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Research Article

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Health-Related Quality of Life in Those with Persistent or Transient Obesity Phenotypes during Two Decades: Tehran Lipid and Glucose Study

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Keywords
Obesity phenotypes · Metabolically healthy obesity · Longitudinal study · Health-related quality of life

Abstract

Introduction: The current study aimed to investigate the association of three stable obesity phenotypes (persistent metabolically healthy normal weight [P MHNW], persistent metabolically healthy obese [P MHO], persistent metabolically unhealthy obese [P MUO]), and one transient (MHO to MUO) obesity phenotype throughout 18 years with health-related quality of life (HRQoL). ***Methods:*** 1,932 participants (649 men and 1,283 women) who completed the HRQoL questionnaire during 2016–2019 were recruited in the current investigation. Based on the body mass index and metabolic status, participants were classified into four obesity phenotypes, including (1) P MHNW, (2) P MHO, (3) P MUO, and (4) transient from MHO to MUO. The HRQoL was compared between groups using analysis of covariance. Participants' age, marital status, occupation status, education level, physical activity, and smoking were adjusted. ***Results:*** After adjustment for confounder variables, a significant difference among obesity phenotypes was indicated in (physical component summary) PCS scores of both sexes and (mental component summary) MCS scores just in women (p value = <0.001). The P MUO had the lowest scores in PCS and MCS, and P MHO had the highest MCS scores compared to other obesity phenotypes in either sex. ***Conclusion:*** The results of the present study indicate the negative effect of long-term concurrence of obesity and metabolic disorders on the HRQoL of adults. However, long-term obesity alone or loss of metabolic health in the short term did not affect individuals' assessment of their physical and mental health. These findings highlight the importance of preventive interventions in people with obesity; also indicate the need for awareness-raising strategies about healthy lifestyles to improve the quality of life in society.

Introduction

Over recent decades, obesity has been a major health concern with a rising trend throughout the world [1]. In 2016, approximately 13% of the world's adult population was considered with obesity based on body mass index

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(BMI) measurement [2]. Although the stage and prevalence of obesity are not the same in different countries, some factors such as rapid urbanization, sedentary lifestyle, and dietary changes are globally known as the main causes of excessive weight gain [3]. In Iran, as a Middle Eastern country facing nutrition and lifestyle transition, the prevalence of overweight/obesity is reported to be 59.3% [4].

A large body of literature has been written on obesity consequences, ranging from the individual (physical and psychological comorbidities) to social and economic burdens [5, 6]. However, not all people with a higher BMI experience the same repercussions and health conditions. In this regard, a concept called "metabolically healthy obesity" (MHO) emerged in the 1950s and referred to obesity without adiposity-associated cardio-metabolic risk factors [7]. Since then, this obesity phenotype has been quite controversial. Some have described the condition as completely benign and argued that complications accompany metabolic disorders, not obesity alone. On the other hand, some longitudinal studies have shown that this is not a stable condition and finally converts to "metabolically unhealthy obesity" (MUO) [8]. According to a recent systematic review, one-third of people with obesity have been categorized in MHO phenotype, but within 10 years, half of them lose their metabolic health [9]. As can be noticed, the MHO phenotype and its transition are not rare but have been less considered in obesity studies.

Health-related quality of life (HRQoL), including physical and mental dimensions of health, is a concept that has been frequently studied in association with obesity among various populations. Numerous studies have shown lower HRQoL in people with obesity [10], while some investigations have found this negative association just in one of the physical or mental dimensions of health [11, 12]. Moreover, sex differences have been indicated in HRQoL scores and subscales [13]. However, some investigations delved deeper into essential details of the mentioned relationship, such as the role of metabolic health profile, to answer whether just high BMI determines poor HRQoL or accumulative effects of BMI and metabolic status. On this subject, lower HRQoL in MUO compared to MHO has been indicated among different populations [13–15].

Despite all efforts to elucidate the relationship between obesity phenotypes and quality of life, there are still ambiguities in this regard. The associations of (1) weight and metabolic status in the long run with a person's perception of their health, as well as (2) the HRQoL in individuals with obesity who lost their metabolic health in the short term, have not been well-documented yet. The current study aimed to investigate the association of three stable (persistent metabolically healthy normal weight [P MHNW], persistent metabolically healthy obese [P MHO], persistent metabolically unhealthy obese [P MUO]) and one transient (MHO to MUO) obesity phenotypes with HRQoL throughout 18 years to make a clear comparison possible.

