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ORIGINAL ARTICLE

Factors associated with overweight and obesity in adults using structural equation model: mediation effect of physical activity and dietary pattern

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Abstract

Purpose This study aimed to determine the indirect effect of risk factors associated with overweight and obesity through physical activity (PA) and dietary pattern (DP), using structural equation model in the adults' population.

Methods This cross-sectional study was conducted on 10,000 adults from baseline data of Ravansar Non Communicable Disease cohort study, in the west region of Iran in 2018. Structural equation modeling was used to assess the causal effects of associated factors on obesity and overweight as the outcome.

Results In general, the population at higher economic level was significantly more dependent on the healthy DP. The direct effect of socioeconomic status (SES) on overweight and obesity was −0.070, the indirect effect was 0.127, and the total effect was 0.057. When stratified by gender, in women, SES had a weak direct effect ($\beta = 0.024$) and indirectly, through the variables of PA and DP, had a significant effect ($\beta = 0.088$) on the outcome. The same situation has been observed in men. That is a weak direct effect of SES ($\beta = 0.070$) and a significantly indirect effect, through three variables such as PA, DP, and smoking status, on the outcome.

Conclusion Factors associated with overweight and obesity not only by direct effect, but also can indirectly and through mediators (such as DP and PA as two important mediation variables) cause this outcome.

Level of evidence Level V, cross-sectional descriptive study.

Keywords Obesity · Overweight · Physical activity · Dietary pattern · Socioeconomic status · Structural equation modeling

Introduction

According to the World Health Organization (WHO), overweight and obesity are the fifth leading cause of death worldwide and a major risk factor for chronic diseases such as diabetes, cardiovascular disease, cancer, sleep apnea, and poor physical health [1]. Approximately, 44% of diabetes, 23% of ischemic heart disease, 7–41% of all types of cancers are related to overweight and obesity [1–4]. In addition, there is an increasing trend of prevalence of

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overweight and obesity in both developed and developing countries with much more reporting in developed countries compared to the developing ones [5].

Obesity is a multifactorial disorder caused by complex biological, behavioral, and environmental interactions. A study on twins that lived apart and in different environments showed that environmental influences on obesity were more than genetic effects [6, 7]. The recent theory of the scientific community shows that the current epidemic of obesity is mainly due to behavioral factors such as unhealthy dietary pattern, increased intake of high-calorie foods, specific dietary behavior (having meals outside home), and low physical activity, which have been caused by the increasing urbanization and industrialization of societies [8–11]. The results of previous studies on the correlation between obesity-related variables showed contradictory results at different levels of the variables. Gender differences in the relationship between obesity and depression have been also reported with a significant relationship in women [12, 13].

It has also been shown that inequality in the socioeconomic status (SES), such as education, employment, and income in developed and developing countries, are associated with overweight and obesity [14, 15]. In addition to the abovementioned factors, several studies have examined age, sex, place of residence, sleeping hours, and smoking status as factors affecting the development of obesity and conflicting results have been reported from different regions of the world [9, 10, 16]. An important point that has recently been addressed in the etiology of overweight and obesity, but the limited study has been found, is the mediating role of risk factors on this outcome. The mediators support indirect relation on the development of the outcome.

Two important risk factors, which have been well studied their direct effects on overweight and obesity, are dietary pattern and physical activity. Considering the importance of these two risk factors, the present study aimed to determine the indirect effect of the risk factors associated with overweight and obesity through these two mediation factors, using the structural equation model (SEM) in the adults' population.

Materials and methods

Study design and participant

In this cross-sectional study, we used data from baseline phase for Ravansar Non Communicable Disease (RaNCD) cohort study, in the west region of Iran in 2018. It is a part of Prospective Epidemiological Research Studies in Iran (PERSIAN), conducted in different Iranian ethnicities, in coordination with the Ministry of Health and Medical Education. In fact, 10,000 adults have been recruited for RaNCD.

Ravansar is one of the cities of Kermanshah province. The city of Kermanshah (about 1,000,000 populations), is the center of the province and the largest and most important Kurdish settlement in the western region of Iran. The Ravansar district population is about 50,000 people, mainly from Iranian Kurdish ethnicity. There are three urban and two rural healthcare centers and also 32 active local primary health care units (health house) in rural areas in Ravansar district.

All of the participants, meeting the inclusion criteria have provided oral and written informed consent. Eligibility criteria in the cohort study comprised of being in the age range of 35–65 years, permanent inhabitants of the Ravansar region (Ravansar town and all villages in its vicinity), and having Iranian nationality.

