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Correlation between physical activity, appetite, and body composition during menopausal transition and postmenopause in Iranian women

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Abstract

Background: Hormone fluctuations in women are accompanied by an increase in obesity. Although obesity has various causes, the interaction between obesity and menopausal status remains unclear.

Objectives: This study aimed to investigate the interaction between lifestyle physical activities (PAs), such as occupational and household activities, and purposeful exercise, such as sports, with appetite and their correlation with body composition during the menopausal transition (MT) and postmenopausal (PM) phases.

Design: This was a descriptive cross-sectional design.

Methods: Women aged 42–62 years, in the MT or PM phases, were included. PA and appetite were measured using the validated Beacke questionnaire and the Simplified Nutritional Appetite Questionnaire, respectively. Body weight, height, waist circumference, and hip circumference were measured to estimate the body mass index (BMI) and waist-to-hip ratio (WHR).

Results: A total of 101 women were included in the study. A significant positive relationship was found between appetite and PA in the MT group ($r = 0.55$, $p < 0.001$). In the MT group, PA ($\beta = -0.38$, $p = 0.009$) and appetite ($\beta = 0.42$, $p = 0.004$) predicted 16% of the BMI, while PA and appetite predicted 16% of the WHR. Only PA contributed significantly to the prediction of WHR ($\beta = -0.33$, $p = 0.0.02$). In the PM group, PA and appetite predicted 15% of the WHR ($p = 0.030$), and PA was a significant predictor of the WHR ($\beta = -0.29$, $p = 0.0.03$). There was no significant difference between the BMI and WHR in active women who regularly performed purposeful exercise compared to inactive women during the PM phase ($p > 0.05$). However, the appetite of active women was higher than of inactive women ($p = 0.003$).

Conclusions: Menopausal status was effective on obesity indices, appetite, and PA. Lifestyle PA was superior to appetite in predicting obesity indices during the MT and PM phases, and particularly during PM; hence, PA was more important than exercise in determining obesity.

Plain language summary

Exploring the impact of physical activity and appetite on obesity in women during menopause and after

This study looked at how physical activity (PA) and appetite affect obesity in women going through menopause and after. Hormonal changes during menopause can lead to weight gain, but how this relates to activity levels and appetite is not well understood. Researchers included 101 women aged 42 to 62 who were either in the menopausal transition (MT) or postmenopausal (PM). They assessed the participants' levels of physical activity and appetite using questionnaires and measured body weight and measurements to calculate body mass index (BMI) and waist-to-hip ratio (WHR). The results showed a strong link between appetite and physical activity in women going through menopause. Both PA and appetite

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were found to influence BMI and WHR in these women. Interestingly, while both factors predicted obesity measures, it was mainly physical activity that played a key role in affecting the waist-to-hip ratio. In the postmenopausal group, physical activity and appetite also influenced waist-to-hip ratio, but there was no significant difference in BMI and WHR between women who exercised and those who did not. However, active women reported a higher level of appetite compared to inactive women. In conclusion, the study found that menopausal status impacts body composition and appetite. Lifestyle physical activity was more influential than appetite in predicting obesity during both the menopausal transition and after menopause, highlighting the importance of staying active rather than just focusing on exercise in managing body weight

Keywords
postmenopause, premenopause, physical activity, appetite, body mass index, waist-to-hip ratio

