Incidence of Overweight and Its Predictors in Adults after 10 Years of Follow-up: Yazd Healthy Heart Project

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ABSTRACT

Background: Obesity and overweight are important public health problems which are rapidly growing throughout the world. This study aims to provide 10-year incidence estimates of obesity and overweight in adults along with their risk factors in an Iranian adult population. **Methods:** This cohort study was conducted within the framework of the Yazd Healthy Heart Project (YHHP) throughout phases from 2005-2006 to 2015-2016 among urban adult population. The participants comprised of 1000 males and 1000 females aged 20-74 years from urban areas of Yazd. Cox proportional hazards model was used to examine the potential risk factors for obesity and overweight. **Results:** A total of 2000 participants aged 47.09 ± 16.97 years and body mass index (BMI) of 21.99 ± 2.21 kg/m^2 were entered in this study at baseline. After 10 years of follow-up, the cumulative incidence of overweight for the entire population was 38.6% (41.6% in women and 36.8% in men). Furthermore, the 10-year cumulative incidence of obesity was 14.8% in the population (20.8% for women and 10.5% for men). Female participants showed a significantly higher incidence rate compared to males either for obesity or overweight. Regarding risk factors, there was a significant association between non-smoking (HR= 1.54, 95% CI: 1.06-2.25), socio-economic status (HR= 1.82, 95% CI: 1.13-2.94), and education (HR= 1.56, 95% CI: 1.14-2.13) with overweight ($P < 0.05$). **Conclusion:** This study revealed the incidence rate of obesity and overweight is significantly high in adult population of Yazd, Iran especially in women. The most important predictors of overweight seem to be smoking, lower socio-economic status, and education.

Keywords: *Overweight; Obesity; Incidence; Cohort; Risk factors*

Introduction

Excessive weight gain as a global epidemic is one of the major health threats in the world (Lim *et al.*, 2020), which is rising more rapidly in developing countries, such as Iran (Prentice, 2005,

Rahmani *et al.*, 2015). Although under-nutrition had been a major nutrition-related concern to most of countries around the world for many years, recently a rapid increase in the mean weight of populations has caught the professionals' attention. It is due to the fact that obesity and overweight have shown to be associated with major chronic diseases, such as cardiovascular diseases (Dwivedi *et al.*, 2020), diabetes, and cancer (Lega and Lipscombe, 2020) which are the most common leading causes of death.

According to the WHO, the worldwide prevalence of obesity was tripled between 1975 and 2016; ended in 39% of adults being overweight and 13% being obese in 2016 (World Health Organization, 2017). In addition, the prevalence of Iranian adults with overweight and obesity has been shown to be 36.6% and 22.7% in 2016, respectively (Djalalinia *et al.*, 2020). In a 20-year cohort study conducted in Tehran, the prevalence of overweight and obese adults was reported 20.8% and 63.6%, respectively (Barzin *et al.*, 2018b). In a 5-year follow-up study in Yazd, the prevalence of obesity and overweight was reported 27.1% and 38.5% in 2014, respectively (Ghadiri-Anari *et al.*, 2013). Although many of the Iranian studies have reported the prevalence of adulthood obesity and overweight, a few studies have been conducted on their incidence rates, most of which were conducted on populations other than Yazd (Barzin *et al.*, 2018a, Erfanifar *et al.*, 2021, Hosseinpanah *et al.*, 2016, Nemesure *et al.*, 2008, Sarebanhassanabadi *et al.*, 2017). Further incidence studies are required to determine the potential predictors for developing excessive weight in adults of Yazd province. In spite of the importance of excessive weight gain, there is limited knowledge regarding the factors related to the increasing levels of overweight and obesity to develop appropriate prevention strategies. This longitudinal population-based cohort study was conducted to establish obesity and overweight incidence in adults living in urban areas of Yazd and to assess the potential predictors of these two common public health problems in the same population.

