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Original Article

Determinants of Weight Change in a Longitudinal Study of Iranian Adults: Isfahan Cohort Study

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Abstracts:

Background: The extensive rise in the prevalence of obesity is a matter of great concern and poses a global threat to people's health. Obesity and overweight are considered to be the consequence of a collection of conditions including genetic, social, environmental, behavioral, and physical factors. The aim of this study was to investigate the determinants of weight change over seven years in a prospective study in an Iranian population.

Methods: The Isfahan Cohort Study (ICS) is an ongoing longitudinal study started in 2001. A total of 6504 adults aged ≥ 35 years participated in this study. Subjects were followed every 2 years by phone calls. The interview and measurements were repeated in 2007 for 3284 subjects with the same protocol as the baseline study. Obesity indices, including body mass index (BMI) and waist circumference (WC) were measured at both time points. For the purpose of data analysis, multiple multinomial logistic regression, Chi-square, and ANOVA tests were used.

Results: In males, weight gain was more frequent from normal to overweight (11.7%), while in females, weight gain was observed more from overweight to obesity (11.4%). Younger individuals gained weight more than older individuals ($P < 0.001$); it was the same for lower education level ($P = 0.007$). Weight gain was negatively (OR: 0.98, 95% CI: 0.97–0.99 in male and OR: 0.96, 95% CI: 0.95–0.98 in female) and weight loss was positively (OR: 1.03, 95% CI: 1.01-1.05 in male and OR: 1.02, 95% CI: 1.01–1.04 in female) associated with age in both sexes. Education more than 12 years in women and between 6–12 years in men was negatively associated with weight gain while smoking was positively related to weight loss in females and weight gain in males.

Conclusion: Our data showed that multiple factors affect weight change, among which age, smoking, and education are important determinants in Iranian adults.

Keywords: Obesity, overweight, dietary index, physical activity, weight gain

Cite this article as: Sarrafzadegan N, Talaei M, Sadeghi M, Mohammadifard N, Taheri M, Lotfizadeh M, Esmaillzadeh A, Khosravi-Boroujeni H. Determinants of Weight Change in a Longitudinal Study of Iranian Adults: Isfahan Cohort Study. *Arch Iran Med*. 2014; **17(8):** 539 – 544.

Introduction

The extensive rise in the prevalence of obesity is a matter of great concern and poses a global threat to the health[1,2] and has harmful effects on economy.[3] It has been well established that obesity and overweight raise the risk of some major causes of mortality and morbidity such as hypertension, type 2 diabetes, stroke, coronary heart disease, and some types of cancers including prostate, breast, ovarian, cervical, colon and gall bladder cancer.[4]

Since the last two decades, concurrently with dietary and other lifestyle changes, obesity is becoming increasingly more prevalent.[5] The World Health Organization estimated that at least 300 million of adults throughout the world are obese and more than one billion are overweight.[6] Early literature provided evidence that obesity is the most significant nutritional disorder in developed countries; however, it is becoming more serious in developing countries, as well.[7] As a result of urbanization, Western lifestyle, and demographic transition, the prevalence of obesity has been rapidly increasing in many developing countries.[8] People living in countries in transition have been experiencing remarkable changes in lifestyle and dietary habits, improvements in socioeconomic status and education. They become accustomed to Western diets and sedentary behaviors which are the primary risk factors for obesity. During the last 2 decades, the prevalence of obesity and overweight has increased, ranging from 50% to 65% in developed countries.[9,10] In the same period, the prevalence of overweight and obesity has also escalated in Iran to 49.7% in men and 63.9% in women, which is higher than the values reported in some developing countries.[11]

Because weight loss procedures need tremendous activities, primary prevention of weight gain is a worldwide preference. Thus, understanding the most important determinants of overweight and obesity is critical. Obesity and overweight are considered to be the consequence of multiple conditions including genetic, social, environmental, behavioral, and physical factors[12,13]; however, the most common determinants are age, gender, economic status, ed-

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Accepted for publication: 7 May 2014

ucation, lack of physical activity, urbanization, and smoking,[14] but supporting data are surprisingly contradictory.