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Introduction

Due to increased life expectancy, women spend 30%–40% of their lives postmenopause (PM),[1] which can be associated with chronic diseases and mobility limitations.[2] Menopause is defined as the cessation of the menstrual cycle and is diagnosed as 12 months without menstruation. Menopausal transition (MT) is defined as a dynamic change of the menstrual cycle, amount of bleeding, and duration of menstrual flow.[3] The reduction of estrogen levels during MT and PM is associated with many changes, which may lead to weight gain, increased visceral fat, decreased lean body mass, and changes in body composition.[4] Hormonal changes and chronological aging influence fat distribution and energy expenditure.[5] Estrogen increases resting energy expenditure[6]; hence, its suppression during menopause can be an important cause of obesity. Food intake and appetite can also affect menopausal obesity.[7] Estrogen is considered an important factor in regulating appetite, metabolism, and food intake, and due to decreased estrogen levels during PM, changes in food intake and weight gain are expected.[8] Significant hormonal changes during the MT can ultimately increase the risk of eating disorders.[9] Estrogens suppress appetite by influencing the central nervous system and regulating energy balance. Consequently, it can be hypothesized that a significant decrease in estrogen levels during menopause increases appetite.[8] Unlike androgens, estradiol causes a decrease in appetite, and estrogenic stimuli inhibit feeding in rodents through the estrogen receptor alpha (α) in different regions of the brain.[10] Neurotransmitters and gastrointestinal peptides interact with sex hormones to maintain energy expenditure and appetite.[7]

Estrogen increases energy expenditure associated with physical activity (PA); therefore, during menopause, a reduction in resting energy expenditure occurs because of estrogen deficiency.[11] Some evidence suggests that during MT, PA is reduced and women spend more sedentary time.[12] PA regulates appetite through its effect on satiety signaling, and PA reduces fat, which in turn reduces its derived estrogen. According to previous studies, PA and exercise have beneficial effects on appetite regulation and energy expenditure.[13] Moreover, a reduction in sex hormone levels during menopause has indirect adverse effects on skeletal muscles, which can lead to a decrease in PA and basal energy expenditure.[5] Therefore, estradiol can influence appetite and obesity through various mechanisms.

Higher PA levels can reduce the probable negative effects of menopause on muscle function,[14] and PA is the most crucial lifestyle factor for maintaining a normal body weight in the elderly.[15] Regular PA causes positive changes in fat distribution and body composition in pre- and PM women.[16] After menopause, hormonal, lifestyle, and environmental changes can lead to weight gain.[17] However, the effect of menopause on weight gain, predominantly by affecting appetite and PA, remains unclear. Therefore, evaluating the relationship between PA, appetite, and body composition during the phases before and after menopause will indicate the possible role of hormonal changes in determining the relationship between appetite, PA, and body composition. This study aimed to investigate the relationship between lifestyle PA, such as occupational and household activities, purposeful exercise, such as sports, and appetite, and their correlation with body composition during the MT and PM phases.

Materials and methods

Study design

We followed the STROBE Guidelines to prepare the article. This was a cross-sectional descriptive study of pre- and PM women referred to various retirement and sport centers in Yasuj, the capital city of Kohgiluyeh, and Boyer-Ahmad provinces in southwestern Iran, from July 2022 to January 2023. Yasuj has a population of approximately 135,000, with diverse ethnic groups, good health, and sports facilities.

Participants

The study proposal and procedures were in accordance with the principles set forth in the Helsinki Declaration and were approved by the Graduate and Ethics Committee of the University (registration number: SEP.1403.48.2408). The participants were informed of the study procedure, and written informed consent was obtained from each participant before participation in the study.

For calculating the sample size, the prevalence of overweight and general obesity was reported to be at 90.6% in premenopausal women and 72.6% in PM women,[18] which is very high, and to detect a simple correlation ($r=0.4$), using a two-sided test, 5% significance level ($\alpha=0.05$), and with 80% power ($\beta=0.2$), the required sample size was calculated to be 47 participants based on the following formula[19]:

$$\text{Fisher's arctanh transformation was}: c(r) = \frac{1}{2}\log_0 \frac{1+r}{1-r}$$

Given a sample correlation (r) based on N observations that was distributed about an actual correlation value (parameter) ρ, then $C(r)$ was normally distributed with mean $C(\rho)$ and variance of $(\sigma)^2 = \frac{1}{(n-3)}$