Materials and Methods

Study population: This cohort study was carried out within the framework of the Yazd Healthy Heart Project (YHHP), a population based cohort study. The selection process of participants was described in detail elsewhere (Sarebanhassanabadi *et al.*, 2017). In total 2000 participants (50% males) aged 20-74 years were recruited to the YHHP using a cluster random sampling method over 2005-2006 from the urban population of Yazd. Every individual was contacted, invited to the Yazd cardiovascular research center (YCRC) and recruited to participate in the study for further measurements and next follow-ups. Twenty two participants were excluded from the study due to missing data. In the latest phase of the project in 2015-2016, individuals were invited to YCRC again for follow-up. The data were collected by a researcher made questionnaire validated using content validity during 2005–2006. The details of the questionnaire included demographic information, anthropometric parameters, and lipid profiles, smoking status, educational levels, socioeconomic status, and physical activity.

In the current study, all the 2000 participants were participated to determine the incidence of obesity and overweight separately and their predictors. After excluding those who were obese at the baseline and those who had consumed glucocorticoids or other hormonal drugs (total number of excluded participants N = 376); 1602 participants remained. Of these participants, 534 had no further follow-ups. Final analysis was performed on 1068 participants (taking into account a drop-out rate of 33.3%, **Figure 1**). For those who were recognized as overweight participants, after excluding those who were overweight or those who had consumed glucocorticoids or other hormonal drugs at the baseline; 810 participants remained. Of these, 294 participants refused to follow the study. The final analysis was done on 516 participants (**Figure 2**).

Measurements and definitions: To reduce subjective errors, trained staff were responsible for collecting data, measurements, and demographic

information.

Weight was assessed regarding standard protocols when patients were minimally clothed by an electronic scale (Omron Karada Body Scan and Scale, Model BF511, Omron Co. Osaka, Japan) with an accuracy of up to 0.1 kg. Height was strictly measured without footwear using wall-mounted stadiometer, to the nearest 0.1 cm. To measure waist circumference (WC), the narrowest level over light clothing was selected using an un-stretched tape, without any pressure to body surface, and measurements were recorded to the nearest 0.1 cm. In addition, cut-off point of WC was determined as ≥102 cm for men and ≥88 cm for women (National Cholesterol Education Program Adult Treatment Panel III, 2002). Body mass index (BMI) was calculated as weight in kilograms divided by the height in squared meters (kg/m^2). Obesity and overweight were defined according to the World Health Organization (WHO): BMI≥٢۵ as being overweight and BMI ≥30 kg/m^2 as being obese (World Health Organization, 2017).

A qualified physician, using an automatic digital blood pressure monitor (model M6 Comfort; Omron Co.), measured systolic and diastolic blood pressure two times on the right arm, with the participant in a seated position, asked to rest for 15 min period between measurements. The mean of the two measurements was considered to be the participant's blood pressure. Blood samples were drawn from all the study participants after an overnight fasting of 12–14 h. All blood analyses were performed at the research laboratory on the day of blood collection. Fasting blood sugar (FBS) was measured by the enzymatic colorimetric method using glucose oxidase. Plasma triglyceride (TG) levels were measured by enzymatic colorimetric kits using cholesterol esterase/cholesterol oxidase and glycerol phosphate oxidase, respectively. High-density lipoprotein cholesterol (HDL-C) was measured after precipitation of the apolipoprotein B–containing lipoproteins with phosphotungstic acid.

Economic status was classified in to three groups (low, moderate, and high) based on scoring variables, including home area (square meters), household income, and owning a private car. In addition, based on educational level (primary school, high school, diploma, academic degree), participants were divided into three categories of low, moderate, and high. International physical activity scoring system was utilized for dividing participants in to three groups of low, moderate, and vigorous physical activity levels. Moreover, smoking habit was recorded for each participant and they were classified in to two categories of smokers and non-smokers. The details were reported in a previous study (Sarebanhassanabadi *et al.*, 2018).

Ethical consideration: Ethical approval of the current study was obtained from the Ethics Committee of Shahid Sadoughi University of Medical Sciences in Yazd, Iran (ethical code: IR.SSU.MEDICINE.REC. 1395.287). Also, informed consent was obtained from all participants at the first and second phases of the study.