Materials and Methods

Study Design and Population

The current study was conducted in the framework of Tehran Lipid and Glucose Study (TLGS), an integrated population-based cohort program designed to prevent noncommunicable diseases (NCDs) and reduce their related risk factors. The study contains two principal stages, including the 1st phase, for estimating the prevalence of NCDs from (1999–2002) and the subsequent 5 phases (2002–2019), a 20-year follow-up completed every 3 years. Data were collected from 15,005 individuals aged ≥3 years living in district 13 of Tehran, the capital of Iran. More features of the program were published elsewhere [13, 16].

Among the 2,392 participants whose obesity phenotype (BMI and metabolic syndrome) could be identified and diagnosed during the 18-year follow-up, 460 people were excluded from the study due to unknown quality of life at the last measurement. The data of 1,932 individuals (649 men and 1,283 women) were included in the analysis as the final sample of the present study. The Research Institute for Endocrine Sciences, Shahid Beheshti University of Medical Sciences, has approved the ethics of this study. Participants were aware of the study objectives and, before data gathering, signed written informed consent.

Definition and Measurements

Biochemical Measurements

Trained staff collected the blood samples of all participants after 12–14 h of overnight fasting. All blood samples were analyzed at the TLGS laboratory. Fasting blood sugar (FBS) was estimated by the enzymatic colorimetric strategy with the glucose oxidase procedure. Total cholesterol and triglyceride (TG) levels were measured using enzymatic calorimetric tests with cholesterol esterase and 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. Additional data have been previously distributed regarding the biochemical measurements [17].

Clinical and Anthropometric Measurements

Based on the TLGS standard protocols [18], trained staff measured participants' waist circumference, weight, and height. Waist circumference was measured at the level of the umbilicus using an unstretched tape meter, without any pressure to the body surface, and was recorded to the nearest 0.1 cm. Weight was measured to the nearest 100 g while participants were minimally clothed and barefoot, using a digital electronic weighing scale (Seca 707, range

0.1–150 kg; Hanover, MD, USA). Height was measured using a tape meter stadiometer while participants were barefoot and standing with shoulders in normal alignment [19]. BMI was calculated by dividing the weight in kilograms by the square of height in meters, and obesity was considered as a BMI ≥30.00 (kg/m^2) [20]. After participants rested for 15 min, a trained physician took the systolic blood pressure (SBP) and diastolic blood pressure (DBP) two times using a standard mercury sphygmomanometer calibrated by the Iranian Institute of Standards and Industrial Researches. The mean of the two measurements was considered as blood pressure [16].

Metabolic Syndrome

According to the Joint Interim Statement (JIS) [21], the metabolic syndrome contains three of five following risk factors, including (1) hyperglycemia (FBS ≥100 mg/dL) or drug treatment, (2) dyslipidemia (TG ≥150 mg/dL) or drug treatment, (3) reduced HDL-C (<40 mg/dL for men and <50 mg/dL for women) or drug treatment, (4) hypertension (SBP ≥130 mm Hg, DBP ≥85 mm Hg) or drug treatment, (5) ethnic-based central obesity (waist circumference ≥90 cm for men and women) [22].

Obesity Phenotypes

The participants were classified into four obesity phenotypes, including (1) P MHNW, (2) P MHO, (3) P MUO, and (4) transient from MHO to MUO [23]. Metabolically unhealthy status was defined as having three or more aforementioned metabolic syndrome risk factors.

Sociodemographic Characteristics

All sociodemographic characteristics were obtained using TLGS documents encompassing age, sex, marital status (single, married, previously married), education levels (diploma and less, higher), and job status (employed, unemployed).

Smoking Status and Physical Activity

Participants were categorized into two groups based on their smoking behavior: smokers (daily and occasionally smokers) and non-smokers (ex-smokers or never smokers). Utilizing the Modifiable Activity Questionnaire (MAQ) [24] that was previously validated in Iran, the level of physical activity was measured. The MAQ estimates leisure time and occupational physical activities per hour/week. Besides, metabolic equivalent activities of each leisure-time physical activity (MET) are multiplied to figure the energy use for every domain. Complete physical activity was determined by adding every domain's energy use and was classified into three levels low (<600), moderate (600–3,000), and high (≥3,000) physical activity [25].