In RaNCD study, the inclusion criteria were all participants in the first phase of the cohort. Exclusion criteria were unwillingness to attend the study, living in Ravansar less than 9 months a year, being a recent inhabitant of the Ravansar (less than 1 year), being unable to come to cohort center, or to communicate with interviewers (due to mental or physical disability, blindness, deafness, dumbness, and affected by any acute psychological disorder).

Exclusion criteria for present were pregnant women, chronic diseases such as cancers and thyroid disorders, use of thyroid drugs, insulin and diabetes treatment, use of drugs to increase or decrease weight, and hormonal medications.

Socio-demographic and economic characteristics such as age, sex, job, education, welfare and medical information were collected using digital questionnaires, and filled by an expert interviewer. In addition, information on personal habits (including cigarette smoking and alcohol consumption, dietary habits and physical activity) were included in a digital questionnaire. Details of the rational and design of study have been published previously [17].

Definitions and measures

Anthropometric parameters including body weight, standing height, waist circumferences, and visceral fat area were measured according to standard methods (Lohman, 1988). Body weight was measured using Bio-Impedance Analyzer BIA (Inbody 770, Inbody Co, Seoul, Korea) with a precision of 0.5 kg. Height was measured by BSM 370 (Biospace Co, Seoul, Korea) with the precision of 0.1 cm. To determine abdominal obesity, waist circumference (WC) was selected as an indicator of obesity.

The outcome variables in this study, overweight and obesity, were classified as latent variables with three markers

including body mass index (BMI), WC, and visceral fat used quantitatively.

Dietary patterns were evaluated using a food frequency questionnaire (FFQ), which its validity was confirmed in Iran [18]. The questionnaire comprised of ten sections including 125 food items such as bread and cereal, legumes, meat and its products, milk and dairy products, vegetables, fruits, and others (varieties of oils, fats, sugar, sweets and salt).

The standard physical activity questionnaire of PERSIAN cohort was implemented to assess participants' physical activity. The questionnaire consisted of 22 questions regarding the amount of an individual's daily activity. Based on the intensity of activity, physical activity was divided into three groups (light, moderate, vigorous).

Diagnosis of depression was based on both the use of antidepressant drugs and self-reporting. Diagnosis of skeletal–musculoskeletal disorders was also observed with regard to drug use and self-disclosure and includes people with impaired walking, joint pain, back pain, and leg pain. Sleep duration was also measured in 24 h and was used quantitatively.

Statistical analysis

Data management and statistical analyses were performed using STATA version 14.2 (StataCorp, College Station, TX, USA) and AMOS version 23.

The mean and standard deviation for continuous variables and the frequency (%) for categorical variables were reported separately for men and women. Principal component analysis (PCA) with orthogonal varimax rotation was conducted to estimate factor loadings.

Normality of data was checked using Kolmogorov–Smirnov test. Kaiser–Meyer–Olkin (KMO) test is the criterion for measuring the sampling adequacy. In this study, the KMO index of the wealth variable was 0.738 and for the dietary pattern was 0.822, which confirms the sufficiency of the sample size in multivariate analysis. The Bartlett's test was confirmed for wealth ($P<0.001$, $\chi^2=7068.7$, $df=55$), and ($P<0.001$, $\chi^2=29528.5$, $df=276$) for the dietary pattern.

The wealth variable was measured using 15 items (including housing, car, washing machine, dishwasher, freezer, computer, internet access, motorcycle, car rental, car type, vacuum cleaner, color TV, TV type, bathroom, cell phone) by PCA method. Data from FFQ were divided into 24 food groups.

The participants were asked to report their usual intake (portion size) of each food item for the past year on a daily, weekly, monthly, and yearly basis. The portion sizes were then converted into daily intakes (g). Three dominant dietary patterns were identified among participants using PCA. These patterns are as follows: healthy dietary pattern, unhealthy dietary pattern, and mixed dietary pattern. Food items with a factor loading above 0.30 were remained in each dietary pattern [19].

Normality of data in AMOS software was investigated using skewness and kurtosis. All variables used in the model were normal. It should be noted that variables with skewness between $+3$ and -3 and kurtosis between $+10$ and -10 were considered as normal variables.

SEM was used to assess the associations between obesity and its associated factors. SEM is one of the main methods for analyzing the complex data and one of the new methods for examining direct and indirect effects of a set of variables on a set of outcomes. It means analyzing various variables, which in a theory-based structure shows the simultaneous effects of variables. Through this method, it is possible to test the acceptability of theoretical models in specific societies, using the data.