Data analysis: Statistical Package for Social Sciences (SPSS 19, IBM Corporation, New York, USA) was used to analyze of the data. Student t-test was used for comparison of continuous variables, including age, weight, BMI, systolic and diastolic blood pressure, TG, HDL-cholesterol, and WC between two groups of completed and lost to follow-up. Chi-square test was used for the comparison of categorical data, including gender, smoking, economic status, physical activity, and educational levels. In this study, P-value of less than 0.05 was considered as significant level. Cox proportional hazards model was used to estimate the risk of overweight and obesity after a 10-year follow-up considering age, gender, smoking, economic status, physical activity, and educational levels.

Results

The baseline characteristics of the participants without overweight who were lost to follow-up and those completing the study are shown in **Table 1**. As indicated, there were significant differences in age, weight, systolic blood pressure, socioeconomic status, and education. The participants in the follow-up group were significantly younger, had higher body weight, and lower systolic blood pressure compared to another group. **Table 4** reveals that the participants

without obesity in the follow-up group were significantly younger, had higher body weight, BMI, and waist circumference and they had lower fasting blood glucose and systolic blood pressure compared to those who lost to follow-up. Moreover, education ($P = 0.001$) and socioeconomic status ($P = 0.001$) were significantly different between the follow-up and lost to follow-up groups. There was no significant difference in diastolic blood pressure, TG, HDL-C, physical activity, and smoking between the two groups.

The annual incidence rate of overweight in men, women, and total population was 3.7%, 4.2%, and 3.9%, respectively. The annual incidence rate of obesity in men, women, and total population was 1.06%, 2.1%, and 1.49%, respectively (**Table 5**).

Table 2 indicates that the overall incidence of overweight during 9.8-year follow-up was 38.37/1000 person-year. Indeed, the incidence of overweight in women was greater than men, 41.43/1000 person-year in women and 37.22/1000 person-year in men, but there was no significant difference between the two groups. However, the incidence of obesity in women was significantly higher than men (**Table 6**).

Elderly participants aged 65-74 years had a lower risk of developing overweight compared to the participants aged 20-30 years (**Table 2**). Older participants had a greater risk of obesity which was not significant in different age groups except for the participants aged 30-39 years (Table 6). Among remaining predictive variables, moderate level of education and economic status showed significant association with developing the risk of overweight (**Table 2**). Furthermore, non-smoking was significantly associated with higher risk of obesity and overweight. There was no significant difference between the variables of physical activity, education, and economic status with the risk of obesity (**Table 6**).

Table 3 represents the association between predictive variables and hazard ratio for overweight based on gender. The lowest rate of incident overweight was observed in men aged 65-74 years (HR = 0.44, 95% CI: 0.20 – 0.97) compared to the participants aged 20-30 years. Non-smoking was also significantly associated with higher risk of overweight in men (HR = 1.57, 95%CI: 1.05-2.36) and total population (HR = 1.54, 95%CI: 1.06-2.25). There was no significant difference between the risk of overweight and other variables, including physical activity, education, and economic status in males. In females, only moderate educational level was significantly associated with higher risk of overweight (HR = 2.03, 95%CI: 1.23 – 3.35).

