Iran J Public Health, Vol. 54, No.6, Jun 2025, pp.1272-1281

Original Article

Mediating Role of Physical Activity in the Relationship between Personality Traits and Body Mass Index (BMI) among the Participants of the Employees' Health Cohort Study of Iran (EHCSIR): A Generalized Structural Equation Modeling

*Seyed Abbas Motevalian [1], Seyyed Amir Yasin Ahmadi [2], *Arash Tehrani-Banihashemi [2]*

1. *Research Center for Addiction and Risky Behaviors (ReCARB), Psychosocial Health Research Institute (PHRI), Iran University of Medical Sciences, Tehran, Iran*
2. *Preventive Medicine and Public Health Research Center, Psychosocial Health Research Institute, Iran University of Medical Sciences, Tehran, Iran*

***Corresponding Author:** Email: tehranib@gmail.com

(Received 19 Sep 2024; accepted 18 Dec 2024)

Abstract

Background: Considering the high importance of the problem of obesity and its related factors, we aimed to investigate the mediating role of physical activity in the relationship between personality traits and body mass index (BMI) in the participants of the employees' health cohort study of Iran (EHCSIR) using generalized structural equation modeling (GSEM).

Methods: A secondary analysis with cross-sectional approach was conducted on the existing data using multilevel GSEM. The primary data of the cohort was collected from July 2017, Iran University of Medical Sciences, Tehran, Iran. Personality traits were exposure, physical activity was the mediator, and BMI was the outcome. Sex was the stratifying variable. Then, pathways with the largest P values were removed one by one using backward stepwise approach.

Results: The data of a total of 3554 participants of EHCSIR were used. Sex was subjected for grouping the analysis. In males, extroversion (EX) was the only personality trait associated with both physical activity and BMI. In the direct pathway, EX was positively associated with BMI. In the indirect pathway, EX was negatively associated with BMI (P <0.1). The total effect was positive. In females, physical activity was not associated with BMI, and therefore, no indirect pathway was formed from personality traits to BMI (P >0.1).

Conclusion: The role of personality traits in obesity was more dominant in females, while in males, physical activity had a role in obesity. The hypothesized mediation pathway of the study title was not approved in females, and in males, was approved only for EX personality trait.

Keywords: Structural equation modeling; Body mass index; Personality; Physical activity; Statistical models

Introduction

Overweight and obesity are important health-related problems. Obesity is known as a risk factor for many diseases, including many types of cancer (1) and also recently, the risk factor of the

severe form of coronavirus disease 2019 (2). Obesity has global and national importance. Globally, based on the information obtained from the global burden of disease (GBD), the body mass index (BMI) in 2019 has increased significantly compared with 1990 (3). In Iran, a meta-analysis showed that 21.4% of Iranians over the age of 50 were obese (4). In another meta-analysis, it was shown that 13% of Iranian soldiers were obese (5).

So far, several risk factors for obesity and overweight have been identified. These factors include a wide range of biological and social factors. Examples of biological risk factors include genetic factors. These genetic factors are classified into monogenic and polygenic categories. In this regard, the first genome-wide association study (GWAS) was conducted in 2005, and the latest gene identified (2018) was *ADCY3* (6). It is clear that nutrition plays an important role in obesity. Among teenagers, it has been observed that nutritional patterns and teenage stress are factors influencing obesity (7). Among social factors, it has been seen that low-income people living in highly urbanized areas of middle-income countries have a higher risk of obesity compared with wealthy people living in the same countries, and this difference seems to be due to it is easier consuming cheap and energy-dense foods (8). Behavioral and psychological factors are also mentioned. A study among college students has shown that obesity is associated with physical inactivity, eating attitudes, and obesity-related behaviors (9). Personality traits play a very important role in obesity both as a risk factor and as a protective factor (10).