The structural equation technique is a combination of two parts: the model of measurement [confirmatory factor analysis (CFA)] and the structural model (path analysis, generalization of regression analysis) [20].

The conceptual model of study is shown in Fig. 1. In the conceptual model, there are three latent variables, including the main dependent variable (overweight and obesity) with a marker variable (1) BMI, (2) WC, and (3) visceral fat area (VFA). Two other latent variables that play the role of an independent variable in the model include SES with three indicators: (1) wealth, (2) education level, (3) place of residence, and chronic disease variable has two markers: (1) depression and (2) musculoskeletal disorders. Other variables in the model are observed variables, including physical activity, sleep duration, dietary pattern, smoking, and contraceptive use. Because of different prevalence of variables between genders, use of contraceptive pills in women and smoking in men, two different models were separately provided for men and women.

At first, a CFA was conducted between latent variables, including obesity, SES, and chronic diseases. Then, SEMs were used to evaluate the direct and indirect effects of latent and observed variables in the model on overweight and obesity.

To confirm the model fit, the comparative fit index (CFI), incremental fit index (IFI), normed fit index (NFI) equal to or greater than 0.90 and root mean square error of approximation (RMSEA) equal to or less than 0.08 were applied. Model estimates were made using maximum likelihood estimation (MLE). In all analyses, P values <0.05 were considered significant [20].

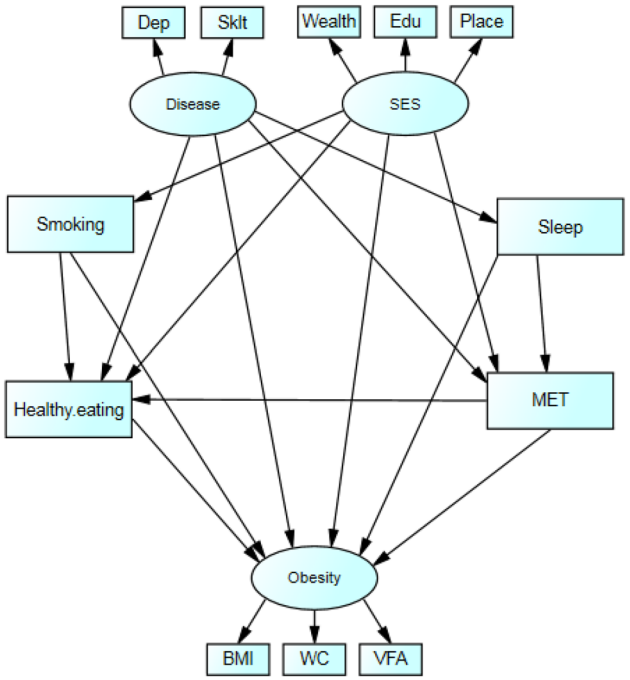

Fig. 1 A conceptual model for the association of socio-demographic, dietary pattern, and life style with overweight and obesity. *Dep* depression, *Sklt* musculoskeletal disorders, *Disease* chronic disease, *Edu* education years, *Place* city or rural, *SES* socioeconomic status, *Healthy eating* healthy dietary pattern, *Smoking* smoking status, *Sleep* sleep duration, *MET* physical activity, *BMI* body mass index, *WC* waist circumference, *VFA* visceral fat area

Results

Characteristics of the sample

Overall, 8885 participants with complete information were included in the analysis, with an average age of 47.49 ± 8.18 years. About 66.69% of participants were male, 90% of the participants were married, and 60% were the inhabitants of the city. The prevalence of depression in the population was 3.58%, which was significantly higher in women compared to men (Table 1). The average BMI was 28.51 ± 4.86 and 26.33 ± 4.04 kg/m^2 in women and men, respectively ($P = 0.001$). The average physical activity in women was 39.39 ± 4.58 and in men was 43.05 ± 10.64 MET/min per day ($P \leq 0.001$). The average sleep duration in the total population was 7.05 ± 1.22 h per day ($P \leq 0.001$).

Among women, 29.55% ($n = 1321$) had menopause and 76.26% ($n = 3427$) used contraceptives. The prevalence of overweight and obesity was 43.63% ($n = 3879$) and 26.46% ($n = 2351$), respectively ($P \leq 0.001$). The prevalence of obesity in women was 36.11% ($n = 1615$) and in men 16.68% ($n = 736$) ($P \leq 0.001$).