The risk of obesity in men and women is reported in **Table 7**. There was no significant difference between the risk of obesity and all categorized variables except for age in women.
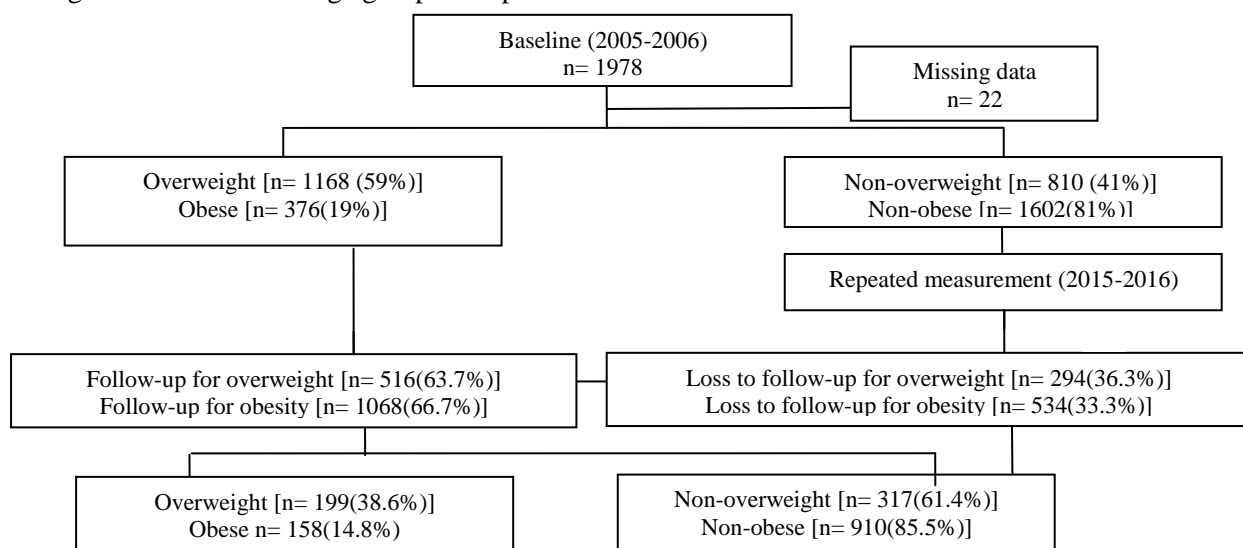

Figure 1. Flow diagram showing recruiting process during a 10-year follow-up study for overweight and obesity

Table 1. Characteristics of the follow-up and lost to follow-up in non-overweight participants at the baseline.

Variables	Follow-up	Lost to follow-up	Total	P-value[a]
Age (year)	44.09 ± 15.47[b]	52.35 ± 18.20	47.09 ± 16.97	<0.001
Weight (kg)	62.80 ± 9.34	59.43 ± 9.31	61.57 ± 9.46	<0.001
BMI (kg/m^2)	22.14 ± 2.17	21.73 ± 2.26	21.99 ± 2.21	0.11
Systolic blood pressure (mmHg)	123.58 ± 14.66	127.23 ± 16.58	124.90 ± 15.47	0.002
Diastolic blood pressure (mmHg)	80.37 ± 8.54	81.15 ± 8.85	80.65 ± 8.66	0.218
Fasting blood glucose (mg/dl)	95.45 ± 40.36	99.50 ± 46.69	96.92 ± 42.77	0.214
Triglyceride (mg/dl)	150.27 ± 96.15	149.00 ± 86.82	149.81 ± 92.83	0.851
HDL-cholesterol(mg/dl)	53.62 ± 14.60	55.38 ± 14.66	54.26 ± 14.64	0.100
Waist circumference (cm)	84.76 ± 9.60	84.26 ± 9.37	84.58 ± 9.51	0.476
Gender				
Male	326 (63.2)[c]	166(56.5)	492(60.7)	0.062
Female	190 (36.8)	128(43.5)	318(39.3)	
Current smokers	110 (21.3)	78(26.5)	188(23.2)	0.100
Socioeconomic status				
Low	70 (28.7)	52(42.3)	122(33.2)	0.006
Moderate	106 (43.4)	52(42.3)	158(43.1)	
High	68 (27.9)	19(15.4)	87(23.7)	
Physical activity				
Low	225 (62.3)	146 (70.5)	371 (65.3)	0.095
Moderate	118 (32.7)	50 (24.2)	168 (29.6)	
Vigorous	18 (5.0)	11 (5.3)	29 (5.1)	
Education				
Low	249 (51.2)	198 (68.5)	447 (57.7)	<0.0001
Moderate	173 (35.6)	70 (24.2)	243 (31.4)	
High	64 (13.2)	21 (7.3)	85 (11.0)	

[a]:Chi-square used for categorical variables and ANOVA test used for quantitative variables ; [b]: mean ± SD; [c]: n (%)

Table 2. Hazard ratio of overweight after a 10-year follow-up.

