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Dietary and non-dietary determinants of central adiposity among Tehrani women

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Abstract

Objective: To determine the correlates of central adiposity.
Design: Population-based cross-sectional study.
Subjects: A total of 926 women (aged 40–60 years) from all districts of Tehran.
Methods: Demographic data were collected and anthropometric indices were measured according to standard protocols. Dietary intakes were assessed by means of a semi-quantitative food-frequency questionnaire. The suggested cut-off point for waist-to-hip ratio (WHR $\geq$ 0.84) for Tehrani people, adjusted for their age group, was used to determine central adiposity. Logistic regression analysis was used to determine the correlates of WHR, which were adjusted for age, taking medications and body mass index (BMI). The components of dietary intake were determined by factor analysis. Pearson correlation was used to determine the association between the dietary components and WHR. Analysis of covariance was employed to compare the mean values of WHR in different lifestyle groups, with adjustment for BMI and age.
Results: Mean WHR was 0.82 ± 0.06. The possibility of being centrally obese was higher in women with light physical activity (odds ratio: 2.11; 95% confidence interval: 1.40–2.53), depressed women (1.36; 1.02–1.93), smokers (1.21; 1.02–1.56) and unemployed women (1.41; 1.13–1.72). Marriage (1.31; 1.10–1.82), menopause (1.22; 1.02–1.61), low vitamin C intake (2.31; 1.25–4.25) and low calcium intake (1.30; 1.07–3.78) were associated with central fat accumulation. Dairy consumption was inversely correlated with central fat accumulation ($r = -0.2$, $P < 0.05$).
Conclusion: Central adiposity is associated with poor lifestyle factors including low physical activity, depression, smoking, low intake of vitamin C, low intake of calcium and dairy products and high fat consumption. Thus lifestyle modifications should be encouraged to achieve a healthier body shape.

Keywords
Central adiposity
Lifestyle factors
Waist-to-hip ratio
Nutrition

Obesity has now become a major global problem that is associated with risk of many non-communicable diseases[1–3]. Although obesity is related to disease risk[4], some studies suggest that the pattern of body fat distribution is a more important determinant than general obesity[5–7]. Abdominal obesity has also been shown to be associated with increased risk of overall mortality in many populations[8]. Despite some recent studies proposing waist circumference (WC) as an indicator for central fat accumulation[9,10], there is no universal agreement regarding the use of WC at present[11] and waist-to-hip ratio (WHR) is the most commonly used index of central fat distribution[12]. Abdominal obesity is reported in 36% of adult women in Greece[13]; according to reports, 65% of Omanian[14] and 55% of Indian women[15] are centrally obese.

Although obesity has strong genetic determinants, its increasing prevalence in populations around the world suggests that environmental factors are promoting or exacerbating the problem. Some possible associations of obesity with factors such as socio-economic status, gender, marriage, physical activity and educational level, among others, are mentioned in different populations[16–19]. In most studies the prevalence of central fat accumulation is higher in women than men. In Iran, it has been reported that 67% of women and 33% of men older than 20 years are centrally obese[20]. A study of secular trends in central fat accumulation in Iran showed a 6% increase in central adiposity among men and a 9% increase among women between 1998 and 2002[21].

Almost all of the previous studies[21–24] conducted in Iran used the World Health Organization (WHO) cut-off

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points to determine central fat accumulation and no previous studies have used the specific cut-off points[25] suggested for Tehrani adults. Therefore, the present study was performed to investigate the correlates of central fat accumulation based on the optimal anthropometric cut-off values of Tehrani adults in a representative population of women.

Subjects and methods

Subjects

In this cross-sectional study, 926 women aged 40–60 years living in different districts of Tehran were selected by cluster random sampling. An A to Z map of Tehran, called *Rahyab-e-Tehran* and published by the geographic information centre of the municipality of Tehran, was used for sampling. The book contains a map of Tehran divided into 185 pages. We divided each page into 30 blocks: five sections horizontally and six sections vertically. From among 5550 blocks in the whole book, 50 blocks were randomly chosen with 1460 individuals totally. After excluding subjects who had at least one missing variable, 926 women were included in the present analysis. To make sure that the sample was representative of the general population, the age groups of the subjects were compared with those of Tehran and Iran's population. The age distribution of subjects in this study is similar to that of the urban population in Tehran and Iran.