Under the null hypothesis, the test statistic was:

$$Z = C(r)\sqrt{N-3} \text{ where } Z \sim N(0,\ 1)$$

The sample size to achieve specified significance level and power was: $N = \left(\frac{z_{a+Z_p}}{C(r)}\right)^2 + 3$

In this study, 310 women aged 42–62 years voluntarily participated through announcements in various retirement and sports centers as they were referred to the researchers (non-randomly). The self-reported menopausal status was assessed, and the volunteer participants were divided based on their menopause status: (1) MT and (2) PM. The two groups were comparable in terms of ethnicity, economic status, and education level. The MT group had significant irregularity in the length and order of the menstrual cycle, with changes in the amount of bleeding, and two periods in the last 3 months. The PM group had at least 1 year and at most 10 years following the last menstruation. The inclusion criteria for both groups were ages between 42 and 62 years, stable lifestyle routine, and stable mental and physical health, such that their daily PA, weight, and appetite were not affected by a specific disease, medication, or supplement. The exclusion criteria were as follows: age outside the range of 42–62 years; poor mental and physical health; using medicine and supplements in a way that affects their PA, weight, and appetite; and not having a stable lifestyle program.

Assessments

Questionnaires were completed during face-to-face interviews to measure appetite and PA. The Baecke questionnaire,[20] which includes 3 domains and 16 questions about PA during the previous 12 months, was used to measure PA. Within each domain, multiple questions are evaluated using a 5-point Likert scale that ranges from "never" to "always" or "very often." Our study adhered to the original scoring system of the questionnaire, wherein the work domain was assessed using the average score derived from eight occupational inquiries; the sports domain was evaluated based on the average score from four sports-related questions; and the non-sports leisure domain was determined by the average score from four habitual PA performed during leisure time. Each domain was assigned a score ranging from 1 to 5 points, with a total score of 3 (minimum) to 15 (maximum). Specific questions were included to ascertain the frequency of the two most commonly reported sports activities in terms of months per year and hours per week dedicated to regular sports participation.

The validity and reliability of the Persian version of this questionnaire were reported by Sadeghisani et al. in Iran.[21] Women who participated in purposeful exercise or sports for at least three sessions per week were regarded as active, and women who did not participate in any kind of purposeful exercise were considered inactive. Women who participated in irregular exercise, such as two or fewer sessions of exercise per week, or had variable and unstable lifestyle programs were excluded from the study.

The Simplified Nutritional Appetite Questionnaire[22] was used to measure the appetite, and includes four items that measure appetite, satiety, taste of food, and the ability to eat. Consequently, the sum of all the items indicates the level of appetite. The total score ranged from 4 to 20 points. The sum of all scores indicated appetite measurements. Mohammadi et al.[23] verified the validity and reliability of the Persian version of the questionnaire in Iran.[23]

The height of the subjects was recorded to the closest 0.1 cm using a stadiometer (SECA, Hamburg, Germany). Weight in light clothing without shoes was measured using a standard scale (GS 203; Beurer, ULm, Germany) with an accuracy to the nearest 0.1 kg. Body mass index (BMI) was calculated as weight (kg) divided by height squared (m^2).

Hip and waist circumferences were measured to estimate the waist-to-hip ratios (WHR). Waist and hip circumferences were measured twice, accurate to 0.1 cm, with an inelastic and flexible tape (made in Iran) while

subjects stood lightly clothed on a horizontal plane at the end of the normal breathing out phase. The average of the two measurements was used for further analyses. Waist circumference was measured at a point midway between the top of the iliac crest and lower rib margin, whereas hip circumference was measured at the level of the greater trochanters. The WHR was calculated as waist (cm)/hip (cm) ratio.

To prevent possible bias, all interviews and measurements were conducted by one of the researchers using the same instruments.