Variables		At risk (n)	Person year	Cases (n)	Incidence/1000 person-year	Hazard ratio HR(95%CI)
Age groups (y)	20-30	126	1260.60	50	39.66	1
	30-39	90	898.66	44	48.96	0.99(0.65-1.49)
	40-49	102	1005.86	46	45.73	1.35(0.90-2.03)
	50-65	135	1327.71	43	32.38	0.77(0.51-1.17)
	≥65	63	637.51[b]	16	25.09	0.50(0.28-0.88)
Gender	Male	326	3223.54	120	37.22	1
	Female	190	1906.80	79	41.43	1.03(0.78-1.37)
Smoking	Smoker	110	1097.32	33	30.07	1
	Non-smoker	406	4033.02	166	41.16	1.54(1.06-2.25)
Socioeconomic status	Low	70	721.02	28	38.83	1
	Moderate	106	1067.30	48	44.97	1.82(1.13-2.94)
	High	68	682.46	20	29.30	0.98(0.55-1.74)
Physical activity	Low	225	2235.13	81	36.23	1
	Moderate	118	1169.35	44	37.62	1(0.69-1.44)
	Vigorous	18	180.34	9	49.90	1.36(0.68-2.73)
Education	Low	249	2490.48	93	37.34	1
	Moderate	173	1694.08	74	43.68	1.56(1.14-2.13)
	High	64	644.62	20	31.02	0.79(0.48-1.29)
Total		516	5130.34	199	38.37	-

Table 3. Hazard ratio of overweight based on gender after a 10-year follow-up.

Variables	Men					Women				
	At risk (n)	Person year	Cases (n)	Incidence/1000 person-year	Hazard ratio HR(95%CI)	At risk (n)	Person year	Cases (n)	Incidence/1000 person-year	Hazard ratio HR(95%CI)
Age groups (y)										
20-30	78	778.47	32	41.10	1	48	482.13	18	37.33	1
30-39	56	561.50	26	46.30	0.88(0.52-1.49)	34	337.17	18	53.38	1.23(0.64-2.39)
40-49	66	652.68	26	39.83	1.12(0.66-1.89)	36	353.17	20	56.62	1.80(0.95-3.42)
50-65	86	828.77	28	33.78	0.91(0.54-1.51)	49	498.94	15	30.06	0.58(0.29-1.16)
≥65	40	402.12	8	19.89	0.44(0.20-0.97)	23	235.39	8	33.98	0.52(0.22-1.22)
Smoking										
Yes	108	1075.78	33	30.67	1	-	-	-	-	-
No	218	2147.75	87	40.50	1.57(1.05-2.36)	-	-	-	-	-
Socioeconomic status										
Low	46	466.23	17	36.46	1	24	254.79	11	43.17	1
Moderate	78	782.18	36	46.02	1.68(0.93-3.01)	28	285.12	12	42.08	2.22(0.91-5.39)
High	49	490.60	13	26.49	0.80(0.38-1.65)	19	191.87	7	36.48	1.61(0.60-4.29)
Physical activity										
Low	159	1564.40	60	38.35	1	66	670.73	21	31.30	1
Moderate	79	781.38	28	35.83	0.91(0.58-1.43)	39	387.97	16	41.24	1.23(0.64-2.37)
Vigorous	16	159.40	7	43.91	1.06(0.48-2.34)	2	20.94	2	95.51	4.03(0.92-17.61)
Education										
Low	134	1331.64	50	37.54	1	115	1158.84	43	37.10	1
Moderate	118	1147.14	46	40.09	1.38(0.92-2.07)	55	546.94	28	51.19	2.03(1.23-3.35)
High	51	517.05	16	30.94	0.67(0.38-1.18)	13	127.58	4	31.35	1.74(0.61-4.94)
Total	326	3223.54	120	37.23	-	190	1906.8	79	41.43	-

Table 4. Baseline characteristics of the follow-up and lost to follow-up participants in obese and non-obese participants.