As the evidence shows, the problem of obesity requires an interdisciplinary and multidisciplinary approach. Considering the wide range of risk factors, it is very difficult to distinguish between the roles of these factors due to their confounding effect on each other. The number of studies that have moderated the contribution of different factors is very few. For example, it is not known to what extent personality traits alone and to what extent they influence obesity through factors such as physical activity. Therefore, it is necessary to study the etiology of obesity more accurately with the help of statistical modeling. Structural equation modeling (SEM) is a statistical technique to investigate the complex relationships between the variables. Using SEM in the present study, helps to study the roles of the variables in a structural framework.

Considering the high importance of the problem of obesity along with the need to further investigate its etiology, in this study we aimed to investigate the mediating role of physical activity in the relationship between personality traits and BMI in the participants of the employees' health cohort study of Iran (EHCSIR) using generalized structural equation modeling (GSEM).

Materials and Methods

A secondary use and analysis of the existing data with cross-sectional approach was conducted on the data of EHCSIR using GSEM. The primary data of the cohort was collected from July 2017, Iran University of Medical Sciences, Tehran, Iran: https://irancohorts.ir/employees-health-cohort-study-of-iran/#toggle-id-2. The dataset was cleaned according to the variables of this study. All the ethical issues regarding data management were regarded including data privacy (registration number: IR.IUMS.REC.1402.104). The data were used as unknown and informed consent had been previously obtained from the participants.

This study consisted of six groups of variables.

1- Outcomes: The outcome variables were variables related to obesity including BMI (quantitative), obesity (BMI >30 kg/m^2) and overweight (BMI: 25 – 30 kg/m^2). According to the brainstorming of the researchers, BMI (quantitative form) was finally considered for SEM.

2- Independent variables: Personality traits were considered as the main independent variables including neurotic (NEU), sensation seeking (SS), extroversion (EX), active (AC) and aggressive (AG). Zuckerman-Kuhlman-Aluja personality questionnaire shortened from (ZKA-PQ/SF) was used, and a score was reported each of these five personality traits. Psychometric analysis of ZKA-

PQ/SF in Persian language has been previously published and approved. The Cronbach's alpha was 0.93 for the whole questionnaire, and for AG, AC, EX, NEU and SS it was 0.77, 0.70, 0.91, 0.86 and 0.65, respectively for each. As well, its validity was approved (11).

3- Mediator: Physical activity was considered as the mediator. At first, international physical activity score questionnaire (IPAQ) was used and the scores were reported as minutes *per* week (METs). Since the results were right-skewed and zero-inflated (not suitable for SEM), an ordinal scaling was generated with scales non-sufficient (METs <600), sufficient (METs: 600 – 1200) and high level (METs >1200). This variable was named "ordinal PA". Psychometric analysis of IPAQ in Persian language has been previously published and approved with reliability of 0.842 (12).

4- Demographic variables: Among the demographic variables of EHCSIR, age and education were considered for this study according to the brain storming of the researchers.

5- Moderator: Sex was considered for stratified analysis as an effect modifier.

6- Multilevel variable: There were a lot of workplaces of the participants (called workplace ID). In addition, there were fewer main groups of workplace (called workplace group). Therefore, the multilevel variable was workplace ID nested within workplace group.

The sample size was calculated based on R square estimation. In this way, based on this assumption that R square in regressions with the purpose of association measurement (not necessarily with the purpose of prediction) should be about 0.10, with the assumption of 0.02 error in the estimation of R square, the presence of 10 covariates, 95% power and significance level of 0.05, 1083 cases were needed. Finally, all the people in the previous dataset would be included in the study.

Multilevel GSEM was performed using maximum likelihood method. First, a directed acyclic graph (DAG) was designed based on brainstorming of the researchers in repetitive in person meetings. This DAG was subjected for running GSEM and GSEM was run separately in male and female groups. Then, pathways with the largest P values were removed one by one using backward stepwise approach up to the time that all the remained pathways had P <0.1. In addition to GSEM, independent t test and chi-square were used for comparison of demographic variables between males and females. All the statistical process was done in Stata 17 (Stata Corp. LLC, TX, US).