Confirmatory factor analysis (CFA)

Before performing the SEM, a CFA was performed between the three latent variables in the model that covariance values and fitting indices were acceptable. The covariance between the variables of obesity and chronic diseases was 0.69, between SES and chronic diseases was 0.57, and between obesity and SES was 0.24. The fitting of this analysis was confirmed by four indices (IFI = 0.968, NFI = 0.964, CFI = 0.968, and RMSEA = 0.080).

Structural equation modeling (SEM)

Structural equation modeling for the total population ($n = 8885$) was confirmed with four fitting indexes (RMSEA = 0.080, NFI = 0.920, IFI = 0.912 and CFI = 0.920). Due to the higher sample size, Chi-squared test was statistically significant for model fit results ($P < 0.001$). The value of R^2 for the latent dependent variable (overweight and obesity) was 0.22, which means that the variables in the model explain 22% of the variance of outcome. The value of R^2 for the healthy dietary model, which plays the mediation role in the model, was 0.33. So that physical activity, SES, and smoking explain 33% of the variance of the dietary pattern (Fig. 2).

Direct and indirect associations and the role of mediation variables in models related to women, men, and the entire population are presented in this model (Table 2).

In the total study population, the physical activity has an inverse effect on overweight and obesity, and having chronic diseases significantly increase obesity. The direct effect of physical activity on overweight and obesity was − 0.173, the indirect effect was 0.024, and its total effect was 0.150. In general, the population at higher economic level was significantly more dependent on the healthy dietary pattern. The direct effect of SES on overweight and obesity was − 0.070, the indirect effect was 0.127, and the total effect was 0.057. Therefore, physical activity, dietary pattern, and smoking can be mediating variables for overweight and obesity (Fig. 3).

In the men model, SES can indirectly, through three other variables, including physical activity, dietary patterns, and smoking, lead to overweight and obesity. The direct effect of sleeping hours on overweight and obesity was 0.016, the indirect effect was 0.090, and the total effect was 0.106. Its indirect effect, that is, the effect on physical activity and its reduction is more remarkable. Therefore, physical activity is a mediator between sleep duration and overweight and obesity. In men, depression and musculoskeletal disorders directly reduce physical activity and sleep hours, and increase overweight and obesity; this is also true in the total effect. In addition, smoking reduces their adherence to healthy dietary patterns

Table 1 Characteristics of study participants stratified by genders

Variables	Mean ± SD or frequency (%)			*P* value*
	Total (*n* = 8885)	Men (*n* = 4412)	Women (*n* = 4473)	
Age (years)	47.79 ± 8.18	47.54 ± 7.99	48.04 ± 8.36	0.003**
Weight (kg)	72.98 ± 13.66	76.98 ± 13.40	69.44 ± 12.98	0.001**
Body mass index (kg/m^2)	24.87 ± 9.53	26.33 ± 4.04	28.51 ± 4.86	0.001**
Waist circumference (cm)	97.16 ± 10.49	96.12 ± 9.65	98.18 ± 11.16	< 0.001**
Waist hip ratio	0.94 ± 0.06	0.93 ± 0.06	0.94 ± 0.05	< 0.001**
Visceral fat area (cm^2)	120.78 ± 51.41	96.22 ± 41.79	144.99 ± 48.43	< 0.001**
Body fat (%)	33.51 ± 9.48	26.97 ± 6.92	39.96 ± 6.89	< 0.001**
Skeletal muscle mass (kg)	26.63 ± 5.76	31.00 ± 4.38	22.32 ± 3.09	< 0.001**
Body fat mass (kg)	24.87 ± 9.53	21.27 ± 8.35	28.41 ± 9.30	< 0.001**
Calories intake (kcal)	3418.55 ± 1263.92	3863.93 ± 1265.45	2979.24 ± 1097.86	< 0.001**
Sleep duration (h)	7.05 ± 1.22	6.95 ± 1.19	7.15 ± 1.25	< 0.001**
Physical activity				
Light	2406 (27.09)	1429 (32.40)	977 (21.85)	< 0.001**
Moderate	4513 (50.81)	1477 (33.49)	3036 (67.89)	
Vigorous	1963 (22.10)	1504 (34.10)	459 (10.26)	
Place of residency				
Rural	3619 (40.73)	1700 (38.53)	1919 (42.90)	< 0.001**
Urban	5266 (59.27)	2712 (61.47)	2554 (57.10)	
Education level				
Illiterate	2129 (23.96)	565 (12.18)	1565 (34.97)	< 0.001**
Primary	3341 (37.60)	1262 (28.60)	2079 (46.48)	
Secondary	2687 (30.24)	1990 (45.11)	697 (15.59)	
Academic	728 (8.19)	595 (13.49)	133 (2.97)	
Smoking behavior				
None	7065 (79.52)	2815 (63.80)	4250 (95.01)	< 0.001**
Current	734 (8.26)	999 (22.64)	87 (1.95)	
Former	1086 (12.22)	598 (13.55)	136 (3.04)	
Economic status				
1	1980 (22.28)	698 (15.82)	12,829 (28.66)	< 0.001**
2	1663 (18.72)	814 (18.45)	849 (18.98)	
3	1769 (19.91)	1036 (23.48)	733 (16.39)	
4	1850 (20.82)	922 (20.90)	928 (20.75)	
5	1623 (18.27)	942 (21.35)	681 (15.22)	
Depression				
No	8567 (96.42)	4324 (98.01)	4243 (94.86)	< 0.001**
Yes	318 (3.58)	88 (1.99)	230 (5.14)	
Musculoskeletal disorders				
No	4560 (51.32)	2520 (57.12)	2040 (45.61)	< 0.001**
Yes	4325 (48.68)	1892 (42.88)	2433 (54.39)	