The HRQoL Questionnaire

The short form of the Health-Related Quality of Life (HRQoL) questionnaire with 12-item as a shorter version of the SF-36 [26] was used in the current study. The questionnaire has been validated in Iran, and the internal consistency was competent. It comprises two main scales encompassing Physical Component Summary (PCS) and Mental Component Summary (MCS), with four different subscales for each main scale. The questionnaire estimates four physical health-related components: physical functioning, role limitations, bodily pain, general health, and four mental health-related subscales, including vitality, social functioning, role limitations, and mental health. The scoring range for each scale is from 0 to 100 to calculate the worst and the best health-related states [27].

Statistical Analysis

All analysis analyses were separately done for males and females. Baseline characteristics were expressed as mean ± SD and frequency (percentage), respectively, for continuous and categorical variables. For comparing continuous and categorical variables between groups, ANOVA and χ^2 tests were run, respectively. The HRQoL was compared between groups using analysis of covariance and participants' age, marital status, occupation status, education level, physical activity, and smoking were adjusted. Statistical analyses were conducted using IBM SPSS software ver. 22.0 (IBM Co., Armonk, NY, USA), and a 2-sided p value <0.05 was considered statistically significant.

Results

The mean age of 1,932 participants (66.4% women) at baseline was 37.58 ± 12.25 for men and 34.80 ± 10.40 for women. The sociodemographic status, smoking status, physical activity as well as metabolic variables of the participants, at baseline are presented in Table 1. Obesity phenotypes prevalence in men and women was, respectively, as follows: 71.0% (n = 461) and 62.2% (n = 798) for – P MHNW phenotype, 3.7% (n = 24) and 4.8% (n = 61) for P MHO phenotype, 15.7% (n = 102) and 17.8% (n = 229) for P MUO phenotype, and 9.6% (n = 62) and 15.2% (n = 195) for the transition from MHO to MUO phenotype. Most individuals regardless of their obesity phenotype had a high school diploma or less (78.9% men and 86.1% women). The majority of males in all groups were employed (82.9%), while most females were unemployed (85.6%). Most participants in all groups were married (73.7% men and 78.3% women). The sociodemographic characteristics of participants in the 6th phase (last examination) are illustrated in the online supplementary Table (for all online suppl. material, see www.karger.com/doi/10.1159/000529596).

Table 2 shows the mean of unadjusted HRQoL subscales. There was a significant difference in five scales, including physical function, general health, PCS (p = <0.001), bodily pain (p = 0.006), and vitality (p = 0.05) among males, respectively. In contrast, it was a statically significant difference in all scales among females. Table 3 illustrates the mean of all HRQoL scales after adjustment for age, marital status, job status, education level, smoking status, and physical activity level, a significant difference among obesity phenotypes was indicated in PCS scores of both sexes, and MCS scores just in women (p value = 0.013). All subscales of HRQoL were signifi-

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Table 1. Sociodemographic characteristics of participants at baseline across different obesity phenotypes