Iran as a developing country is experiencing a rapid socio-demographic, nutritional, and epidemiological transition and is facing a rapid increase in the prevalence of overweight and obesity[11] as well as some related diseases like diabetes[15] and coronary heart diseases (CHD).[16] The aim of this study was therefore to investigate the weight change pattern in both sexes and its most common determinants in Iran.

Subjects and Methods

Participants

The Isfahan cohort study (ICS) is an ongoing longitudinal study on 6504 adults aged 35 years or above, from urban and rural areas of three counties (Isfahan, Arak, and Najafabad) in central Iran.[17] Details of the sampling procedure have been published previously.[18,19] Participants were selected in 2001 and were followed up until 2011. For this analysis, 3284 participants who underwent the second measurements in 2007 were recruited.

The study was ethically approved by the Ethics Committee of Isfahan Cardiovascular Research Center, a World Health Organization-collaborating center and informed written consent was obtained from each participant individually

Data collection

Using a standard questionnaire, trained health professionals carried out interviews asking questions about socioeconomic status, demographic characteristics and behaviors (smoking, physical activity and nutritional habits). Interviews, physical examination, and blood sampling was carried out at the nearest health center. Quality of diet was assessed by global dietary index (GDI). GDI represents the average intake frequency of the 29 food items in seven categories. Smaller GDI represents better dietary habits.[20] Measurement of height and weight were conducted by a secured metal ruler in barefoot and a calibrated scale in light clothing, respectively. Body mass index (BMI) was calculated as weight (Kg) divided by height squared (m^2). Waist circumference (WC) was measured horizontally as the smallest circumference below the lowest ribs.

Follow-up surveys

After the baseline assessment in 2001, the participants were followed up every 2 years (in 2003, 2005 and 2007) by telephone calls. A full structured interview, similar to the baseline investigation, was also conducted in 2007. All measurements, including anthropometrics, were repeated at this stage. Gaining or losing 3 Kg or more were considered as weight change and lower changes were considered as stable weight.

Statistical methods

All data were analyzed by the SPSS software (SPSS Inc., Chicago, IL, USA; version 15.0). To compare weight change between age groups, we used analysis of variance, and to compare general characteristics of participants across weight change groups, we used analysis of variance and chi-square where appropriate. Binominal confidence interval was used to assess the incidence of sliming and weight gain. To explore the associations between weight change determinants and weight gain or weight loss, we employed the multiple multinomial logistic regression method.

Results

Totally, 1680 women and 1604 men aged 35 years or older were included. The prevalence rates of underweight, overweight and obesity were 3.3%, 42.2% and 32.9% in females and 6.0%, 42.6% and 13.2% in males.

Table 1 shows the distribution of weight change status in age groups in men and women. As baseline age increased, the percentage of weight gain decreased (40.5% to 17.8% in female and 35.6% to 18.8% in male) while the percentage of weight loss increased in both sexes (17.0% to 32.5% in female and 16.3% to 33.5% in male) ($P < 0.001$).

Table 2 shows weight loss or gain based on BMI and WC during 7 years of follow-up separated by males and females. In general, weight gain was seen more than weight loss and the highest percentage was observed from normal to overweight (9.77%).

The associations between socioeconomic and behavioral determinants and weight change are shown in Table 3. Younger individuals gained weight more than older individuals ($P < 0.001$) and in individuals with lower education level, weight gain was higher ($P = 0.007$). In higher BMI categories in comparison with lower ones, the percentage of weight gain decreased while the percentage of weight loss increased. Diet (based on GDI) was significantly healthier in the weight loss group ($P < 0.001$). There were no significant differences for sex, marriage, job, physical activity, smoking and sleep duration between weight gain and weight loss groups.