Results

The data of a total of 3554 participants of EHCSIR including 35.57% male and 64.43% female were used after removal of the observations with missing data. The mean age was 42.79±8.02 years. For education, 61.73% of the participants had bachelor degree or more (high degree). Demographic characteristics, the outcomes and the main variables are shown and compared between males and females. Briefly, having high degree was more common in females (*P* <0.001), BMI was higher in males (*P* =0.013), the high-level physical activity was more common in males (*P* <0.001), and for ZKA domains, AG score was higher in males, NEU score was higher in females and SS score was higher in males (*P* <0.001) (Table 1).

According to our hypotheses, a primary graph of GSEM was designed base on brainstorming. In this graph, BMI was the final outcome, personality traits were independent variables, ordinal PA was mediator, and age and high degree education were the demographic variables affecting directly personality traits and ordinal PA. The multilevel latent variable (workplace ID nested within workplace group) had arrows toward ordinal PA and BMI (Fig. 1). Sex was subjected for grouping the analysis.

Table 1: Demographic characteristics, outcomes and predictors of the participants in genders

Variable	Role	Mean ± SD / n (%)			Association
		Male	Female	Total	P value (test)
Age (yr)	Demographic	42.77±8.21	42.81±7.91	42.79±8.02	0.911 (independent t)
High degree	Demographic				<0.001 (chi-square)
No		748 (55.00)	612 (45.00)	1360 (100)	
Yes		516 (23.52)	1678 (76.48)	2194 (100)	
AG	Independent	29.78±8.20	28.77±7.55	29.13±7.80	<0.001 (independent t)
AC	Independent	44.24±7.35	43.80±7.10	43.95±7.19	0.080 (independent t)
EX	Independent	45.33±7.14	44.87±7.36	45.03±7.28	0.071 (independent t)
NEU	Independent	33.83±7.54	36.11±7.77	35.30±7.77	<0.001 (independent t)
SS	Independent	38.50±7.21	37.51±6.89	37.86±7.02	<0.001 (independent t)
Ordinal PA	Mediator				<0.001 (chi-square)
Non-sufficient		782 (32.30)	1639 (67.70)	2421 (100)	
Sufficient		309 (37.59)	513 (62.41)	822 (100)	
High level		173 (55.63)	138 (44.37)	311 (100)	
BMI	Outcome	27.63±4.08	27.24±4.54	27.38±4.38	0.013 (independent t)