	Men						Women					
	total (649)	persistent MHNW (461)	persistent MHO (24)	persistent MUO (102)	transition from MHO to MUO (62)	*p* value	total (1,283)	persistent MHNW (798)	persistent MHO (61)	persistent MUO (229)	transition from MHO to MUO (195)	*p* value
Age, year	37.58±12.25*	37.02±12.56	34.71±10.40	39.90±11.43	39.03±11.47	0.07	34.80±10.40	30.57±8.10	35.44±10.24	45.00±8.78	39.92±9.93	<0.001
Education level												
Diploma and less	512 (78.9)[a]	357 (77.4)	22 (91.7)	80 (78.4)	53 (85.5)	0.206	1,105 (86.1)	644 (80.7)	59 (96.7)	222 (96.9)	180 (92.3)	<0.001
Higher	137 (21.1)	104 (22.6)	2 (8.3)	22 (21.6)	9 (14.5)		178 (13.9)	154 (19.3)	2 (3.3)	7 (3.1)	15 (7.8)	
Job status												
Employed	537 (82.9)	367 (79.8)	21 (87.5)	93 (91.2)	56 (90.3)	0.01	185 (14.4)	150 (18.8)	7 (11.5)	9 (3.5)	19 (9.7)	<0.001
Unemployed	111 (17.1)	93 (20.2)	3 (12.5)	9 (8.8)	6 (9.7)		1,098 (85.6)	648 (81.2)	54 (88.5)	220 (96.1)	176 (90.3)	
Marital status												
Single	170 (26.2)	142 (30.8)	6 (25)	14 (13.7)	8 (12.9)	0.003	225 (17.5)	209 (26.2)	5 (8.2)	4 (1.7)	7 (3.6)	<0.001
Married	478 (73.7)	318 (69)	18 (75)	88 (86.3)	54 (87.1)		1,004 (78.3)	570 (71.4)	51 (83.6)	207 (90.4)	176 (90.3)	
Previously married	1 (0.2)	1 (0.2)	0 (0)	0 (0)	0 (0)		54 (4.2)	19 (2.4)	5 (8.2)	18 (7.9)	12 (6.2)	
Smoking status												
Smoker	231 (35.8)	163 (35.7)	4 (16.7)	47 (46.1)	17 (27.4)	0.01	37 (2.9)	19 (2.4)	2 (3.3)	7 (3.1)	9 (4.7)	0.406
Nonsmoker	414 (64.2)	294 (64.3)	20 (83.3)	55 (53.9)	45 (72.6)		1,240 (97.1)	775 (97.6)	59 (96.7)	222 (96.9)	184 (95.3)	
Physical activity												
Low	436 (67.9)	300 (66.1)	14 (58.3)	73 (71.6)	49 (79)	0.11	854 (67)	528 (66.7)	36 (59)	163 (71.2)	127 (65.8)	0.29
High	206 (32.1)	154 (33.9)	10 (41.7)	29 (28.4)	13 (21)		421 (33)	264 (33.3)	25 (41)	66 (28.8)	66 (34.2)	
BMI, kg/m^2	25.26±5.58	22.22±2.82	31.87±2.58	33.32±3.61	32.03±2.078	<0.001	26.70±5.92	22.70±2.95	32.73±2.73	33.81±3.11	32.85±2.70	<0.001
WC, cm	86.19±14.37	78.77±8.41	101.17±7.42	106.38±9.00	102.35±7.39	<0.001	84.16±14.35	75.22±8.40	94.18±9.43	102.15±7.87	96.13±9.03	<0.001
SBP, mm Hg	113.23±14.07	110.04±12.65	11.62±9.00	126.54±14.93	116.06±11.00	<0.001	111.66±15.18	106.13±10.72	111.65±13.24	126.90±18.41	116.33±13.22	<0.001
DBP, mm Hg	74.14±10.22	71.59±9.12	72.17±7.29	84.81±9.80	76.66±7.61	<0.001	74.14±9.97	70.56±8.29	75.08±7.99	83.87±9.59	77.03±8.57	<0.001
Hypertension												
Yes	56 (8.7)	18 (3.9)	1 (4.2)	35 (35)	2 (3.2)	<0.001	132 (10.3)	13 (1.6)	2 (3.3)	95 (41.5)	22 (11.3)	<0.001
No	590 (91.3)	442 (96.1)	23 (95.8)	65 (65)	60 (96.8)		1,148 (89.7)	782 (98.4)	59 (96.7)	134 (58.5)	173 (88.7)	
FBS, mg/dL	90.14±14.60	87.75±10.17	87.62±6.55	100.10±24.93	92.53±14.90	<0.001	88.90±17.30	84.50±7.53	85.21±6.60	106.26±32.38	87.62±7.60	<0.001
HDL-C, mg/dL	40.98±10.00	42.68±9.61	44.80±10.43	32.60±6.86	40.63±10.08	<0.001	46.57±11.06	48.46±10.98	48.88±9.22	39.50±8.26	46.48±11.43	<0.001
Total cholesterol, mg/dL	189.30±40.96	182.20±39.19	186.67±37.75	211.55±38.91	206.55±41.07	<0.001	193.47±43.10	179.14±34.66	192.34±31.61	233.78±45.89	205.16±40.67	<0.001
TG, mg/dL	109[b] (79–170)	94 (73–130)	102.5 (76.3–123.5)	239.5 (191–336.5)	125 (1,101.7–170.7)	<0.001	101 (75–145)	85 (64–107)	101 (80–119)	216 (168.5–259.5)	119 (100–142)	<0.001

