *et al.* (2015) reported that the risk of AO increase with increasing intake of meat and fish. But Park *et al.* (2018) found that both types of protein were inversely associated with obesity.

Table 3: Qualitative protein consumption in terms of vegetable and plant protein sources by selected male subjects with different grades of abdominal obesity (N = 102)

Proteins sources	Grade 0 (n = 32)	Grade 1 (n = 34)	Grade 2 (n = 36)	P value
Plant sources				
Pulses (g)	8.98 ± 4.14	9.47 ± 4.3	9.52 ± 5.23	0.89^{ns}
Cereals (g)	27.61 ± 8.52	26.19 ± 8.15	25.19 ± 7.04	0.45^{ns}
Total (g)	36.59 ± 12.66	35.66 ± 12.45	37.71 ± 12.27	-
Animal sources				
Milk and milk products (g)	20.26 ± 9.24	21.75 ± 11.38	19.61 ± 10.77	0.74^{ns}
Eggs (g)	1.58 ± 4.55	2.31 ± 4.72	2.74 ± 6.20	0.65^{ns}
Chicken/meat/fish (g)	5.12 ± 10.92	7.73 ± 13.27	8.36 ± 15.26	0.57^{ns}
Total (g)	26.96 ± 24.71	31.79 ± 29.37	30.71 ± 32.23	-
Animal: plant protein ratio	0.74	0.89	0.81	-

Values are mean ±SD; The values in parenthesis are percentages; ns: Non-significant; AO: Abdominal Obesity; Grade 0 of AO: Waist circumference: <94 cm; Grade I of AO: Waist circumference: 94.1 to 101.9 cm; Grade II of AO: Waist circumference: >102 cm.

Carbohydrates: The intake of available carbohydrates (Table 4) by the subjects varied from 220.61 to 240.77g in the subjects with no AO or AO of grade I or II. The corresponding range for dietary fibre was 44.19 to 51.14 g. Merchant *et al.* (2009) reported that sufficient amount of carbohydrates in the range of 290 to 310 g day^{-1} is needed to reduce obesity. Moreover, the traditional insoluble fibres are required to add bulk as well as rapidly fermentable, viscous fibres to bring cholesterol lowering effect which leads to beneficial health effect in obesity.

Fats: The saturated fatty acid (SFA), mono-unsaturated fatty acid (MUFA) and poly-unsaturated fatty acid intake (PUFA) of the subjects in three groups did not vary significantly ($p \leq 0.001$). However on calculating the ratio of SFA:MUFA:PUFA, it was found that the ratios of three fatty acids were 1.67:1:0.97, 1.67:1:1 and 1.84:1:1.12 by the subjects in grade 0, I and II of AO, respectively (Fig. 2). A ratio of 1:1:1 for the three fatty acids have been reported as an ideal one for protecting against metabolic complications (Ghafoorunissa and Krishnanurthy, 2000). Though the subjects in all the three categories had higher intake of SFA but the maximum intake was found in the subjects of grade II AO. Hence, indicating that disproportion of fatty acids among the subjects may pose a risk of cardiovascular diseases. Saturated fat intake was positively associated with the prevalence of metabolic syndrome, independent of total dietary fat, MUFA and PUFA intake (Hosseinpour-Niazi *et al.*, 2015).

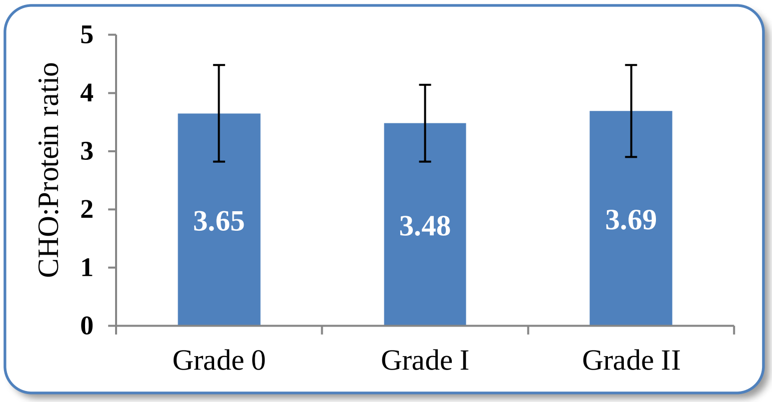

Fig. 1: The ratio of carbohydrates and protein ratio in the diets of selected male subjects with different grades of abdominal obesity