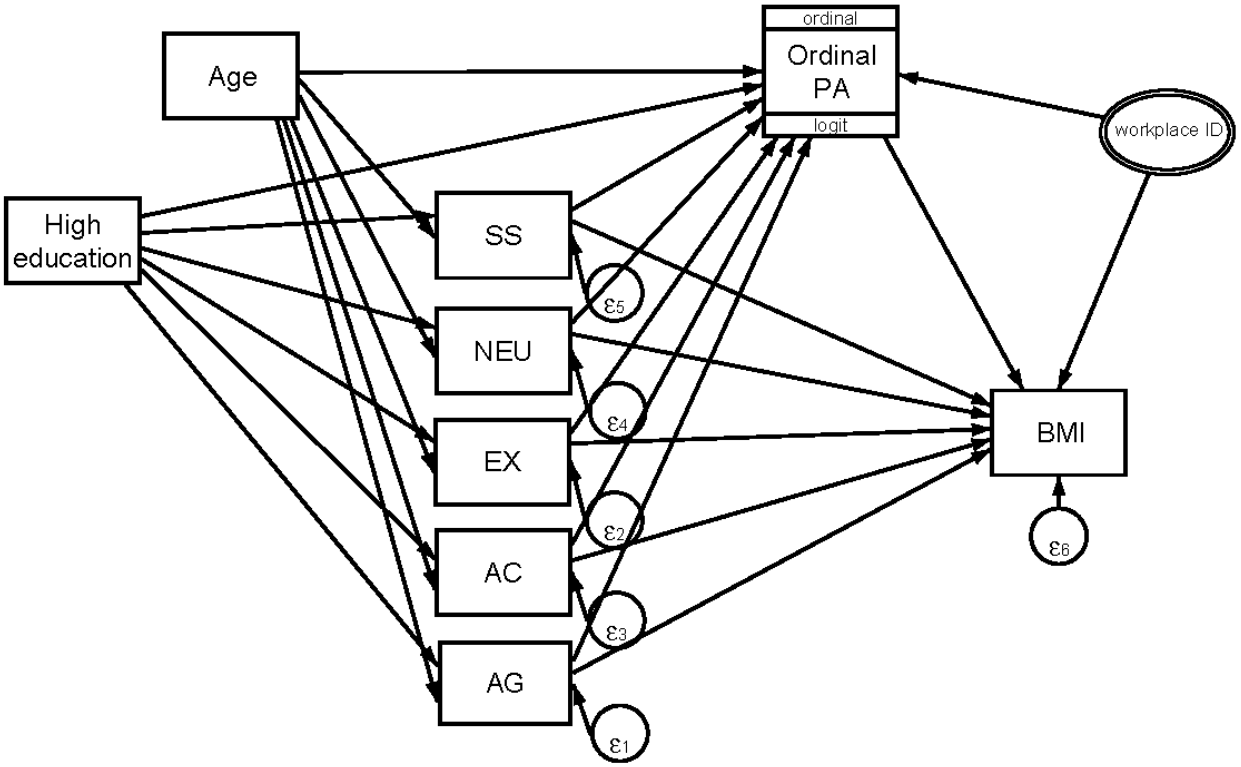

Fig. 1: SEM graph of study hypothesis (before analysis), square: observed variable, small circle: error, double lined circle: multilevel variable

The report of GSEM in male group is shown. Accordingly, EX was the only personality trait associated with both ordinal PA and BMI. In the direct pathway, EX was positively associated with BMI (coefficient =0.051). In the indirect pathway, EX was negatively associated with BMI (coefficient = 0.024 × -0.3 = -0.007). Therefore, the total effect was positive (coefficient =0.044) (Table 2, Fig. 2). Considering one SD as the remarkable unit of change in the score of personality traits, 7.14 score increase in EX was associated with 0.314 kg/m^2 increase in BMI regarding total effect.

Table 2: Multilevel GSEM report in male participants

Outcome	Predictor	Coefficient	SE	z	*P*>|z|	95% CI	
BMI							
	EX	0.051	0.016	3.17	0.002	0.019	0.082
	Ordinal PA	-0.303	0.163	-1.85	0.064	-0.622	0.017
	Random effect	0.126	0.157	0.80	0.422	-0.182	0.433
	Constant	25.503	0.735	34.69	<0.001	24.062	26.944
Ordinal PA							
	EX	0.024 (OR =1.024)	0.009	2.75	0.006	0.007	0.040
	Age	-0.028 (OR =0.972)	0.007	-3.82	<0.001	-0.043	-0.014
	High degree	-0.226 (OR =0.798)	0.122	-1.84	0.065	-0.466	0.014
	Random effect	0.396	0.104	3.81	<0.001	0.192	0.600
AG							
	Age	-0.129	0.028	-4.63	<0.001	-0.184	-0.074
	Constant	35.304	1.214	29.09	<0.001	32.925	37.683
EX							
	Age	-0.083	0.024	-3.41	0.001	-0.131	-0.035
	Constant	48.887	1.061	46.06	<0.001	46.807	50.967
AC							
	Age	-0.042	0.025	-1.68	0.093	-0.091	0.007
	High degree	-1.269	0.418	-3.03	0.002	-2.089	-0.449
	Constant	46.558	1.103	42.19	<0.001	44.395	48.721
NEU							
	Age	-0.052	0.026	-2.01	0.045	-0.102	-0.001
	High degree	-0.865	0.430	-2.01	0.044	-1.708	-0.023
	Constant	36.393	1.134	32.10	<0.001	34.170	38.615
SS							
	Age	-0.201	0.024	-8.37	<0.001	-0.247	-0.154
	High degree	1.338	0.400	3.34	0.001	0.553	2.122
	Constant	46.527	1.055	44.10	<0.001	44.459	48.595
Ordinal PA							
	Cut1	0.186	0.537			-0.867	1.239
	Cut2	1.601	0.539			0.544	2.658
	Var (Random effect)	1 (constrained)					
	Var (e.BMI)	16.445	0.657			15.206	17.785
	Var (e.AG)	66.049	2.627			61.096	71.405
	Var (e.EX)	50.506	2.009			46.718	54.601
	Var (e.AC)	53.461	2.127			49.451	57.796
	Var (e.NEU)	56.446	2.245			52.213	61.023
	Var (e.SS)	48.861	1.944			45.197	52.823