**P* value < 0.05 (Student's *t* test) compare men with women

***P* value < 0.05 (Chi-squared test) compare men with women

and also increases overweight and obesity. Considering the effects observed in the men model, the dietary pattern, physical activity, and smoking are mediation factors.

In the women model, sue of contraceptive pills are significantly associated with weight gain. In women, as with men, depression and musculoskeletal disorders have significantly reduced physical activity and the number of sleeping hours. In women, chronic diseases indirectly, through physical activity, lead to overweight and obesity. The effect of chronic diseases on overweight and obesity was directly and indirectly estimated at 0.282 and 0.024, respectively.

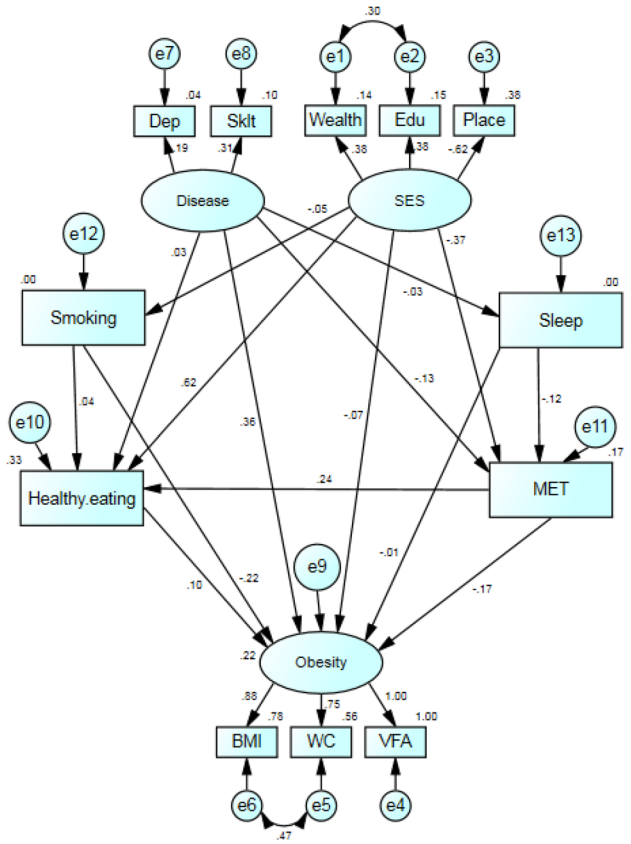

Fig. 2 Final structural models in total population. The path standardized coefficients of variables are presented on pathways for men and women. RMSEA = 0.080, NFI = 0.920, IFI = 0.912, CFI = 0.920. *Dep* depression, *Sklt* musculoskeletal disorders, *Disease* chronic disease, *Edu* education years, *Place* city or rural, *SES* socioeconomic status, *OCP* contraceptive pill, *Healthy eating* healthy dietary pattern, *Sleep* sleep duration, *MET* physical activity, *BMI* body mass index, *WC* waist circumference, *VFA* visceral fat area, *e* error

Discussion

Our findings have shown that the known risk factors associated with overweight and obesity, not only by direct effect, but also can indirectly and through mediators cause the outcome. In the present study, dietary patterns and physical activity were identified as two mediation variables, which affect overweight and obesity with the impact of SES, depression, musculoskeletal disorders, smoking status, and sleep duration. The effect of these mediation variables is somewhat different in men and women.