MHNW, metabolically healthy normal weight; MHO, metabolically healthy obese; MUO, metabolically unhealthy obese; BMI, body mass index; WC, waist circumference; SBP, systolic blood pressure; DBP, diastolic blood pressure; FBS, fasting blood sugar; HDL-C, high-density lipoprotein cholesterol. Data are presented as * mean ± SD, [a] frequency(%) and [b] median (Q1-Q3).

Table 2. Sex-specific HRQoL unadjusted scores among different obesity phenotypes

	Persistent MHNW	Persistent MHO	Persistent MUO	Transition from MHO to MUO	*p* value
Men					
PCS	50.71±0.33*	47.77±1.42	46.84±0.82	49.20±0.87	<0.001
Physical function	90.45±0.91	92.71±4.63	80.64±2.60	85.48±2.96	<0.001
Role physical	87.09±0.91	84.37±4.00	81.37±2.42	88.31±2.44	0.06
Bodily pain	85.79±0.94	72.91±4.49	80.88±2.54	86.69±2.49	0.006
General health	53.14±1.07	43.75±3.45	39.21±1.92	45.56±2.54	<0.001
MCS	50.79±0.46	53.06±1.37	50.29±1.14	52.50±1.32	0.38
Vitality	70.98±1.11	78.12±3.47	65.93±2.69	77.62±3.22	0.05
Social function	84.87±1.09	88.54±4.25	82.35±2.53	88.71±2.68	0.33
Role emotional	82.73±0.96	82.29±3.75	79.29±2.48	81.85±2.56	0.53
Mental health	74.38±0.92	77.60±3.45	72.67±2.31	77.62±2.75	0.42
Women					
PCS	48.28±0.29	44.41±1.28	40.81±0.65	43.32±0.67	<0.001
Physical function	83.30±0.83	73.77±4.15	60.37±2.16	70.00±2.17	<0.001
Role physical	75.81±0.80	73.56±3.65	61.02±1.88	66.53±1.86	<0.001
Bodily pain	76.06±0.84	74.59±3.00	64.30±2.02	67.18±2.06	<0.001
General health	50.12±0.78	38.93±2.71	30.02±1.11	38.07±1.53	<0.001
MCS	46.92±0.37	49.72±1.56	44.74±0.81	46.27±0.86	0.008
Vitality	61.84±24.90	61.06±3.99	50.00±2.00	57.31±2.07	<0.001
Social function	79.38±0.93	80.73±3.62	73.69±2.03	73.20±2.22	0.004
Role emotional	72.41±0.82	76.64±3.12	65.23±1.75	68.65±1.87	<0.001
Mental health	66.40±0.74	70.28±3.28	57.42±1.69	63.33±1.77	<0.001

MHNW, metabolically healthy normal weight; MHO, metabolically healthy obese; MUO, metabolically unhealthy obese; PCS, physical component summary; MCS, mental component summary. * Data are presented as mean ± SE.

Table 3. Sex-specific HRQoL full-adjusted scores among different obesity phenotypes