SE: standard error, CI: confidence interval, OR: odds ratio, Var: variance, e.: error

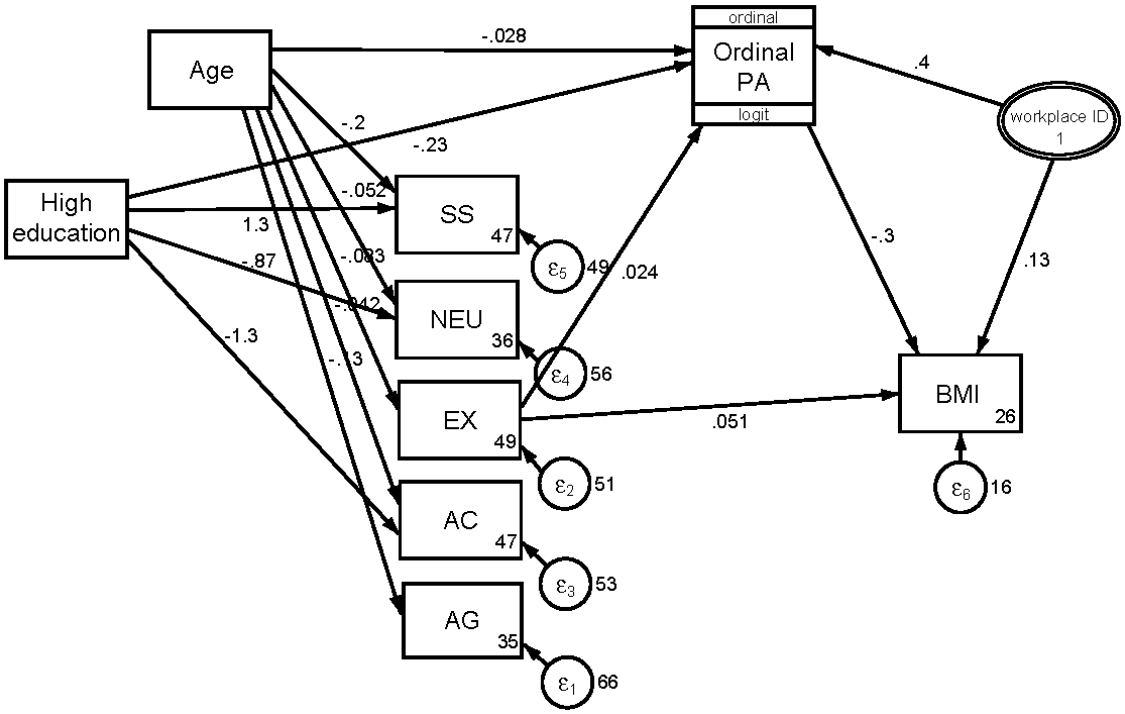

Fig. 2: SEM graph in male participants, square: observed variable, small circle: error, double lined circle: multilevel variable (variance constrained to one)

The report of GSEM in female group is shown. Accordingly, ordinal PA was not associated with BMI, and therefore, no indirect pathway was formed from personality traits to BMI. Nevertheless, most of the personality traits were separately associated with ordinal PA and BMI (Table 3, Fig. 3).