In women, SES had a direct effect on overweight and obesity, but indirectly through physical activity and dietary pattern had a significant effect on the outcome. In men, the same situation has been observed and the direct effect of SES variable was weak, but indirectly through three variables such as physical activity, dietary pattern, and smoking status significantly contribute to the expected outcome. A similar finding from a study conducted on urban adult population was found that SES directly and indirectly affects overweight and obesity, only in women [21].

In other studies, the direct effect of SES on overweight and obesity has been investigated using regression analysis (not the SEM and without examining indirect effects). They show a higher proportion of obesity in lower socioeconomic classes, especially in women [22, 23]. Some of the other studies with conflicting results have reported that the proportions of overweight and obesity are increasing in higher socioeconomic groups [24, 25].

There was found that the direct effect of healthy dietary patterns on overweight and obesity is higher in women compared to men. In this study, the dietary pattern was identified as an important mediator, which the SES, chronic diseases, and through physical activity it determines weight changes in individuals. Our finding appeared similar to the study conducted on Iranian urban population, which suggested that having a poor dietary pattern in men has a direct impact on overweight and obesity, but no relationship has been found in women [21].

Healthy dietary patterns, including fish, chicken, rice, fruits and vegetables, reduce overweight and obesity, on the other hand, unhealthy dietary patterns, including high levels of lipids and carbohydrates, are the causes of overweight and obesity [26]. A study on military families reported a significant positive association between red meat consumption and abdominal obesity, while there was no significant relationship between white meat consumption (chicken and fish) and general and abdominal obesities [27]. BMI and WC have an inverse relationship with a healthy dietary pattern and a direct association with the unhealthy dietary pattern [8].

The results showed that in the total population and the stratified results by men and women, depression and musculoskeletal disorders directly reduce physical activity, reduce sleep hours per day, and ultimately increase overweight and obesity. Several studies have investigated the relationship between obesity and depression and often confirmed the association, especially in women [28], as depressed women often have higher BMI and fat mass [29]. Musculoskeletal disorders affect the lifestyles of individuals, including physical activity and weight changes, resulting in decreased physical activity and the incidence of obesity in people [30]. Physical activity is a factor that is frequently discussed in the explanation of obesity. The findings of this study showed that increased physical activity, directly reduces overweight and obesity, but indirectly increases the obesity. Because in indirect relation, increased physical activity may lead to more food intake and ultimately leads to obesity. Several studies have reported a correlation between the increase in physical activity and the reduction in BMI, WC, abdominal obesity, and general obesity and fat mass [31, 32].

Table 2 Direct, indirect, and total effect between predictors and outcomes

Predictor	Response	Estimate standardized coefficient								
		Total			Men			Women		
		Direct Effect	Indirect effect	Total effect	Direct effect	Indirect effect	Total effect	Direct effect	Indirect effect	Total effect
Socioeconomic status	Physical activity	−0.369*	–	−0.369*	−0.468*	–	−0.468*	−0.259*	0.00	−0.259*
	Healthy dietary pattern	0.617*	−0.090*	0.526*	0.427*	−0.106*	0.320*	0.481*	−0.034	0.446*
	Smoking	−0.050*	–	−0.050*	−0.172*	–	−0.172*	–	–	–
	Contraceptive	–	–	–	–	–	–	0.068*	–	0.068*
	Obesity	−0.070*	0.127*	0.057*	0.070	0.082*	0.152*	0.024	0.088*	0.113*
Chronic disease	Physical activity	−0.128*	0.004	−0.124*	−0.200*	0.014	−0.186*	−0.172*	0.027*	−0.145*
	Healthy dietary pattern	0.033	−0.030*	0.003	0.274*	−0.060*	0.214*	0.390*	0.019*	0.019
	Smoking	–	–	–	0.305*	–	0.305*	–	–	–
	Sleep duration	−0.034*	–	−0.034*	−0.121*	–	−0.121*	−0.120	0.00	−0.120*
	Obesity	0.357*	–	0.379*	0.466*	−0.062	0.404*	0.282*	0.024*	0.306*
Sleep duration	Physical activity	−0.122*	–	−0.122*	−0.113*	–	−0.113*	−0.225*	–	−0.225*
	Healthy dietary pattern	0.00*	−0.029*	−0.029*	–	−0.028*	−0.028*	–	−0.030	−0.030
	Obesity	0.014*	0.018*	0.004*	0.016	0.090*	0.106	−0.038	0.022	−0.016
Physical activity	Healthy dietary pattern	0.240*	–	0.240*	0.245*	–	0.245*	0.133*	–	0.133*
	Obesity	−0.173*	0.024	−0.150*	−0.067	–	−0.078*	−0.115*	0.016*	−0.099*
Smoking	Healthy dietary pattern	0.036*	–	0.036*	−0.046	−0.011	−0.046*	–	–	–
	Obesity	−0.222*	0.004	−0.219*	−0.206*	0.002	−0.204*	–	–	–
Healthy dietary pattern	Obesity	0.099*	−0.003	0.096*	−0.045	–	−0.045	0.117*	–	0.117*
Contraceptive	Obesity	–	–	–	–	–	–	0.088	–	0.088*