Variables	Follow-up	Lost to follow-up	Total	P-value[a]
Age (year)	46.5 ± 14.4[b]	51.9 ± 17.1	43.8 ± 15.4	0.001
Weight (kg)	68.9 ± 11.0	65.1 ± 11.3	48.3 ± 15.5	0.001
Body mass index (kg/m^2)	24.8 ± 3.1	24.2 ± 3.3	24.6 ± 3.2	0.004
Systolic blood pressure (mmHg)	126.7 ± 15.3	129.1 ± 6.9	127.5 ± 15.9	0.007
Diastolic blood pressure (mmHg)	82.0 ± 8.8	82.2 ± 9.1	82.1 ± 88.9	0.569
Fasting blood glucose (mg/dl)	99.1 ± 40.5	106.7 ± 54.1	101.6 ± 45.6	0.004
Triglyceride (mg/dl)	171.1 ± 106.1	171.3 ± 114.7	171.2 ± 109.0	0.983
HDL-cholesterol(mg/dl)	53.5 ± 13.6	54.3 ± 13.8	53.8 ± 13.6	0.267
Waist circumference (cm)	90.9 ± 10.6	89.6 ± 10.8	90.5 ± 10.7	0.020
Gender				
Male	621 (58.1)[c]	260 (48.7)	881	0.001
Female	447 (41.9)	274 (51.3)	721	
Current smokers	205 (19.2)	110 (20.6)	315	0.627
Socioeconomic status				
Low	134 (26.5)	84 (40.2)	218	0.001
Moderate	207 (41.0)	81 (38.8)	288	
High	164 (32.5)	44 (21.1)	208	
Physical activity				
Low	498 (66.0)	267 (73.0)	765	0.062
Moderate	219 (29.0)	84 (23.0)	303	
Vigorous	38 (5.0)	15 (4.1)	53	
Education				
Low	561 (54.4)	355 (67.5)	916	0.001
Moderate	353 (34.2)	132 (25.1)	458	
High	118 (11.4)	39 (7.4)	157	

[a]:Chi-square used for categorical variables and ANOVA test used for quantitative variables ; [b]: mean ± SD; [c]: n (%)

Table 5. Cumulative and annual risk of overweight and obesity based on gender and total population.

Variables	At risk (n)	Loss to follow-up (n)	Cases (n)	9.9-yr cumulative incidence rate (%)	Annual incidence rate (%)
Overweight					
Men	492	166	120	36.8	3.7
Women	318	128	79	41.6	4.2
Total	810	294	299	38.6	3.9
Obesity					
Men	621	260	65	10.5	1.06
Women	447	274	93	20.8	2.1
Total	1068	534	158	14.8	1.49

Table 6. Hazard ratio of obesity after a 10-year follow-up.

Variables	At risk (n)	Person year	Cases (n)	Incidence/1000 person-year	Hazard ratio HR(95%CI)
Age groups (year)					
20-30	177	1778.81	20	11.24	1
30-39	190	1884.75	42	22.28	2.07(1.21-3.54)
40-49	243	2407.73	34	14.12	1.44(0.83-2.51)
50-59	219	2148.87	35	16.28	1.62(0.93-2.81)
≥60	239	2392.73	27	11.28	1.03(0.57-1.84)
Gender					
Male	621	6142.5	65	10.58	1
Female	447	4470.38	93	20.80	1.77(1.28-2.44)
Smoking					
Yes	205	2049.26	20	9.75	1
No	862	8554.48	138	16.13	1.74(1.09-2.79)
Socioeconomic status					
Low	134	1361.8	21	15.42	1
Moderate	207	2068.01	29	14.02	1.01(0.57-1.78)
High	164	1644.38	29	17.63	1.39(0.79-2.44)
Physical activity					
Low	498	4951.97	78	15.75	1
Moderate	219	2192.03	28	12.77	0.82(0.53-1.26)
Vigorous	38	381.76	5	13.09	0.82(0.33-2.02)
Education					
Low	561	5592.9	90	16.09	1
Moderate	353	3479.83	52	14.94	1.004(0.71-1.41)
High	118	1176.07	12	10.20	0.6(0.33-1.1)
Total	1068	10612.88	158	14.88	

Table 7. Hazard ratio of obesity based on gender after a 10-year follow-up.