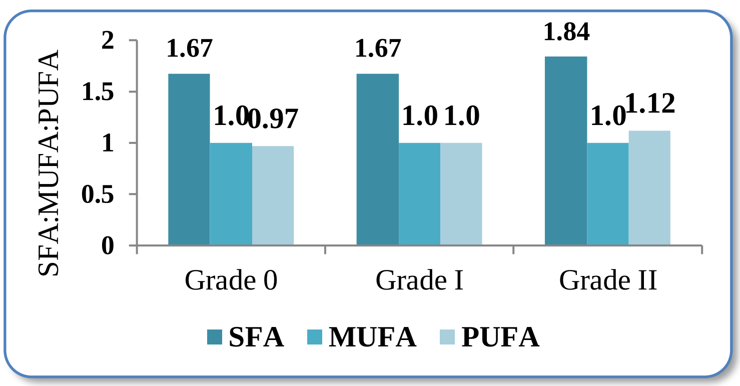

Fig. 2: The ratio of saturated, mono-unsaturated and poly-unsaturated fatty acids in the diets of selected male subjects with different grades of abdominal obesity

Table 4: Qualitative consumption of carbohydrates in terms of available and unavailable carbohydrates of selected male subjects with different grades of abdominal obesity

(N= 102)

Type of carbohydrates	Grade 0 (n = 32)	Grade 1 (n = 34)	Grade 2 (n = 36)	P value
Available (g)	227.11 ± 71.97	220.61 ± 51.65	240.77 ± 50.78	0.288^{ns}
Dietary fibre (g)	48.91 ± 13.54	44.29 ± 10.94	51.14 ± 12.15	0.064*
Total (g)	276.02 ± 85.85	264.90 ± 62.59	291.91 ± 62.93	-

Values are mean ± SD; Values in parenthesis are percentages; ns: Non-significant; *Significant at 10%; AO: Abdominal Obesity; Grade 0 of AO: Waist Circumference: <94 cm; Grade I of AO: Waist Circumference: 94.1 to 101.9 cm; Grade II of AO: Waist Circumference: >102 cm.

Table 5: Alcohol use of the selected male subjects with different grades of abdominal obesity (N = 102)

Type of alcohol	Grade 0 (n = 32)		Grade I (n = 34)		Grade II (n = 36)		P value
	N	Intake (mL day^{-1})	n	Intake (mL day^{-1})	n	Intake (mL day^{-1})	
Whisky	9 (28)	132 ± 38	11 (32)	112 ± 44	14 (39)	126 ± 55	0.61^{ns}
Scotch	0	0	2(6)	85 ± 7	1(3)	120	-
Brandy	0	0	1(3)	180	0	0	-
Beer	1(3)	200	1(3)	180	0	0	-
Rum	2(6)	135 ± 50	1(3)	60	2(6)	75 ± 63	0.55^{ns}

Values are mean ± SD; AO: Abdominal Obesity; ns = Non-significant;
Values in parenthesis are percentages; Grade 0 of AO: Waist Circumference: <94 cm; Grade I of AO: Waist Circumference: 94.1 to 101.9 cm; Grade II of AO: Waist Circumference: >102 cm.

According to Gupta *et al.* (2010), high total fat and SFA intake and a low intake of MUFAs and omega-3 PUFAs showed imbalanced nutrition, which could be responsible for increase in the prevalence of obesity and insulin resistance in urban Asian Indian adolescents and young adults.