Table 4 displays the determinants of weight gain and weight loss in full adjusted models. Weight gain was negatively (OR: 0.98, 95% CI: 0.97–0.99 in male and OR: 0.96, 95% CI: 0.95–0.98 in female) and weigh loss was positively (OR: 1.03, 95% CI: 1.01–1.05 in male and OR: 1.02, 95% CI: 1.01–1.04 in female) associated with age in both sexes. Although weight loss was not significantly related to education, education more than 12 years in females and between 6–12 years in males was negatively associated with weight gain. Overweight was positively associated with weight loss (OR: 1.59, 95% CI: 1.16–2.19) and negatively with weight gain (OR: 0.67, 95% CI: 0.51–0.88) in males but not in females. Obesity was significantly associated with weight loss in both sexes but negatively associated with weight gain only in females ($P < 0.001$). Smoking was positively related to weight loss in females ($P = 0.004$) and weight gain in males ($P = 0.043$).

Discussion

Worldwide, overweight and obesity have augmented over the last few decades probably because of changes in behavioral patterns. In the current study, we looked for weight changes during 7 years of follow-up and found that weight gain was more frequent than weight loss. We also showed that some factors are associated with long-term weight change, including education, smoking and age as well as initial weight status.

Lifestyle changes are probably the most significant reasons for weight gain and cause both men and women to gain extra weight. Within months after these changes, body weight reaches a new stable weight.[21] Even small increases in body weight could cause long-term adiposity and related metabolic dysfunction and chronic diseases.[22]

During 7 years of follow-up, this study found that the incidence of obesity for individuals who were initially overweight was 5.7%

Table 1. Frequency of body weight changes during 7 years of follow-up based on sex and age groups*.

	Total N (%)	Weight loss N (%)	Stable weight N (%)	Weight gain N (%)	*P*
Females					
Age groups (years)					<0.001
35–44	696 (41.4)	118 (17.0)	296 (42.5)	282 (40.5)	
45–54	537 (32.0)	123 (22.9)	253 (47.1)	161 (30.0)	
55–64	284 (16.9)	81 (28.5)	135 (47.5)	68 (23.9)	
≥65	163 (9.7)	53 (32.5)	81 (49.7)	29 (17.8)	
Males					
Age groups (years)					<0.001
35–44	652 (40.6)	106 (16.3)	314 (48.2)	232 (35.6)	
45–54	456 (28.4)	112 (24.6)	217 (47.6)	127 (27.9)	
55–64	305 (19.0)	84 (27.5)	147 (48.2)	74 (24.3)	
≥65	191 (11.9)	64 (33.5)	91 (47.6)	36 (18.8)	

* Individuals who gained or lost more than 3 Kg of weight were considered as having weight change and those who gained or lost less than 3 Kg were considered as having stable weight.

Table 2. Cumulative incidence of slimming and weight gain based on BMI and waist circumference during 7 years of follow-up.

	Male	Female	Total
	% (95% CI)	% (95% CI)	% (95% CI)
General obesity*			
Slimming			
Obese to overweight	4.24 (3.31–5.34)	7.02 (5.85–8.35)	5.66 (4.90–6.51)
Obese to underweight	0	0.06 (0.001–0. 3)	0.03 (0.00–0.17)
Obese to normal	0.44 (0.17–0.89)	0.83 (0.46–1.39)	0.64 (0.39–0.97)
Overweight to normal	7.42 (6.18–8.81)	4.46 (3.53–5.56)	5.90 (5.13–6.77)
Over weight to underweight	0.19 (0.04–0.55)	0.36 (0.13–0.77)	0.27 (0.13–0.52)
Normal to underweight	1.87 (1.27–2.66)	0.65 (0.33–1.17)	1.25 (0.89–1.69)
Weight gain			
Normal to overweight	11.53 (10.01–13.19)	8.09 (6.83–9.50)	9.77 (8.78–10.84)
Normal to obese	0.49 (0.21–0.98)	0.95 (0.54–1.54)	0.73 (0.47–1.09)
Overweight to obese	5.67 (4.59–6.92)	11.43 (9.95–13.05)	8.62 (7.68–9.63)
Underweight to overweight	0.19 (0.04–0.55)	0.59 (0.29–1.09)	0.39 (0.21–0.67)
Underweight to normal	2.49 (1.78–3.38)	1.73 (1.16–2.47)	2.10 (1.63–2.65)
Underweight to obese	0.12 (0.01–0.45)	0.12 (0.01–0.43)	0.12 (0.03–0.31)
Central obesity**			
Slimming			
Obese to normal	14.9 (13.2–16.7)	6.01 (4.92–7.26)	10.35 (9.33–11.4)
Obesity			
Normal to obese	12.5 (10.9–14.2)	6.84 (5.68–8.16)	9.59 (8.61–10.7)