Variables	Men					Women				
	At risk (n)	Person year	Cases (n)	Incidence/1000 person-year	Hazard ratio HR(95%CI)	At risk (n)	Person year	Cases (n)	Incidence/1000 person-year	Hazard ratio HR(95%CI)
Age groups (year)										
20-30	101	1013.29	20	19.73	1	76	765.52	8	10.45	1
30-39	104	1036.03	19	18.33	1.55(0.75-3.3.19)	86	848.71	23	27.09	3.02(1.34-6.79)
40-49	144	1426.31	12	8.41	0.91(0.40-2.05)	99	981.42	22	22.41	2.33(1.03-5.24)
50-59	127	1242.23	12	9.66	0.89(0.39-2.02)	92	906.64	23	25.36	2.78(1.24-6.26)
≥60	145	1426.64	10	7	0.72(0.31-1.69)	94	968.09	17	17.56	1.45(0.62-3.37)
Smoking										
Yes	199	1987.26	17	8.55	1	6	62	3	48.38	1
No	422	4155.24	48	11.55	1.47(0.84-2.57)	441	4408.38	90	20.41	0.53(0.16-1.68)
Socioeconomic status										
Low	79	797.08	9	11.29	1	55	564.71	12	21.24	1
Moderate	147	1453.91	18	12.38	1.59(0.68-3.68)	60	614.10	11	17.91	0.71(0.30-1.68)
High	112	1114.29	14	12.56	1.39(0.58-3.32)	52	530.09	15	28.29	1.59(0.74-3.43)
Physical activity										
Low	324	3181.72	34	10.68	1	174	1770.25	44	24.85	1
Moderate	133	1327.75	12	9.03	0.66(0.33-1.31)	86	864.27	16	18.51	0.89(0.49-1.59)
Vigorous	30	302.97	2	6.60	0.45(0.10-1.91)	8	78.79	3	38.07	2.27(0.69-7.42)
Education										
Low	268	2661.81	26	9.76	1	293	2931.09	64	21.83	1
Moderate	228	2235.04	25	11.18	1.12(0.64-1.96)	125	1244.80	27	21.69	1.05(0.67-1.65)
High	98	975.90	12	12.29	0.95(0.47-1.91)	20	200.16	0	-	-
Total	621	6142.50	65	10.58		447	4470.38	93	20.80	

Discussion

This present study provided the incidence estimates for obesity and overweight after 9.8-year follow-up in Yazd. The findings indicated a high incidence of obesity and overweight in a 9.8 year follow-up of. It is revealed that the incidence of obesity was higher in women than men. Nevertheless, the incidence of overweight in women was greater than men, but there was no significant difference between two groups. Among predictive variables, moderate economic status and moderate education were considerably associated with higher risk of overweight. However, non-smoking was significantly associated with higher risk of overweight and obesity. Limited studies are conducted on the incidence of obesity and overweight. Indeed, most published reports are based on cross-sectional studies which are useful to provide the prevalence estimates (Ayatollahi and Ghoreshizadeh, 2010, Ghadiri-Anari *et al.*, 2013, Kiadaliri *et al.*, 2015). Due to discrepancies in culture, socio-behavioral habits, ethnicity and socioeconomic status, the incidence rate may be different in various populations. In a study conducting by Pan *et al*. on 432,607 participants in the United States, the overall crude incidence of obesity was reported 4% per year which was higher than the incidence of obesity in the current study (1.49%) (Pan *et al.*, 2011). Furthermore, a study indicated that the incidence of obesity significantly decreased by increasing the level of education. However, this association was not significant in the current study. A study also reported that the incidence of obesity was higher in the current and former smokers, which is not in line with the present study. However, findings from other studies examining the association between smoking and BMI or prevalence of obesity were similar to the current study. However, there was no conclusive evidence between smoking and increasing or decreasing incidence rate of weight gain (Lahti-Koski *et al.*, 2002, Tavani *et al.*, 1994). Higher incidence rate of obesity in women was reported by Nemesure *et al.* They reported that the incidence of obesity was 6.9% in men and 13.1% in women, which is in