Anthropometry

All anthropometric measurements were made according to the WHO protocol[26]. Weight was measured using digital scales while subjects were minimally clothed and without shoes, and recorded to the nearest 100 g. Height was measured to the nearest 1 cm using a tape meter while subjects were in a standing position without shoes, with their shoulders in a normal position. WC was measured at the narrowest level, and hip circumference at the maximal level, over light clothing, using an unstretched tape meter without any pressure to the body surface, and was recorded to the nearest 0.1 cm. Body mass index (BMI) was calculated as weight (kg) divided by the square of height (m^2). WHR was computed as WC divided by hip circumference. The cut-off for WHR was determined as ≥0.84 based on the suggested cut-off[25] for Tehrani women, adjusted for their age group. We used normative threshold values for all anthropometric measures by assessing only the youngest adults, because anthropometric indicators such WC and cardiovascular risk factors increase with age. Accordingly, establishing the thresholds with values from any subpopulation is necessary[27]. On the other hand, a previous study in Iran showed that the so-called 'action level 2' cut-off point of WC had low predictive value for cardiovascular risk factors in Tehrani women[28].

Dietary intake assessment

Dietary intake was assessed by means of a semi-quantitative food-frequency questionnaire (FFQ). All the questionnaires were completed by trained dietitians with at least 5 years' experience in the Nationwide Food Consumption Survey project[29]. The FFQ consisted of a list of foods with a standard serving size. Participants were asked to report their frequency of consumption of each food item during the previous year on a daily (e.g. bread), weekly (e.g. rice, meat) or monthly (e.g. fish) basis. To assist the subjects to report accurately, household utensils were used. The questionnaires were validated 12 years ago in the Nationwide Food Consumption Survey project, which has been reported in Farsi[30]. We revalidated them with 16 families before this study was begun (unpublished data). Standard reference tables were used to convert household portions to grams for computerised analysis[31]. Following coding of diaries, the dietary recall form was linked to a nutrient database (Nutritionist III) and nutrient intakes were calculated from the quantities of foods consumed.

Lifestyle factors

Information about age, occupation, medication use, marriage, parity, menopausal status, smoking and drinking coffee was obtained using a pre-tested questionnaire. To ascertain physical activity status a validated questionnaire[32] was used. Depression was assessed by applying the Beck questionnaire[33].

Statistical analysis

Associations between lifestyle factors and central adiposity were assessed by logistic regression modelling. Lifestyle factors were categorised as follows. Occupation: unemployed, retired, employed; parity: 0, 1–2, ≥3; menopausal status: postmenopause, premenopause; smoking: non-smoker, smoker; drinking coffee: yes, no; physical activity: light, moderate, heavy; depression: depressed, mildly depressed, normal.

Logistic regression analysis adjusted for age and BMI was used to determine the correlates of central fat accumulation. WHR was dichotomised at a pre-selected cut-off based on the suggested cut-off for Tehrani women[25]. Subjects were classified on the basis of percentile cut-off points of nutrient intakes: <25, 25–50, 50–75 and >75. Only those nutrients which had a significant correlation with WHR were entered into the model. All nutritional and non-nutritional factors were simultaneously entered into the model. Stepwise multiple linear regression analysis was used to determine the predictors of WHR. Analysis of covariance was employed to compare the mean values of WHR in different lifestyle groups and the

Table 1 Characterstics of Tehrani Women

Variable	Mean ± SD	Range
Age (years)	48 ± 5	40 – 60
Weight (kg)	75 ± 39	40 – 110
Height (cm)	154 ± 6.0	101 – 175
Body mass index (kg m^{-2})	29.4 ± 4.6	19 – 46
Waist circumference (cm)	85.1 ± 9.9	60 – 118
Waist-to-hip ratio	0.82 ± 0.06	0.63 – 1.38
Frequency of women in different groups of lifestyle-related factors (%)		
Physical activity level		
Light	45	
Moderate	30	
Heavy	25	
Depression		
Normal	36	
Mildly depressed	40	
Depressed	24	
Smoking		
Smoker	8	
Non-smoker	92	
Coffee consumption		
Yes	14	
No	86	
Menopausal status		
Postmenopause	51	
Premenopause	49	
Marriage		
Married	79	
Single	21	
Occupation		
Unemployed	64	
Retired	10	
Employed	26	

SD – standard deviation.