	Persistent MHNW	Persistent MHO	Persistent MUO	Transition from MHO to MUO	*p* value
Men					
PCS	50.12±0.59*	46.64±1.56	46.56±0.90	49.16±1.04	<0.001
Physical function	89.09±1.72**	90.01±4.54	79.42±2.62	85.12±3.04	0.001
Role physical	84.59±1.64	80.30±4.33	84.59±1.64	80.30±4.33	0.074
Bodily pain	84.54±1.76	70.60±4.63	79.03±2.67	85.67±3.10	0.005
General health	49.57±1.79	38.93±4.71	36.39±2.72	43.24±3.16	<0.001
MCS	49.53±0.83	51.53±2.18	48.43±1.26	50.72±1.46	0.267
Vitality	66.47±2.00	72.61±5.26	62.12±3.03	70.28±3.52	0.041
Social function	85.45±1.90	88.18±5.01	82.12±2.89	88.73±3.36	0.231
Role emotional	79.40±1.75	77.89±4.60	74.55±2.66	77.62±3.09	0.314
Mental health	72.08±1.69	74.92±4.44	69.09±2.56	74.56±2.98	0.290
Women					
PCS	48.08±0.67	45.47±1.24	43.39±0.88	44.95±0.85	<0.001
Physical function	78.92±2.08	73.50±3.84	65.01±2.72	71.53±2.64	<0.001
Role physical	73.75±1.89	74.57±3.50	65.05±2.48	68.50±2.40	<0.001
Bodily pain	77.88±2.02	77.48±3.73	68.86±2.64	70.85±2.56	<0.001
General health	48.67±0.78	39.13±2.67	33.56±1.54	39.81±1.53	<0.001
MCS	45.61±0.88	48.50±1.62	43.29±1.15	44.96±1.11	0.013
Vitality	61.95±2.10	62.23±3.88	51.59±2.75	58.56±2.67	<0.001
Social function	75.63±2.20	77.76±4.06	71.54±2.87	70.79±2.77	0.097
Role emotional	72.34±1.91	77.27±3.53	66.06±2.50	69.28±2.42	0.005
Mental health	48.89±1.62	40.56±3.00	34.60±2.12	40.86±2.06	0.001

MHNW, metabolically healthy normal weight; MHO, metabolically healthy obese; MUO, metabolically unhealthy obese; PCS, physical component summary; MCS, mental component summary. * Data are presented as mean ± SE. ** Adjusted for age, marital status, job status, education level, smoking status, and physical activity level.

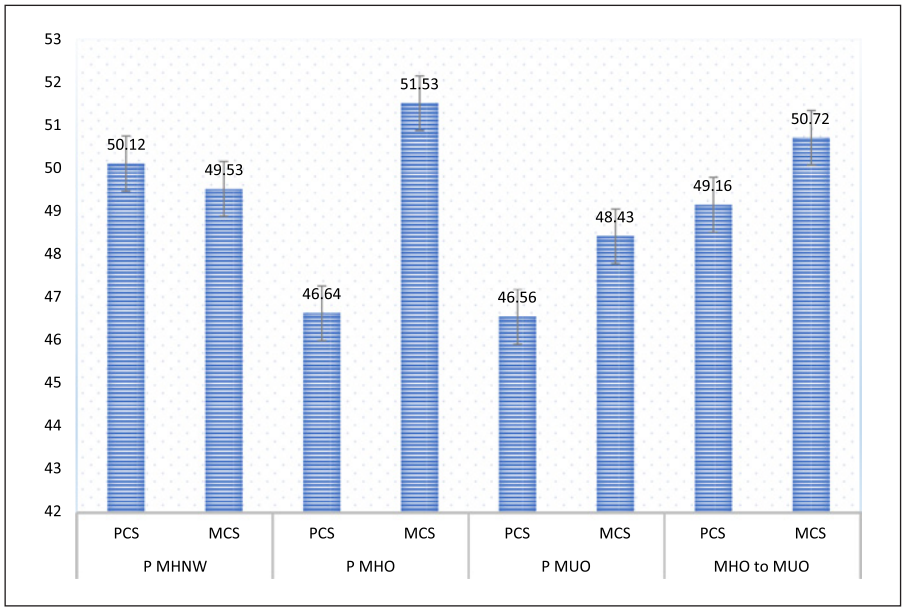

Fig. 1. HRQoL means in men across different obesity phenotypes over 18 years. MHNW, metabolically healthy normal weight; MHO, metabolically healthy obese; MUO, metabolically unhealthy obese; PCS, physical component summary; MCS, mental component summary.