*Based on categories of body mass index; **Based on waist circumference.

and 11.4% and the incidence of overweight for individuals who were initially normal was 11.7% and 8.9% in men and women, respectively. In another study, these percentages were 6.9% and 7.9% for overweight to obese and 23.0% and 13.8% for normal to overweight which show almost the same pattern worldwide.[23] We detected a negative association between weight gain and age in the current study. We also found that weight gain was more common in younger age groups in both sexes which is in line with other studies, indicating that the peak of obesity prevalence was at the age category of 35 to 44 years.[24,25] The lower frequency of overweight and obesity in older people is possibly attributable to weight loss ocurring in older age, the occurrence of chronic diseases that need weight loss or to the higher mortality in obese people.[26] However, another study showed that the risk of obesity increased with age.[27] A review suggested that young adulthood is a susceptible time for gaining weight and university students are at risk of weight gain, as well.[28]

Early literature presented information about the positive association between socioeconomic status and obesity.[14] Education, as one of socioeconomic status indicators, has been linked to weight change. An inverse relationship was observed between education level and obesity.[27] Higher education was inversely associated with weight gain in women in our study. Primarily, higher education level may be related to less healthy diet but eventually, this relationship reverses.[29] A study concluded that education level is a protective factor against obesity in countries in transition.[30] Another study revealed that waist to hip ratio and BMI were lower in higher educated individuals, especially women, possibly because of healthier diet[31] or because they have better knowledge of risks of overweight and obesity.[27]

Previous studies reported a link between marriage and higher BMI,[2] while others, including our study, failed to show such a relationship.[17] The causality of this relationship is also important. It has been reported that individuals in middle quintiles of the BMI

Table 3. Socioeconomic, behavioral, and biomedical determinants of weight change categories after 7 years of follow-up.

	Total	Weight loss	Stable weight	Weight gain	*P*
Number *n* (%)	3284	741(22.6)	1534(46.7)	1009(30.7)	
age	49.3 ± 10.32	52.1 ± 10.7	49.5 ± 10.3	46.9 ± 9.5	<0.001
Sex (male)	1604(48.8)	366(49.4)	769(50.1)	469(46.5)	0.186
Marriage	3074(93.6)	690(93.1)	1436(93.6)	948(94.0)	0.779
SES					
Education					0.007
0–5 years	2241(68.3)	529(23.6)	1014(45.2)	698(31.1)	
6–12 years	826(25.2)	158(19.1)	406(49.2)	262(31.7)	
>12 years	213(6.5)	51(23.9)	113(53.1)	49(23.0)	
Job					0.114
Manual workers	801(24.4)	179(22.3)	372(46.4)	250(31.2)	
Non-manual workers	679(20.7)	147(21.6)	321(47.3)	211(31.1)	
Retired	218(6.6)	60(27.5)	112(51.4)	46(21.1)	
Housewife	1574(47.1)	345(22.3)	708(45.8)	494(31.9)	
Student-not working	37(1.1)	10(27.0)	19(51.4)	8(21.6)	
BMI categories					<0.001
Underweight	151(4.6)	17(11.3)	69(45.7)	65(43.0)	
Normal weight	977(29.8)	135(13.8)	457(46.8)	385(39.4)	
Overweight	1392(42.4)	323(23.2)	669(48.1)	400(28.7)	
Obesity	764(23.3)	266(34.8)	339(44.4)	159(20.8)	
Behavioral					
GDI	1.02 ± 0.27	0.99 ± 0.28	1.02 ± 0.26	1.05 ± 0.26	<0.001
Physical activity (met.min/day)	898 ± 538	875 ± 516	900 ± 544	912 ± 544	0.358
Smoking	668(20.3)	145(19.6)	303(19.8)	220(21.8)	0.380
Sleep duration	7.61 ± 1.67	7.67 ± 1.78	7.60 ± 1.61	7.58 ± 1.67	0.499

Numerical values are presented as mean ± standard deviation; nominal values are presented as percentages.