Table 2 Odds ratio (OR) and 95% confidence interval (CI) for having waist-to-hip ratio ≥0.84 according to different lifestyle factors

Independent variable*	OR	95% CI
Physical activity level		
Light	2.11	1.40 – 2.53
Moderate	1.13	0.91 – 1.42
Heavy	1.00	–
Depression		
Normal	1.00	–
Mildly depressed	1.05	0.76 – 11.36
Depressed	1.36	1.02 – 1.93
Smoking		
Non-smoker	1.00	–
Smoker	1.21	1.02 – 1.56
Occupation		
Employed	1.00	–
Retired	0.83	0.51 – 1.26
Unemployed	1.41	1.13 – 1.72
Coffee consumption		
No	1.00	–
Yes	0.68	0.39 – 1.17
Marriage		
Single	1.00	–
Married	1.31	1.10 – 1.82
Menopausal status		
Premenopause	1.00	–
Postmenopause	1.22†	1.02 – 1.61
Parity		
0	1.00	–
1–2	1.02	0.83 – 1.42
≥3	1.31†	1.18 – 1.62

*All independent variables were entered simultaneously into the analysis and adjusted for cholesterol, vitamin C, calcium, vitamin B_6, fat intake, body mass index, medication use and age.
† $P < 0.05$.

mean values of vegetable and dairy consumption in centrally obese and normal women with adjustments for BMI and age. To reduce the data from the FFQ, factor analysis was used and then the association between each component and central fat accumulation was assessed by Pearson correlation. The ethical committee of the National Nutrition Research and Food Technology Institute of Shaheed Beheshti University of Medical Sciences approved the proposal of this study, and informed written consent was obtained from all women.

Results

Mean and standard deviation of age, weight, height, BMI, WC and WHR of the women is shown in Table 1.

Table 2 shows the possibility of being centrally obese in different groups based on lifestyle characteristics. The subjects who were less physically active had more chance of being centrally obese compared with the reference group. Unemployment, marriage, menopause and parity were also associated with central fat accumulation.

Women with light physical activity had a higher WHR than women with heavy physical activity (0.85 ± 0.03 vs. 0.80 ± 0.02, $P < 0.05$). Postmenopausal women had higher WHR than premenopausal women ($P < 0.01$). Women with three or more live births also had higher WHR compared with the two other groups ($P < 0.01$). WHR was predicted as follows:

$$\text{WHR} = 0.57 + 0.2 \times \text{BMI} + 0.2 \times \text{age} - 0.08 \times \text{calcium intake}.$$

The possibility of being centrally obese in different groups of nutrient intake is shown in Table 3. Mean values of WHR, with adjustments for age and BMI, in different percentiles of fat and vitamin C intake is shown in Fig. 1.

The dietary intake of the women was factor-analysed into eight components, as shown in Table 4. Among the components, only the dairy group was correlated with WHR ($r = -0.2$, $P < 0.05$).

Discussion

By conducting a systematic epidemiological analysis, we have revealed the factors associated with central fat accumulation in a representative sample of Tehrani women. The appropriate adjustments for confounders in the present study, as well as use of the suggested cut-off points for Tehrani women to determine central fat accumulation, increased the reliability of our results.