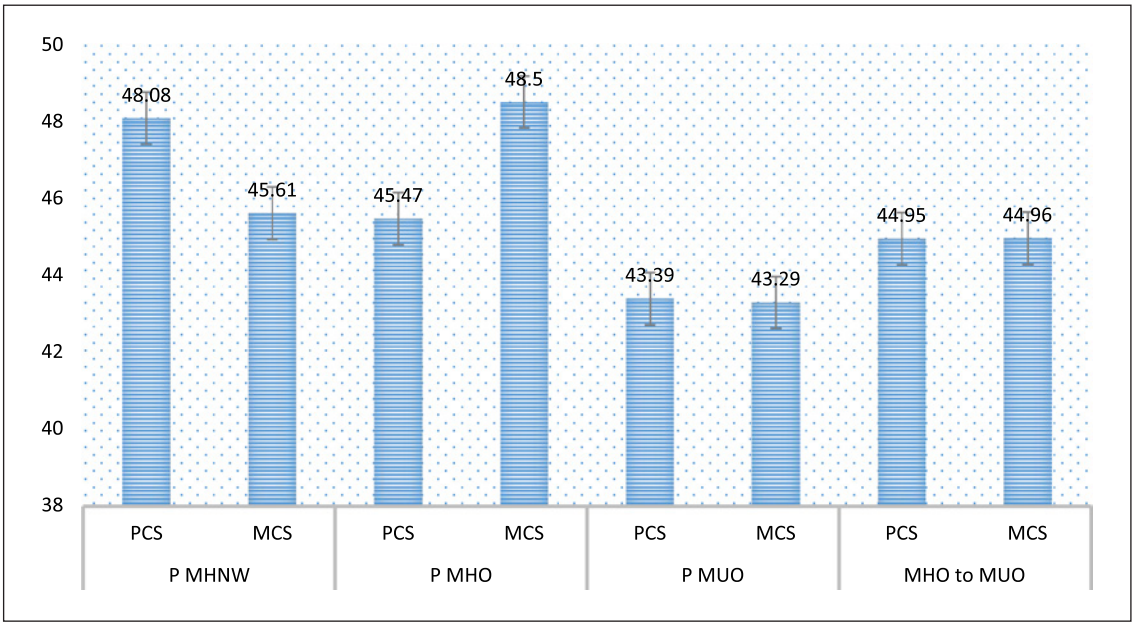

Fig. 2. HRQoL means in women across different obesity phenotypes over 18 years. MHNW, metabolically healthy normal weight; MHO, metabolically healthy obese; MUO, metabolically unhealthy obese; PCS, physical component summary; MCS, mental component summary.

cantly different in women except for social function (p value = 0.097), while men only in some subscales including physical function (p value = 0.001), bodily pain (p value = 0.005), general health (p value = <0.001), and vitality (p value = 0.041) had significantly different scores across obesity phenotypes.

The HRQoL means in men and women across different obesity phenotypes are presented in Figures 1 and 2, respectively. The highest PCS mean (50.12 among men and 48.08 among women) was in P MHNW and the highest MCS mean (51.53 among men and 48.05 among women) was in the P MHO. As expected, the lowest mean of

PCS (46.56 among men and 43.39 among women) and MCS (48.43 among men and 43.29 among women) was in the P MUO. Moreover, women in transition from MHO to MUO had an almost equal mean of PCS (44.95) and MCS (44.96).

Discussion

The current study aimed to compare HRQoL scores among different persistent obesity phenotypes (P MHNW, P MHO, and P MUO) in addition to the common transition from MHO to MUO over 18 years. In total, the current result showed higher HRQoL scores in men across all obesity phenotypes than in women. However, a significant difference in PCS scores among different obesity phenotypes was observed regardless of sex. The findings of the current study regarding MCS indicated significant differences only in women with different obesity phenotypes. As expected, the P MUO had the lowest scores in PCS and MCS in either sex.

In general, higher HRQoL in men compared to women has also been observed in previous studies among different populations and countries [28–30]. Although psychosocial issues in each community play a significant role in determining health-related elements, in this case, higher HRQoL in men than women seems to be a cross-border subject. Due to the considerable extent of the HRQoL concept, a mega-study may be needed to precisely determine gender differences in physical and mental dimensions of health. However, some factors such as socioeconomic status and family factors have been suggested to reduce women's HRQoL generally [31, 32].

Considering the significant differences in PCS scores among different obesity phenotypes, the current results align with the findings of some previous investigations indicating lower PCS in MUO compared to other obesity phenotypes [12, 13, 33]. However, a recent study among the Chinese population addressed the "obesity-HRQoL paradox" since Chinese men with higher BMI reported better HRQoL than their normal-weight counterparts. It should be noted that cardiovascular risk factors were not considered in the mentioned study [29]. Another point about the current results refers to the sex differences in the evaluated relationship. In this regard, women were more affected by the accumulative effect of their metabolic status and BMI; in view of the fact that all the PCS subscales scores of women were statistically different among obesity phenotypes, and there was a clinically significant difference between the P MHNW and P MUO.