Table 4. Determinants of weight gain and weight loss in full adjusted models*.

	Weight loss OR (95% CI)				Weight gain OR (95% CI)			
	Male	*P*	Female	*P*	Male	*P*	Female	*P*
age	1.03 (1.01–1.05)	0.001	1.02 (1.01–1.04)	0.005	0.98 (0.97–0.99)	0.016	0.96 (0.95–0.98)	<0.001
Marriage (single)	1.46 (0.49-4.39)	0.501	0.77 (0.51–1.18)	0.233	1.33 (0.45–3.95)	0.602	1.09 (0.74–1.61)	0.67
SES								
Education								
0-5 years	1		1		1		1	
6-12 years	1.05 (0.75–1.46)	0.790	0.82 (0.56–1.18)	0.275	0.55 (0.35–0.86)	0.009	0.57 (0.23–1.41)	0.226
>12 years	1.16 (0.71–1.88)	0.554	1.17 (0.49–2.75)	0.723	0.95 (0.72–1.27)	0.749	0.66 (0.48–0.90)	0.009
Job								
Housewife/Student	1		1		1		1	
Retired	0.62 (0.25–1.51)	0.292	2.08 (0.26–17.0)	0.49	1.28 (0.50–3.23)	0.61	2.82 (0.37–21.4)	0.325
Non-manual workers	0.98 (0.41–2.34)	0.956	1.10 (0.54–2.26)	0.79	1.47 (0.61–3.51)	0.392	0.94 (0.50–1.78)	0.860
Manual workers	1.09 (0.46–2.59)	0.843	1.83 (0.80–4.18)	0.152	1.77 (0.73–4.26)	0.204	1.59 (0.79–3.19)	0.956
BMI categories								
Normal	1		1		1		1	
Underweight	0.73 (0.37–1.45)	0.366	0.89 (0.28–2.83)	0.840	0.76 (0.47–1.25)	0.287	1.85 (0.98–3.51)	0.058
Overweight	1.59 (1.16–2.19)	0.004	1.39 (0.93–2.10)	0.111	0.67 (0.51–0.88)	0.003	0.76 (0.57–1.01)	0.061
Obesity	2.33 (1.50–3.61)	<0.001	2.66 (1.76–7.02)	<0.001	0.66 (0.43–1.01)	0.057	0.47 (0.33–0.66)	<0.001
Behavioral								
GDI	0.91 (0.54–1.52)	0.725	0.92 (0.56–1.51)	0.752	0.83 (0.52–1.35)	0.456	1.36 (0.85–2.18)	0.203
Physical activity	1.00 (1.00–1.00)	0.894	1.00 (1.00–1.00)	0.692	1.00 (1.00–1.00)	0.663	1.00 (1.00–1.00)	0.761
Smoking	1.00 (0.76–1.33)	0.977	2.99 (1.42–6.29)	0.004	1.29 (1.01–1.64)	0.043	0.86 (0.34–2.21)	0.761
Sleep duration	1.05 (0.96–1.14)	0.310	1.05 (0.97–1.13)	0.229	0.98 (0.90–1.05)	0.517	0.96 (0.90–1.03)	0.283

*Adjusted for other parameters in the table and Stable weight is the reference group for the weight gain/loss.

were more likely to be married than those in the lowest and highest quintiles[32] and that overweight individuals married less often.[33]

Better dietary habits such as Mediterranean diet was negatively correlated with BMI[34,35] and Western diet (high in red and processed meat, potatoes, refined grains, sweets, and desserts) was related to weight gain.[28,36] However, some studies could not find such a relationship[37] or it disappeared after adjusting for potential confounders.[38] In the present study, the association between GDI and weight change became non-significant after adjusting for other variables in Table 4. It has been argued that other variables, such as age and previous weight loss, are more effective determinants of weight change than dietary habits.[39] Although changes in dietary pattern may affect the body weight, it has a finitude effect and finally remain constant.[38]