Substance use

The majority of the subjects were in the habit of consuming alcoholic drinks while smoking was found in only 2% of the subjects. Other intoxicants such as tobacco, opium, etc. were not consumed by the subjects. The average daily intake of alcoholic drinks by the subjects has been given in Table 5. Whisky was the most commonly consumed alcoholic drinks with 28, 32 and 39% of subjects in grade 0, I and II, respectively with a corresponding daily intake of 132, 112 and 126 mL. Scotch drinking was not prevalent in the subjects in grade I of AO. However, a small number (6 and 3% of subjects in grade I and II of AO) reported to consume scotch with an average daily consumption of 85 and 120 mL, respectively. Brandy and beer were consumed by very small number of subjects in grade I and II of AO (3%). As no significant difference was observed in the volume of alcohol consumption among the subjects in the three groups, the maximum number of subjects who were regular drinkers was highest in grade II of AO (WC: > 102 cm) and least i.e. 28% of the subjects with no AO (WC: < 94 cm). Hu *et al.* (2017) showed that drinking was not associated with overweight/ obesity or AO. Risérus and Ingelsson (2007), on the other hand, showed association of high alcohol intake with AO.

Physical activity

One of the important determinants of obesity is the physical activity performed by the individuals. The lifestyle factors associated with obesity these days included increased TV viewing, use of computers and internet and decreased physical activity (Al-Hazzaa *et al.*, 2012). In present study, the activity of walking to work was performed by 22, 12 and 17% of the subjects in grade 0, I and II of AO, respectively. Daily walking as an exercise was taken up by 91, 94 and 86% of the subjects in grade 0, I and II of AO while jogging was performed by only 10, 6 and 3% of the subjects in grade 0, I and II of AO, respectively. Running and carried weight training/ resistance exercise was performed by very few subjects in grade 0 and I (Table 6). The results clearly showed that subjects with WC: <94 cm and with WC: 94.1 to 101.9 cm were actively involved in exercises than the subjects with WC: >102 cm, which indicated that physical exercises can ward off AO. A small number (5%) performed aerobic exercises with time spent being 15-90 min. Contrarily, 18% subjects performed sports such as tennis, badminton, football, volleyball, basketball and cricket while yoga was performed by 34% subjects; the time spent, however, was in the range of 10 to 70 min. This portrays that sedentary lifestyle with less physical exercise can trigger waist-lines further making prone to various degenerative diseases. Low levels of physical activity have been found associated with increased obesity in many research studies (Katulanda *et al.*, 2010; Ko *et al.*, 2007).

Table 6: Frequency of routine physical activities and daily physical exercises of the selected Punjabi male subjects (N = 102)

Activities	Range [time spent (min)]	mean ± SD
Routine physical activity		
Walking to work	10-360	177.65 ± 138.7
Sitting at work or commuting	30-600	321.76 ± 138.9
Sitting at home while watching TV/DVD	10-300	87.27 ± 59.69
Other sitting at home (e.g. desk, eating, laptop)	30-330	103.43 ± 44.11
Yard work/ gardening	10-150	57.57 ± 33.83
Household work i.e. cooking, cleaning, washing, etc.	5-180	44.26 ± 35.77
Stair climbing, no. of stairs	4-370	111.00 ± 89.00
Daily physical exercise		
Walking as exercise	10-210	52.02 ± 32.05
Jogging (slower than 10 min per mile)	10-75	32.26 ± 19.58
Running (10 min per mile)	10-60	32.50 ± 19.27
Bicycling (including stationary machine)	10-120	35.11 ± 24.82
Aerobic exercise (exercise classes etc.)	15-90	35.00 ± 31.42
Yoga	10-70	29.26 ± 19.03
Weight training or resistance exercise	10-90	47.50 ± 37.64
Sports such as tennis, badminton, football, volleyball, basketball, cricket etc.	17-100	48.44 ± 25.40