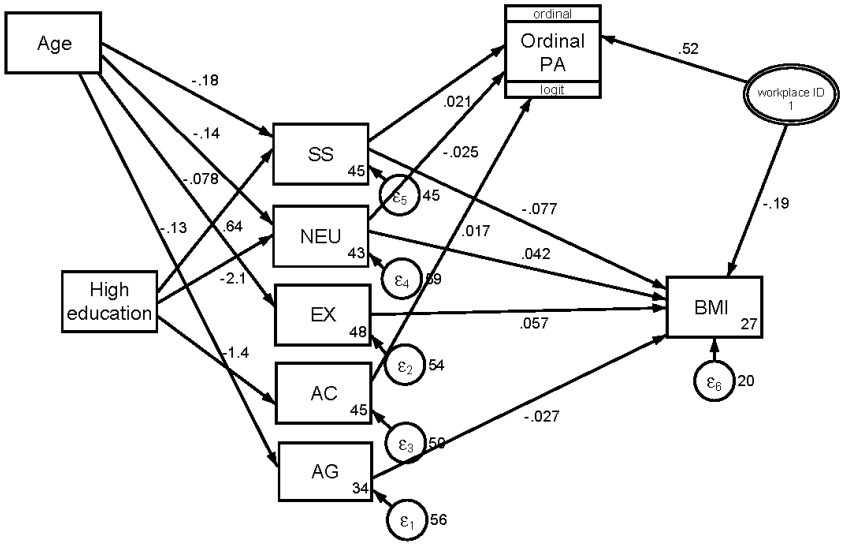

Fig. 3: SEM graph in female participants, square: observed variable, small circle: error, double lined circle: multilevel variable (variance constrained to one)

Table 3: Multilevel GSEM report in female participants

Outcome	Predictor	Coefficient	SE	z	*P*>|z|	95% CI	
BMI							
	AG	-0.027	0.016	-1.67	0.094	-0.058	0.005
	EX	0.057	0.015	3.85	<0.001	0.028	0.086
	NEU	0.042	0.016	2.64	0.008	0.011	0.074
	SS	-0.077	0.016	-4.76	<0.001	-0.109	-0.045
	Random effect	-0.191	0.109	-1.75	0.081	-0.406	0.023
	Constant	26.771	0.832	32.17	<0.001	25.140	28.402
Ordinal PA							
	AC	0.017 (OR =1.017)	0.008	2.22	0.027	0.002	0.031
	NEU	-0.025 (OR =0.975)	0.007	-3.85	<0.001	-0.038	-0.012
	SS	0.021 (OR =1.021)	0.008	2.70	0.007	0.006	0.036
	Random effect	0.515	0.086	6.02	<0.001	0.348	0.683
AG							
	Age	-0.129	0.020	-6.55	<0.001	-0.168	-0.091
	Constant	34.310	0.860	39.88	<0.001	32.623	35.996
EX							
	Age	-0.078	0.019	-4.01	<0.001	-0.116	-0.040
	Constant	48.197	0.843	57.19	<0.001	46.545	49.849
NEU							
	Age	-0.135	0.021	-6.41	<0.001	-0.176	-0.094
	High degree	-2.084	0.377	-5.53	<0.001	-2.822	-1.345
	Constant	43.426	1.025	42.36	<0.001	41.417	45.436
SS							
	Age	-0.184	0.018	-10.01	<0.001	-0.221	-0.148
	High degree	0.645	0.329	1.96	0.050	-0.001	1.291
	Constant	44.933	0.896	50.12	<0.001	43.176	46.690
AC							
	High degree	-1.416	0.334	-4.24	<0.001	-2.070	-0.761
	Constant	44.833	0.286	156.89	<0.001	44.273	45.393
Ordinal PA							
	Cut1	1.415	0.386			0.657	2.172
	Cut2	3.329	0.395			2.555	4.102
	Var (Random effect)	1 (constrained)					
	Var (e.BMI)	20.239	0.604			19.089	21.459
	Var (e.AG)	55.993	1.655			52.842	59.332
	Var (e.EX)	53.732	1.588			50.708	56.936
	Var (e.NEU)	58.933	1.742			55.617	62.448
	Var (e.SS)	45.063	1.332			42.527	47.750
	Var (e.AC)	49.976	1.477			47.164	52.956