The most novel finding of the present study is that PCS scores in three phenotypes (MHNW, MHO, and transition from MHO to MUO) are approximately similar, but P MUO relatively had a lower score. This result indicates that individuals do not recognize considerably lower physical health immediately after the transition from MHO to MUO, and the duration of the obesity phenotype certainly matters. Consistent with this outcome, the association between obesity duration and physical disabilities was shown in Framingham Heart Study [34]. Therefore, since it takes time for a person to realize the decline in the physical dimension of HRQoL, people with heavier weights, even if they do not have metabolic conditions, should be delivered healthy lifestyle training and preventive actions. It must be noted that many interventions aimed just at weight loss have not been effective, and comprehensive plans are needed to help individuals with obesity achieve a healthier life, not simply focusing on weight loss [35].

In terms of MCS, current results showed significant differences among different obesity phenotypes in women, while no significant difference was observed in men. Some previous studies have noted that the association between obesity and MCS is not as robust as PCS (33). Due to the more dynamic nature of mental issues, MCS varies among different genders and cultures. In agreement with our results, the findings of a similar study among the Spanish population with 2 years of follow-up showed no significant association in MCS scores [33]. Another study among the Korean population, focusing on gender differences in the relationship between BMI and HRQoL, found a negative association in women but no such pattern in men [36]. The results of a meta-analysis on HRQoL in people with obesity also emphasized a much greater improvement in the PCS scores than MCS after bariatric surgery [37].

Interestingly, in both sexes, P MHO had the highest MCS scores compared to other obesity phenotypes, even P MHNW. It is well-documented, especially in Western studies, that obesity has psychological repercussions such as depression, anxiety, and low self-esteem, mainly related to body shame and negative body image [38]. Yet, there is no precise information on whether people who keep their weight in the normal range (based on BMI) experience some specific psychological burden or not. Nevertheless, the mental health outcomes of thinspiration in some communities have recently been addressed [39, 40]. In Eastern culture, however, obesity alone does not determine mental health conditions, and physical health outcomes associated with obesity seem to reduce a person's mental state. For instance, it has been indicated that being underweight is associated with lower MCS in

Asia pacific region [41] and MHO women had lower suicidal ideation in Korea [42].

This study has strengths and weaknesses. First, this is one of the initial attempts to investigate the association of obesity phenotypes and HRQoL over 18 years, considering the common transition from MHO to MUO among a large population. Second, considering the details of cardiovascular risk factors along with weight status is also an important point in obesity studies. However, there are some weaknesses in the present research. This study cannot be generalized to rural areas due to implementation among the urban population. In addition, despite the longitudinal nature of the study and all efforts to control confounding variables, HRQoL is a broad concept; controlling all its potential predictors was not feasible.

Conclusion

The results of this study, considering the low scores of MUO compared to transient and MHO, indicate the importance of an obesity phenotype duration. This critical factor can be applied in planning obesity prevention programs as well as informing the MHO phenotype. Since individuals with obesity generally visit healthcare providers when their HRQoL is significantly reduced and the primary stage of prevention is lost, comprehensive programs including the physical and mental dimensions of health in individuals with excess weight could be helpful. Also, the significant difference in the mental dimension of quality of life in women indicates the need for psychological interventions and appropriate mental health services in different obesity phenotypes.

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Statement of Ethics

Participants were aware of the study objectives and, before data gathering, signed written informed consent. All procedures performed in this study 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 and were approved by the Research Ethics Committee of the Research Institute for Endocrine Sciences (RIES), Shahid Beheshti University of Medical Sciences, approval number: I.R.SBMU.ENDOCRINE.REC.1378.121.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

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Author Contributions

Fahimeh Mehrabi and Parisa Amiri: conceptualization, investigation, methodology, and project administration; Leila Cheraghi: formal analysis; Fahimeh Mehrabi and Fatemeh Mahani: writing – original draft; Parisa Amiri, Fatemeh Mahani, Ali Kheradmand, and Fereidoun Azizi: review and editing.

Data Availability Statement

All data generated or analyzed during this study are included in this article and its online supplementary material. Further inquiries can be directed to the corresponding author.

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