Ageing is one of the determinants of WHR. As ageing is unavoidable, attention to the other determinants such as BMI is necessary. The lifestyle factors related to WHR were very similar to those for BMI, most likely because of the correlation between these two factors. In the present study, subjects who were least active were more likely to have WHR above the suggested cut-off, in the line with previous studies[14,34]. This indicates that increased abdominal fat follows inactivity, which provides important information for health promotion and preventing adiposity. Holcomb *et al.* also showed the ability of increased daily physical activity in minimising age-related increases in abdominal obesity[35]. Depression, which may be a consequence of industrial life, is increasing nowadays. In the present study the likelihood of being centrally obese was higher in depressed women than in healthy women. Therefore, paying attention to mental health is important for preventing central fat accumulation. Unemployed women had higher odds ratio of being centrally obese in this study. Doing repeated housework all days and having no distinct budgetary control may be the causes of depression in housewives and progress the central fat accumulation. On the other hand, exposure to food at home may explain this association. Employed women also have higher economic status in most cases. Previous studies showed higher obesity rate among people of lower socio-economic level[36–38]. Smokers in the present study had higher probability of being centrally obese. A longitudinal study has shown that smokers gain weight

Table 3 Odds ratio (OR) and 95% confidence interval (CI) for having a waist-to-hip ratio ≥0.84 according to different nutrient intakes*

Independent variable†	OR	95% CI
Cholesterol intake		
0–49 g	1.00	
50–102 g	1.15	0.71–1.63
103–172 g	1.21	0.83–1.52
>172 g	1.26	0.86–1.71
Vitamin C intake		
0–56 mg	2.31‡	1.25–4.25
57–80 mg	1.82‡	1.08–3.06
81–116 mg	1.36	0.78–2.36
>116 mg	1.00	–
Calcium intake		
0–398 mg	1.30‡	1.07–3.78
399–579 mg	1.13	0.78–2.36
580–773 mg	1.12	0.73–1.86
>773 mg	1.00	–
Vitamin B_6 intake		
0–0.4 mg	0.73	0.41–1.32
0.41–0.5 mg	0.73	0.44–1.19
0.51–0.7 mg	0.45	0.22–1.90
>0.7 mg	1.00	–
Fat intake		
0–37 mg	1.00	–
38–49 g	1.23	0.81–3.61
50–61 g	1.30	0.90–2.13
>61 g	1.41‡	1.11–3.06

*Nutrients are categorised according to percentiles: <25, 25–50, 50–75, >75.
†All independent variables were entered simultaneously into the analysis and adjusted for physical activity level, depression, smoking, coffee consumption, menopausal status, marriage, parity, age, medication use and body mass index.
‡ $P < 0.05$.

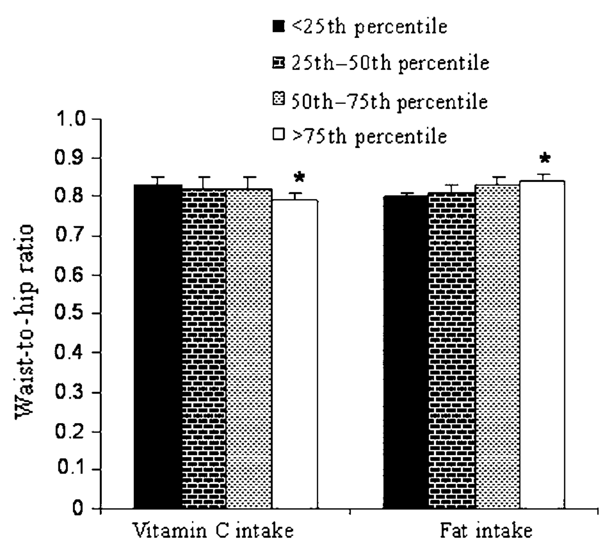

Fig. 1 Waist-to-hip ratio (WHR) in women according to level of vitamin C and fat intake. Values are means with standard error shown by vertical bars. Women in the first percentile of vitamin C and fourth percentile of fat intake had higher WHR ($P < 0.01$) than those in the fourth percentile of vitamin C and first percentile of fat intake

Table 4 Different components of the women's diet

Component							
Dairy	Meat	Vegetables	Fruit	Refined bread	Whole bread	Sweet	Fat
Cheese (0.4)* Milk (0.5) Yoghurt (0.5) *Kashk* (0.4)	Fish (0.4) Poultry (0.4) Eggs (0.4) Red meat (0.4)	Lettuce (0.4) Spinach (0.4) Kale (0.5) Carrot (0.4) Celery (0.4) Tomato (0.4) Cucumber (0.4)	Apple (0.4) Apricot (0.4) Grape (0.5) Orange (0.4) Melon (0.4) Pear (0.5) Berry (0.4)	*Lavash* (0.4) *Baget* (0.5)	*Barbari* (0.5) *Sangak* (0.4) *Taftoon* (0.5)	Sweets (0.4) Sugar (0.4)	Cream (0.4) Oil (0.4) Butter (0.4)

*Loading factor.

more on their waist and less on their hips than predicted from gain in body mass, thus they have a gain in WHR[39]. Other research showed that women who continued to smoke developed significantly higher WHR than those who stopped smoking[40]. Han *et al*[34]. showed that smoking cessation reduces the likelihood of being centrally obese.