*P value < 0.05

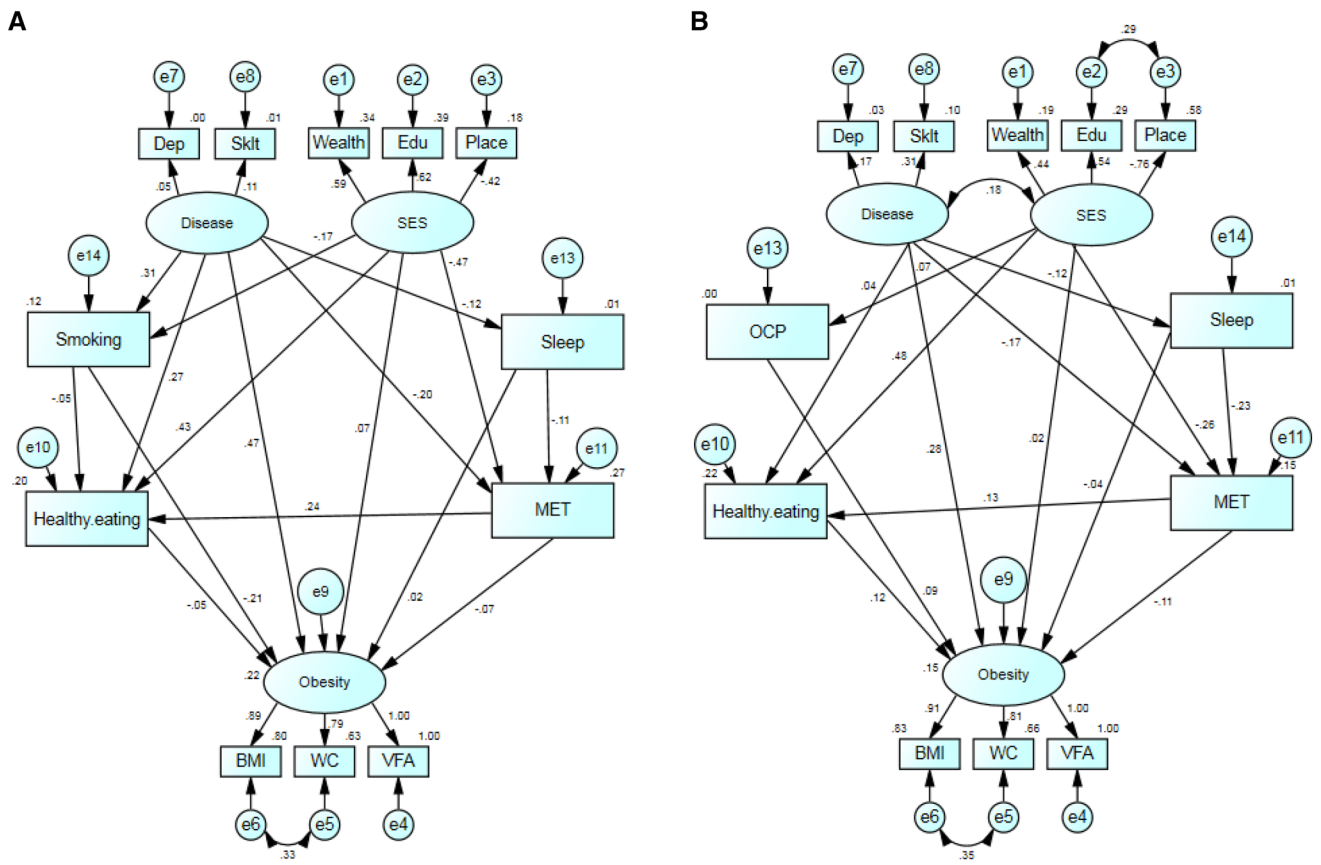

Fig. 3 Final structural models in men (**a**) and women (**b**). The path standardized coefficients of variables are presented on pathways for men and women. In model of women: RMSEA = 0.074, NFI = 0.939, IFI = 0.937, CFI = 0.936 and men = RMSEA = 0.077, NFI = 0.929, IFI = 0.931, CFI = 0.931. *Dep* depression, *Sklt* musculoskeletal disorders, *Disease* chronic disease, *Edu* education years, *Place* city or rural, *SES* socio-economic status, *OCP* contraceptive pill, *Sleep* sleep duration, *MET* physical activity, *Healthy eating* healthy dietary pattern, *BMI* body mass index, *WC* waist circumference, *VFA* visceral fat area, *e* error