SE: standard error, CI: confidence interval, OR: odds ratio, Var: variance, e.: error

Discussion

The present study was conducted to design a causation network emphasizing on the mediation role of physical activity in the association of BMI and personality traits. Briefly, no significant association was found between ordinal PA and BMI in females. According to the larger sample size of females (higher power), this lack of association was reliable. It seems that the effect of personality traits on BMI in females, may have mediators other than physical activity (which shown as direct effect in this study). In males, the only mediation pathway of ordinal PA was for the associa-

tion of EX and BMI. However, the effect of direct pathway was 7.29 folds of indirect pathway (0.051 vs -0.007) showing the dominancy of direct pathway. It seems that the mediation pathway of physical activity does not have an important role in the association of BMI and personality traits.

As mentioned, investigating the etiology of obesity requires an interdisciplinary approach with statistical modeling. For example, some cases of modeling done in previous studies are mentioned. Dishman examined the interaction of genetics and physical activity in a review article. The author showed that genes could influence adaptability to exercise, reward satisfaction and adherence to exercise. Finally, the author proposed a modeling with investigation of gene and environment interactions (13).

Darbandi et al in Kermanshah, in a cross-sectional study on 10,000 participants of the non-communicable psychiatric disease cohort, investigated the role of nutritional pattern and physical activity in obesity and overweight using SEM. Briefly, 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 sex, in women, SES had a weak direct effect, and indirectly, through physical activity and dietary pattern variables, had a significant effect on the outcome. The same situation has been observed in men as well (14). In our study, personality traits were investigated as the independent variables.

In the present study, the association of BMI with physical activity was weak. We investigated the effects of physical activity on BMI. However, most papers of the literature were about the benefits of physical activity in obese patients. For example, the systematic review of Pojednic et al showed that physical activity could improve overall health, boost mood, enhance fitness levels, and reduce the risk of diseases like diabetes and heart conditions. The study emphasized that staying active offers significant advantages beyond just losing pounds, encouraging people with obesity to prioritize exercise for their well-being (15). Another study examined how physical activity levels differ between male and female students at Malaysian and State University of Medan, focusing on how BMI affects these levels. It found that there were noticeable differences in activity levels based on gender, with factors like BMI also playing a role in how active students were. The study highlighted the importance of understanding these differences to promote better health and fitness among university students (16).

Khajeheian et al in Tehran investigated the effect of social networks on children's obesity using SEM by the Taguchi method. The output of SEM yielded significant influencing variables on childhood obesity (17). Wan Mohamed Radzi et al designed a Bayesian SEM for students in Malaysia. In their model, for PhD students, healthy food intake, unhealthy food intake, lifestyle, and mental health had a direct effect on BMI. Mental health, in turn, affected the intake of healthy and unhealthy food (18). As seen in the literature, there are many variables affecting obesity that in our study we found as direct effects instead. However, it should be regarded that without longitudinal data we cannot make a strong causal inference.

The most important limitation of this study was lack of information about nutritional habits of the participants. It seems that many direct pathways found in this study may be attributable to nutritional habits. In addition, secondary design was another limitation. Cross-sectional design resulted in lack of longitudinal data to reach a causal relationship. Although the design of study was cross-sectional without observing temporal precedence of personality traits, we assumed the present causal sequence according to the literature and biological plausibility.

Conclusion

Personality traits including SS, NEU, EX and AG could directly affect BMI in females. In addition, BMI was not associated with physical activity in females. It seems that there are many unknown pathways between personality traits and obesity in females. In males, only EX was associated with

physical activity and BMI. As a brief conclusion, the role of personality traits in obesity was more dominant in females, while in males, physical activity had a role in obesity. The hypothesized mediation pathway of the study title was not approved in females, and in males, was approved only for EX personality trait. However, such a conclusion requires longitudinal data in future studies. Finding other mediators is suggested as future cohort studies with longitudinal data.

Journalism Ethics considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

Acknowledgements

The present study was supported by Iran University of Medical Sciences with grant number 24559.