After adjusting for the effect of age, menopausal women had greater tendency to be centrally obese, which may contribute to the change in sex hormone levels in postmenopausal women. Lipowicz *et al*[41]. showed that after age, marriage is the most important predictor of overweight and obesity. In the current study, the likelihood of being centrally obese was higher in married women; changes in dietary patterns and hormone levels, especially a gain in weight after each pregnancy or lactation, may be the reason. Moreover, we found that multiparous women had also higher WHR, similar to a previous report[34].

Among nutrient intakes, vitamin C, calcium and fat were associated with central fat accumulation in our study. Vitamin C as well as calcium can reduce fat absorption and may reduce abdominal adiposity. Maskarinec *et al.* showed that higher fat intake predicted higher BMI (general obesity)[42] but there are few studies regarding fat and central obesity. Mace *et al.* reported that dietary fat and fat types should be further studied as early determinants of obesity[43]. After analysing the dietary components, only the dairy group showed a negative significant correlation with WHR in the present study. Previous works[44–46] have also shown a negative correlation between dairy consumption and BMI. The mechanism by which milk consumption affects obesity indices is not accurately known. Most studies[47,48] have cited calcium as a responsible factor. So, an inverse relationship has been suggested between calcium intake and body weight and body fat mass in various ways. Its simple effect is the inhibition of fat and fatty acid absorption. However, this is not the major cause; it seems that the major effect of calcium on body weight is mediated by its effects on controlling intracellular calcium[49]. Evidence has shown that the product of *agouti*, a gene that is expressed in human adipocytes, stimulates calcium uptake into the cells which, by its effect on lipolysis and lipogenesis, causes the deposition of fat in adipocytes. This product increases fatty acid synthetase activity and inhibits lipolysis. By a calcium-dependent mechanism[50], vitamin D stimulates calcium entrance into the cell and inhibits lipolysis, so decreasing plasma insulin level by dietary calcium is also mentioned as another reason[51]. Other factors in addition to its calcium content may play a role in the anti-obesity effect of milk. *Trans* fatty acids, conjugated linolenic acid[52,53], protein and bioactive components[54] have been mentioned in some reports. Rosell *et al.* also showed an inverse association between sagittal abdominal obesity and calcium intake in a cross-sectional study[55].

Using suggested cut-off points for Tehrani women to determine the central fat accumulation was a positive point of this study; the use of cross-sectional data was the principal limitation. Moreover, obesity is a heterogeneous disease and besides nutritional and non-nutritional associations, other factors such as heredity and some other environmental factors that we cannot capture in our analysis must be considered. Although the subjects of this study were a representative sample of Tehrani women, the multi-ethnic nature of our country reduces the possibility of extrapolating of our findings to the whole country. This point emphasises the necessity of conducting similar studies in various regions of Iran. However, a recent study in the north of Iran showed similar associated factors for central obesity. With respect to its findings, low level of activity and education, parity, family history of obesity, marriage at earlier age and ageing were responsible for central obesity[56].

Therefore, adverse fat distribution is associated with increasing age, unemployment, marriage, parity and poor lifestyle factors including low physical activity, smoking, depression, low intake of vitamin C and calcium, and high fat consumption. The associations may be different in different populations, so using an appropriate tool for diagnosing central fat accumulation and considering its determinants are important for health promotion. Thus lifestyle modifications such as smoking cessation, more physically active lifestyle, avoidance of depression, adequate intake of vitamin C and calcium and less consumption of fat should be encouraged to achieve a healthier body shape.