agreement with the present study. They have also revealed that the incidence rate of overweight was 22.6% and 24.1% for men and women, respectively (Nemesure *et al.*, 2008). However, the greater incidence of overweight in women compared to men was not significant in the current study. Ortiz-Moncada have reported higher incidence of obesity in women compared to men (29.9% vs. 13.1%, respectively) by following 1008 participants after 8-year follow-up (Ortiz-Moncada *et al.*, 2010). In this study, there was no significant difference between economic and smoking status and changes in BMI over the time. However, the findings of the current study indicated that the incidence rate of obesity and overweight was significant in some variables, such as smoking. Furthermore, in the present study, moderate economic status significantly increased the incidence of overweight. On the other hand, Vasan *et al.* have reported that the incidence of obesity was higher in men according to data from Framingham Heart Study (Vasan *et al.*, 2005). The higher incidence of obesity in women may be justified with high level of unemployment in women in Iran (Hasani, 2013), contributing to obesity (Laitinen *et al.*, 2002). In a study by Hosseinpanah in Tehran, the capital of Iran, during a median of 8-year follow-up, the cumulative incidence of obesity was reported 31.3% (CI: 29.9%–32.7%), 38.1% (CI: 36.2%–40.1%), and 23.4% (CI: 21.6%–25.3%) for total population, women, and men, respectively (Hosseinpanah *et al.*, 2016). However, the cumulative incidence of obesity in the present study was 12.9% in women and 7.4% in men. Similar to the current study, they reported that participants with lower educational level were at higher risk of obesity.

This study was the first cohort study in Yazd to ascertain the incidence of obesity and overweight. The current study had some limitations. First, given that the study was conducted on Yazd population, it cannot be generalized to the general population. Second, due to unavoidable factors, such as migration and death, 33% and 36% of obese and overweight participants were lost to

follow-up. Third, in the current study, repeated measurements were done after 10 years; therefore, the real time of occurrence of overweight and obesity were lost. Fourth, changes of lifestyle could not be checked during the past 10 years. However, the current study had numerous strengths. It is a population-based study with long-term follow-up which assessed the incidence rate of obesity and overweight and its risk factors.

Conclusion

In conclusion, this population-based study reported that the incidence of obesity was higher in women compared to men. The most important predictors of overweight seem to be smoking, lower socio-economic status, and education. Increasing trend of obesity prevalence in Iran as a developing country has heightened concerns about risk of various diseases and medical conditions imposing public health burdens. Therefore, it is necessary to develop health-care plans to decrease incidence of obesity and overweight, especially in women.

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Conflict of interest statement

The authors declare that there is no conflict of interest in the study.

Authors' contributions

1) Sarebanhassanabadi M, Namayandeh SM and Salehi-Abargouei A conceived and designed the experiments;

2) Sarebanhassanabadi M and Namayandeh SM performed the experiments;

3) Sarebanhassanabadi M, Pakseresht MR, Beiki O, and Salehi-Abargouei A analyzed and interpreted the data;

4) Sarebanhassanabadi M, Namayandeh SM and Salehi-Abargouei A contributed reagents, materials, analysis tools or data;

5) Moghtaderi F, Sarebanhassanabadi M and Hosseini S wrote the paper;

6) Pakseresht MR, Beiki O, Seyed Hosseini SM, Namayandeh SM, Emami M, and Salehi-Abargouei A revised the paper.

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