Conflict of Interest

The authors declare that there is no conflict of interests.

References

1. Avgerinos KI, Spyrou N, Mantzoros CS, Dalamaga M (2019). Obesity and cancer risk: Emerging biological mechanisms and perspectives. *Metabolism,* 92:121-135.
2. Földi M, Farkas N, Kiss S, et al (2020). Obesity is a risk factor for developing critical condition in COVID-19 patients: a systematic review and meta-analysis. *Obes Rev,* 21 (10):e13095.
3. Gona PN, Kimokoti RW, Gona CM, et al (2021). Changes in body mass index, obesity, and overweight in Southern Africa development countries, 1990 to 2019: Findings from the Global Burden of Disease, Injuries, and Risk Factors Study. *Obes Sci Pract,* 7 (5):509-524.
4. Vaisi-Raygani A, Mohammadi M, Jalali R, et al (2019). The prevalence of obesity in older adults in Iran: a systematic review and meta-analysis. *BMC Geriatr,* 19 (1):371.
5. Salimi Y, Taghdir M, Sepandi M, Karimi Zarchi AA (2019). The prevalence of overweight and obesity among Iranian military personnel: a systematic review and meta-analysis. *BMC Public Health,* 19 (1):162.
6. Loos RJ, Yeo GS (2022). The genetics of obesity: from discovery to biology. *Nat Rev Genet,* 23 (2):120-133.
7. Ruiz LD, Zuelch ML, Dimitratos SM, Scherr RE (2019). Adolescent obesity: diet quality, psychosocial health, and cardiometabolic risk factors. *Nutrients,* 12 (1):43.
8. Malik VS, Willett WC, Hu FB (2013). Global obesity: trends, risk factors and policy implications. *Nature Rev Endocrinol,* 9 (1):13-27.
9. Desai MN, Miller WC, Staples B, Bravender T (2008). Risk factors associated with overweight and obesity in college students. *J Am Coll Health,* 57 (1):109-114.
10. Gerlach G, Herpertz S, Loeber S (2015). Personality traits and obesity: a systematic review. *Obes Rev,* 16 (1):32-63.
11. Rahnamaie S, Farhadi H (2020). Psychometric properties and normalization of the Zuckerman-kuhlman-Aluja Personality Questionnaire Shortened from (ZKA-PQ/SF). *Clin Psychol Personal,* 18 (2):145-157.
12. Vasheghani-Farahani A, Tahmasbi M, Asheri H, et al (2011). The Persian, last 7-day, long form of the International Physical Activity Questionnaire: translation and validation study. *Asian J Sports Med,* 2 (2):106-16.
13. Dishman RK (2008). Gene–physical activity interactions in the etiology of obesity: behavioral considerations. *Obesity (Silver Spring),* 16 Suppl 3:S60-5.
14. Darbandi M, Najafi F, Pasdar Y, et al (2020). Factors associated with overweight and obesity in adults using structural equation model: mediation effect of physical activity and dietary pattern. *Eat Weight Disord,* 25 (6):1561-1571.
15. Pojednic R, D'Arpino E, Halliday I, Bantham A (2022). The benefits of physical activity for people with obesity, independent of weight loss: a systematic review. *Int J Environ Res Public Health,* 19 (9):4981.

16. Akhmad I, Heri Z, Hariadi H, et al (2024). Physical activity levels among Malaysian University and State University of Medan Students: gender difference and the influence of BMI. *Retos,* (60):429-438.
17. Khajeheian D, Colabi AM, Ahmad Kharman Shah NB, et al (2018). Effect of social media on child obesity: Application of structural equation modeling with the Taguchi method. *Int J Environ Res Public Health,* 15 (7):1343.
18. Wan Mohamed Radzi CWJ, Salarzadeh Jenatabadi H, Alanzi AR, et al (2019). Analysis of obesity among Malaysian university students: A combination study with the application of Bayesian structural equation modelling and Pearson correlation. *Int J Environ Res Public Health,* 16 (3):492.