Relationship of abdominal obesity parameters with physical activity and dietary intake of macronutrients

The correlation coefficients (r) between AO parameters and routine physical activity, physical exercise and daily macronutrient intake of subjects revealed that among the routine activities, walking to work resulted in a significant reduction in waist/hip ratio while yard stick/gardening helped to reduce the visceral fat rating significantly ($p \leq 0.10$) among male subjects (Table 7). Among the physical exercises, walking, jogging, running and weight training were inversely but significantly ($p \leq 0.10$) related to one or more of parameters of AO. The results showed that lower AO like general obesity was significantly related to more physical activity by the subjects. An inverse association of high physical activity with obesity and unhealthy weight gain has been shown by Kwon *et al.* (2016).

Table 7: Correlation coefficients (r) of abdominal obesity parameters with dietary intake of macronutrients, physical activity, and alcohol consumption among the subjects (N = 102)

Physical activity parameters	WC (cm)	Waist/hip ratio	Waist/height ratio	Conicity index	Abdominal volume index	Visceral fat rating
Routine physical activities						
Walking to work	ns	-0.166*	ns	ns	ns	ns
Yard stick/gardening	ns	ns	ns	ns	ns	-0.170*
Sitting at work/commuting	ns	0.220**	ns	ns	ns	ns
Physical exercise						
Walking as exercise	-0.226*	ns	-0.214**	ns	-0.219**	-203**
Jogging (slower than 10 min per mile)	-0.235*	ns	-0.242**	-0.199**	-0.221**	-0.175*
Weight training	ns	ns	ns	ns	ns	-0.206**
Running (10 min per mile)	-0.221*	ns	-0.202**	-0.183*	-0.205**	ns
Alcohol consumption	ns	0.188*	ns	ns	ns	ns
Macronutrient intake						
Carbohydrates	ns	ns	ns	0.170*	ns	ns
Animal: plant protein ratio	ns	0.182*	ns	ns	ns	0.237**

*** Significant at 1%; **Significant at 5%; *Significant at 10%; ns: Non-significant

The present study suggests the potential benefits of regular physical activity and resistance exercise as a significant modifiable factor for prevention and treatment of obesity in general population and sarcopenia in older adults (Lee *et al.,* 2016).

Among macronutrients only carbohydrates showed significantly positive ($p \leq 0.10$) relationship with conicity index (CI). Bigaard (2005) reported a positive association between available carbohydrates and weight/waist-circumference. The available carbohydrates may cause an increase in hunger and lipogenesis, therefore may lead to obesity. The increased blood sugar level builds up as fat when it is not adequately utilized by body. Animal: plant protein intake ratio was positively and significantly ($p \leq 0.10$) correlated with waist/hip ratio and visceral fat rating. The higher intake of animal protein e.g. red meat protected against an increase in waist-circumference and adjusted for BMI (Alkerwi *et al.,* 2015). Ghosh *et al.* (2003) also observed that the increased consumption of chicken and fish was inversely correlated with abdominal obesity among Bangali men.

Conclusion: The study revealed that the prevalence of abdominal obesity was 70% among the studied Punjabi group. The waist hip ratio, waist-height ratio, conicity index and abdominal volume index are more reliable parameters, hence must be assessed to determine the abdominal obesity. Routine physical activities such as walking, jogging, running and sports are inversely related to reduced general as well abdominal obesity. Higher intake of protein was positively associated with general obesity, whereas high carbohydrates were associated with abdominal obesity. Higher ratio of animal: plant protein intake contributed to both general and abdominal obesity. Hence, it is recommended that the men approaching middle age should be motivated to shun general and abdominal obesity through enhanced physical activity and dietary modifications such as reduced carbohydrates and animal foods in order to prevent degenerative diseases with abdominal obesity as a root cause.

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