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References

1 Pi-Sunyer FX. Medical hazards of obesity. *Annals of Internal Medicine* 1993; **119**: 655–60.
2 Higgins M, Kannel W, Garrison R, Pinsky J, Stokes J. Hazards of obesity – the Framingham experience. *Acta Medica Scandinavica* 1988; **723**: 23–36.
3 Must A, Spadano J, Coakley EH, Field AE, Colditz G, Dietz WH. The disease burden associated with overweight and obesity. *JAMA: Journal of the American Medical Association* 1999; **282**: 1523–9.
4 Stevens J, Cai J, Pamuk ER, Williamson DF, Thun MJ, Wood JL. The effect of age on the association between body mass

index and mortality. *New England Journal of Medicine* 1998; **338**: 1–7.
5 Wei M, Gaskill SP, Haffner SM, Stern MP. Waist circumference as the best predictor of non-insulin-dependent diabetes mellitus compared to BMI, WHR other anthropometric measurements in Mexican Americans: a 7-year prospective study. *Obesity Research* 1997; **5**: 16–23.
6 Folsom AR, Kaye SA, Sellers TA, Hong CP, Cerhan JR, Potter JD, *et al*. Body fat distribution and 5-year risk of death in older women. *JAMA: Journal of the American Medical Association* 1993; **269**: 483–7.
7 Pi-Sunyer FX. Obesity: criteria and classification. *Proceedings of the Nutrition Society* 2000; **59**: 505–9.
8 Prineas RJ, Folsom AR, Kaye SA. Central adiposity and increased risk of coronary artery disease mortality in older women. *Annals of Epidemiology* 1993; **3**: 35–41.
9 Pouliot MC, Despres JP, Lemieux S, Moorjani S, Bouchard C, Tremblay A, *et al*. Waist circumference and abdominal sagittal diameter: best simple anthropometric indexes of abdominal visceral adipose tissue accumulation and related cardiovascular risk in men and women. *American Journal of Cardiology* 1994; **73**: 460–8.
10 Reeder BA, Senthilselvan A, Despres JP, Angel A, Liu L, Wang H, *et al*. The association of cardiovascular disease risk factors with abdominal obesity in Canada. Canada Heart Surveys Research Group. *Canadian Medical Association Journal* 1997; **157**: S39–54.
11 Esmaillzadeh A, Mirmiran P, Azizi F. Waist-to-hip ratio is a better screening measure for cardiovascular risk factors compared to other anthropometric indicators in Tehranian adult men. *International Journal of Obesity and Related Metabolic Disorders* 2004; **28**: 1325–32.
12 World Health Organization (WHO). *Obesity: Preventing and Managing The Global Epidemic*. Report of a WHO Consultation on Obesity. Geneva: WHO, 1997.
13 Kapantais E, Tzotzas T, Ioannidis I, Mortoglou A, Bakatselos S, Kaklamanou M, *et al*. First national epidemiological survey on the prevalence of obesity and abdominal fat distribution in Greek adults. *Annals of Nutrition & Metabolism* 2006; **50**: 330–8.
14 Al-Riyami AA, Afifi MM. Prevalence and correlates of obesity and central fat accumulation among Omani adults. *Saudi Medical Journal* 2003; **24**: 641–6.
15 Beegom R, Beegom R, Niaz MA, Singh RB. Diet, central fat accumulation and prevalence of hypertension in the urban population of south India. *International Journal of Cardiology* 1995; **51**: 183–91.
16 Roos E, Lahelma E, Virtanen M, Prattala R, Pietinen P. Gender, socioecomomic status and family status as determinants of food behavior. *Social Science & Medicine* 1998; **46**: 1519–29.
17 Sobal J, Rauschenbach B, Frongillo EA. Marital status changes and body weight changes: a US longitudinal analysis. *Social Science & Medicine* 2003; **56**: 1543–55.
18 Sobngwi E, Mbanya JC, Unwin NC, Kengne AP, Fezeu L, Minkoulou EM, *et al*. Physical activity and its relationship with obesity, hypertension and diabetes in urban and rural Cameroon. *International Journal of Obesity and Related Metabolic Disorders* 2002; **26**: 1009–16.
19 Paeratakul S, Lovejoy JC, Ryan DH, Bray GA. The relation of gender, and socioeconomic status to obesity co-morbidities in a sample of US adults. *International Journal of Obesity and Related Metabolic Disorders* 2002; **26**: 1205–10.