Physical activity is an important indicator of total energy expenditure and may be an important factor to be considered; therefore, it has been supposed that it affects body weight.[24] Negative association between physical activity and obesity indices revealed that most inactive individuals have higher BMI.[24,40] Prior studies have revealed that activity changes was correlated with long term change in body weight,[21,41] while in a study comparing obese and normal weight individuals, total physical activity was not significantly different after adjustment for age.[13] It has been reported that among overweight and obese subjects, 83.2% of women and 41.6% of men were very active[30] and that physical activity may be less important than previously thought.[14,42] Consistent with the latter studies, our analysis did not show an association between physical activity and weight changes. It has been reported that the level of physical activity is variably related to weight change only for some people[30] or some types of activities.[43] Working or different types of job did not affect weight change in either sex. In one study, work-related activities were not associated with obesity[44] while in another study, sitting time was associated with body weight.[45] The status of employment had a significantly positive effect on weight in men but not in women. A possible reason for this association was supposed to be the off-the-job costs for physical exercise.[46] Adverse effects of smoking have been previously addressed. Some studies reported that weight gain could be a consequence of smoking cessation,[47] and weight gain was lower in smokers than never-smokers or quitters.[48] Negative association between BMI and smoking was reported in some studies.[24,40] We also found that smoking was positively associated with weight loss in females and with weight gain in males. It has been proposed that smoking harmfully alters the distribution of body fat and increases central obesity which causes adverse metabolic functions[30]; therefore, weight loss related to smoking has no beneficial effect on body health and should be considered harmful. It is thought that sleep duration is negatively related with increased weight,[49] while cross-sectional studies[50,51] showed a positive relationship between body weight and sleep duration; however, they could not find any relationship with prospective obesity. The association between long sleep duration and obesity might be explained by depression, social isolation or low socioeconomic status.[52] On the other hand, the relationship between sleep deprivation and weight gain might be due to increase in calorie intake, hunger, and hyperphagia[53]; but investigations failed to find the association between sleep deprivation and food intake.[50] No association was observed between sleep duration and weight change in our study. The literature proposed that the association between weight and sleep duration may decline with age.[49,51] Residual confounders or reverse causation might elucidate this different relationship. Future investigations should illustrate how changes in sleep duration over time are associated with weight changes.[21] Obesity is not a homogeneous disorder and we do need improvements in our knowledge through prospective studies to find strategies to protect us from risks of its related diseases.

It has been reported that smoking is lower and diet is healthier in highly educated individuals.[54] A positive association has been observed between socioeconomic status and physical activity and there was a strong link between social class and willing to be thin in women.[55] Moreover, obese people may avoid or choose specific food items or exercise more because of their present body weight status.[27]

Our study has some limitations; we were unable to calculate energy expenditure and energy intake, both of which are important determinants of obesity. Furthermore, there may be other possible confounders such as genetic factors that we did not consider in this study. We also could not evaluate the total sedentary activities including working with computer, reading and watching TV. Physical activity and dietary intake data were self-reported that could be underestimated or overestimated. In spite of these limitations, the main strength of the current study was that it consisted of a large population-based sample from three counties and included both rural and urban areas. It enabled us to understand the pattern of weight change and its determinants in Iran that is important to develop strategies to prevent and control overweight and obesity.

Conclusion

In conclusion factors like smoking and education were important determinants of obesity in Iran. However, obesity is not a homogeneous disorder and improvements in our knowledge through prospective studies are needed to help us finding protective strategies. The current study focused only on some determinants of weight change. Future studies should evaluate other determinants such as calorie intake, energy expenditure, and genetic factors.

Acknowledgements

This cohort study was carried out by the ICRC affiliated to the Isfahan University of Medical Sciences. We are grateful to the Isfahan Provincial Health Center, Najaf-Abad Health Office and Arak University of Medical Sciences. We would also like to extend n sincere appreciation to the ICS team who conducted this large cohort.

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