In a study, a direct relationship between physical activity and body mass has been observed using SEM [33]. A study, on populations aged 15–60 in Iran, using national survey on non-communicable diseases indicates that the prevalence of physical activity in the general population is 44.8% and the chance of low physical activity in women is three times higher than men. In addition, with increasing age and after 55 years old, low mobility has increased by nearly 50% [34].

In this study, individuals who sleep more, had lower physical activity and lower compliance with the healthy dietary patterns, which lead to higher occurrence of overweight and obesity. A U-shape association between sleep hours and BMI has been reported [16, 35]. In comparison with individuals who sleep 7–8 h per night, people who sleep 6 h or less have a higher risk of obesity [16].

We found that smoking in men, which can act as a mediator, was associated with a reduction in overweight and obesity. The relation between smoking and obesity is complex. On the one hand, smoking has a negative association with obesity [10, 36], and smokers have less body weight and BMI than non-smokers [37]. "Mechanisms through which cigarette smoking reduces body weight are by increasing energy expenditure and inhibiting the expected compensatory increase in caloric intake. Nicotine increases energy expenditure both by direct effects on peripheral tissues, largely mediated by catecholamines, and by effects on central nervous system neuroendocrine circuits. Nicotine's effects on the brain also lead to suppression of appetite and smoking per se can serve as a behavioral alternative to eating" [38]. On the other hand, it has been observed that smokers have a larger WC and WHR compared to non-smokers, suggesting that smoking may result in fat accumulation in the abdominal region [39]. Nicotine alone can lead to fat accumulation and also leads to insulin resistance, anti-estrogenic effect, and an increase in levels of stress hormones such as cortisol [40, 41]. Therefore, it is not possible to easily explain the cause of this correlation, and further studies, particularly cohort studies and clinical trials, are needed to

obtain more comprehensive information on the correlation between body mass and smoking.

In women, taking oral contraceptives was significantly associated with weight gain. Evidence suggests that the effect of steroid hormones in obese and non-obese women can be different [42]. Contraceptive pills in people who have been overweight at the beginning of the study, lead to weight gain and in individuals with normal weight had no effect on body weight [43]. Therefore, to examine this relationship, more specialized studies are required and the level of estrogen and progesterone hormones should be examined. Here, only the presence of the correlation was investigated.

This study had some limitations. Since overweight and obesity are a multifactorial disorder and other studies have reported the role of genetics in the etiology of the disease to be close to 70% [44], therefore the low R^2 in the models is the consequence of this factor and considered as one of the limitations of this study. Because the genetic factor has not been investigated in this study, only behavioral and social factors have been evaluated. This survey is based on the population of a small city and cannot be generalized to the entire population of Iran. Other risk factors such as marital status, number of children and the number of births in women, the incidence of certain chronic diseases and the associated treatment, and genetic factors can be evaluated in future studies, using the SEM approach. The limitation of the AMOS software is one of the other points that will not allow researchers to make extensive reviews in the medical fields.

One of the strengths of this study was application of the advanced predictive models, CFA, path, and SEM and a large sample size, simultaneous examination of urban and rural populations, and the risk assessment of many factors whose role in overweight and obesity has so far been studied directly in many studies. It is also the first study in Iran that has been conducted on the Kurd ethnic group and could be an appropriate reference for future studies that will be conducted on other ethnicities, since it provides the possibility of comparisons between ethnicities.

The findings of this study showed that the factors associated with the incidence of overweight and obesity, in addition to the direct effects on the incidence of the outcome, can indirectly cause this outcome, through mediation variables. Furthermore, dietary patterns and physical activity were identified as two mediation variables which are influenced by the variables such as SES, depression, musculoskeletal disorders, smoking status, and sleep time leading to overweight and obesity. The role and effect of these mediation variables are somewhat different in men and women due to differences in lifestyle.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Informed consent Informed written consents were obtained from all the candidates who were willing to participate in the study and they were ensured that they could withdraw from the study at any time they wish. The research was registered (No: 97133) at the Research and Technology Deputy and was approved by the Ethics Committee of Kermanshah University of Medical Sciences under the code, KUMS.REC.1397.092.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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