20 Azadbakht L, Mirmiran P, Azizi F. Obesity prevalence and its determinants. *Iranian Journal of Endocrinology and Metabolism* 2004; **20**: 426–501.
21 Azizi F, Azadbakht L, Mirmiran P. Trends in overweight, obesity and central fat accumulation in Tehranian adults between 1998–1999 and 2000–2001. *Annals of Nutrition & Metabolism* 2005; **49**: 3–8.
22 Ayatollahi SM, Carpenter RG. Height, weight, BMI and weight-for-height of adults in southern Iran: how should obesity be defined? *Annals of Human Biology* 1993; **20**: 9–13.
23 Pishdad GR. Overweight and obesity in adults aged 20–74 in southern Iran. *International Journal of Obesity and Related Metabolic Disorders* 1996; **20**: 963–5.
24 Azizi F, Esmaillzadeh A, Mirmiran P, Ainy E. Is there an independent association between waist-to-hip ratio and cardiovascular risk factors in overweight and obese women? *International Journal of Cardiology* 2005; **101**: 39–46.
25 Mirmiran P, Esmaillzadeh A, Azizi F. Detection of cardiovascular risk factors by anthropometric measures in Tehranian adults: receiver operating characteristic (ROC) curve analysis. *European Journal of Clinical Nutrition* 2004; **58**: 1110–18.
26 World Health Organization (WHO). *Measuring Obesity: Classification and Description of Anthropometric Data*. Copenhagen: WHO, 1989.
27 Dobbelsteyn CJ, Joffres MR, Maclean DR, Flowerdew G. A comparative evaluation of waist circumference, waist-to-hip ratio and body mass index as indicators of cardiovascular risk factors. The Canadian Heart Health Surveys. *International Journal of Obesity and Related Metabolic Disorders* 2001; **25**: 625–61.
28 Esmaillzadeh A, Mirmiran P, Azizi F. Evaluation of waist circumference to predict cardiovascular risk factors in an overweight Tehranian population: findings from Tehran Lipid and Glucose Study. *International Journal for Vitamin and Nutrition Research* 2005; **75**: 347–56.
29 Kimiagar SM, Ghaffarpour M, Houshiar-Rad A, Hormozdyari H, Zellipour L. Food consumption pattern in the Islamic Republic of Iran and its relation to coronary heart disease. *Eastern Mediterranean Health Journal* 1998; **4**: 539–47.
30 Nutrition and Food Technology Research Institute. *National Food Consumption Survey*. Tehran: Nutrition and Food Technology Research Institute, 1995.
31 Ghaffarpour M, Houshiar-Rad A, Kianfar H. *The Manual for Household Measures, Cooking Yields Factors and Edible Portion of Foods*. Tehran: Keshaverzi Press, 1999.
32 Craig CL, Marshall AL, Sjostrom M, Bauman AE, Booth ML, Ainsworth BE, *et al*. International physical activity questionnaire: 12-country reliability and validity. *Medicine and Science in Sports and Exercise* 2003; **35**: 1381–95.
33 Beck AT. *Depression: Clinical, Experimental and Theoretical Aspects*. London: Staples Press, 1969.
34 Han TS, Bijnen FCH, Lean NEJ, Seidell JC. Separate association of waist and hip circumference with lifestyle factors. *International Journal of Epidemiology* 1998; **27**: 422–30.
35 Holcomb CA, Heim DL, Loughin TM. Physical activity minimizes the association of body fatness with abdominal obesity in white, premenopausal women: results from the Third National Health and Nutrition Examination Survey. *Journal of the American Dietetic Association* 2004; **104**: 1859–62.
36 Kang HT, Ju YS, Park KH, Kwon YJ, Im HJ, Paek DM, *et al*. Study on the relationship between childhood obesity and various determinants, including socioeconomic factors, in an urban area. *Journal of Preventive Medicine and Public Health* 2006; **39**: 371–8.
37 Budd GM, Hayman LL. Childhood obesity: determinants, prevention, and treatment. *Journal of Cardiovascular Nursing* 2006; **21**: 437–41.
38 Moreira P, Padrao P. Educational, economic and dietary determinants of obesity in Portuguese adults: a cross-sectional study. *Eating Behaviors* 2006; **7**: 220–8.

39 Shimokata H, Muller DC, Andres R. Studies in distribution of body fat. *JAMA: Journal of the American Medical Association* 1989; **261**: 1169–73.

40 Lissner L, Bengtsson C, Lapidus L, Bjorkelund C. Smoking initiation and cessation in relation to body fat distribution based on data from a study of Swedish women. *American Journal of Public Health* 1992; **82**: 273–5.

41 Lipowicz A, Gronkiewicz S, Malina RM. Body mass index, overweight and obesity in married and never married men and women in Poland. *American Journal of Human Biology* 2002; **14**: 468–75.

42 Maskarinec G, Takata Y, Pagano I, Carlin L, Goodman MT, Le Marchand L, *et al.* Trends and dietary determinants of overweight and obesity in a multiethnic population. *Obesity (Silver Spring, Md.)* 2006; **14**: 717–26.

43 Mace K, Shahkhalili Y, Aprikian O, Stan S. Dietary fat and fat types as early determinants of childhood obesity: a reappraisal. *International Journal of Obesity* 2006; **30**: S50–7.

44 Garrow JS, Webster JD, Pearson M, Pacy PJ, Harpin G. Inpatient–outpatient randomized comparison of Cambridge diet versus milk diet in 17 obese women over 24 weeks. *International Journal of Obesity* 1989; **13**: 521–9.

45 Carruth BR, Skinner JD. The role of dietary calcium and other nutrients in moderation body fat in preschool children. *International Journal of Obesity and Related Metabolic Disorders* 2000; **25**: 559–66.

46 Mirmiran P, Esmaillzadeh A, Azizi F. Dairy consumption and body mass index: an inverse relationship. *International Journal of Obesity and Related Metabolic Disorders* 2005; **29**: 115–21.

47 McCarron DA, Morris CD, Henry HJ, Stanton JL. Blood pressure and nutrient intake in the United States. *Science* 1984; **224**: 1392–8.

48 Fleming KH, Heimbach JT. Consumption of calcium in the US: food sources and intake levels. *Journal of Nutrition* 1994; **124**: 1426S–30S.

49 Welberg JW, Monkelbaan JF, de Vries EG, Muskiet FA, Cats A, Oremus ET, *et al.* Effects of supplemental dietary calcium on quantitative fecal fat excretion in man. *Annals of Nutrition & Metabolism* 1994; **38**: 185–91.

50 Comuzzie AG, Allison DB. The search for human obesity genes. *Science* 1998; **280**: 1374–7.

51 Shi H, Dirienzo D, Zemel MB. Effects of dietary calcium on adipocyte lipid metabolism and body weight regulation in energy-restricted ap2-agoutio transgenic mice. *FASEB Journal* 2000; **8**: 291–330.

52 Awad AB, Bernardis LL, Fink CS. Failure to demonstrate an effect of dietary fatty acid composition on body composition and parameters of lipid metabolism in mature rats. *Journal of Nutrition* 1990; **120**: 1277–82.

53 Belury MA, KempaSteczko A. Conjugated linoleic acid modulates hepatic lipid composition in mice. *Lipids* 1997; **32**: 199–204.

54 Pihlanto-Leppale A, Koskinen P, Piilola K, Tspasela T, Korhonen H. Angiotensin I-converting enzyme inhibitory properties of whey protein digests: concentration and characterization of active peptides. *Journal of Dairy Research* 2000; **96**: 53–4.

55 Rosell M, Johansson G, Berglund L, Vessby B, de Faire U, Hellenius ML. Associations between the intake of dairy fat and calcium and abdominal obesity. *International Journal of Obesity and Related Metabolic Disorders* 2004; **28**: 1427–34.

56 Hajian-Tilaki KO, Heidari B. Prevalence of obesity, central obesity and the associated factors in urban population aged 20–70 years, in the north of Iran: a population-based study and regression approach. *Obesity Reviews* 2007; **8**: 3–10.