Statistical analysis

IBM Statistical Package for the Social Sciences (SPSS 21) software was used for all analyses. Mean ± standard deviation was used to describe variables. The normality of the data distribution was evaluated using the Kolmogorov–Smirnov test. In the case of a normal distribution, the Pearson's correlation coefficient test was used to assess the relationships between variables. Spearman's rank correlation coefficient test was used to assess the relationship between PA and appetite due to a non-normal distribution. Multiple linear regression tests were conducted considering PA and appetite as predictor variables, and BMI and WHR ratio as criterion variables. The Mann–Whitney *U* test was used to compare differences in appetite between active and inactive women; and an independent sample *t*-test was used to compare the differences in BMI and WHR between active and inactive women. The analysis of covariance (ANCOVA) test was used to compare the variables in the PM and MT groups after adjusting for age. No missing data were noted. Statistical significance was set at $p \leqslant 0.05$.

Results

Among the 310 volunteers, 101 were eligible based on the study aims and inclusion criteria. Participants of the study included 57 MT women aged 47 ± 4 years, and 44 PM women aged 54 ± 4 years. The age of menopause in PM women was 49.21 ± 2.04 years, and their duration of menopause was 5.93 ± 3.68 years.

The education levels in the MT and PM groups were similar. Most of the participants (82, 81.18%) were housewives, and the majority of them (92, 92.92%) were married, had a high school (diploma) education (50, 49.50%), and an average income (69, 68.31%). Of these, 52.47% performed the purposeful exercises. The majority of the participants were obese or overweight (88, 87.13%; obese, 44%; overweight, 42%), and 13 (12.87%) participants were of normal weight. Of these, 46 (80.7%) from the MT group and 42 (95.45%) from the PM group were categorized as overweight or obese according to their BMI (⩾25). The demographic characteristics of the participants are presented in Table 1. A significant positive relationship was found between appetite and lifestyle PA in the MT group ($r = 0.55$, $p < 0.001$). However, there was no significant relationship between appetite and lifestyle PA in the PM group ($r = 0.27$, $p = 0.168$).

The regression analyses indicated that in the MT group, PA ($\beta = -0.38$, $p = 0.009$) and appetite ($\beta = 0.42$, $p = 0.004$) precited 16% of the BMI (Table 2). As a result, in the MT group, the increase in PA was accompanied by the decrease in BMI. Moreover, the BMI increased with the increase in appetite. PA and appetite predicted 16% of the WHR in the MT group, whereas only PA contributed significantly to the prediction of WHR ($\beta = -0.33$, $p = 0.02$). In the PM group, PA and appetite predicted 15% of WHR ($p = 0.030$). Between these two factors, PA ($\beta = -0.29$, $p = 0.0.03$) was the most important predictor of the WHR in the PM group. PA and appetite did not predict BMI in the PM group ($p > 0.05$; Table 2).

Comparison of the MT and PM groups indicated that the BMI of the PM group was significantly higher than the MT group (30.4 ± 3.51 versus 28.53 ± 3.6 kg/m^2; $t = -2.577$, $p = 0.011$). However, there was no significant difference in the BMI between the MT and PM groups when compared using the ANCOVA and adjusted by age as the covariate ($p = 0.124$, $np^2 = 0.024$). The WHR in the PM group was significantly higher than the MT group (0.90 ± 0.04 versus 0.83 ± 0.04; $t = -8.32$, $p < 0.001$). The WHR was significantly higher in the PM group than the MT group when compared using the ANCOVA and adjusted by age as covariate ($p < 0.001$, $np^2 = 0.24$). In the PM group, the appetite ($t = 4.05$, $p < 0.001$) and total PA ($t = 5.03$, $p < 0.001$) were lower than in the MT group (Table 2).

A significant difference in appetite between active and inactive women in the MT group was observed ($p = 0.003$). In the MT group, the appetite of active women (16.92 ± 1.40) was greater than in inactive women (15.05 ± 2.33; Figure 1). However, there was no significant difference in appetite between the active and inactive women in the PM group ($p > 0.05$; Figure 1). There were no significant differences in the BMI (Figure 2) or WHR (Figure 3) between the active and inactive women in either groups ($p > 0.05$).

Discussion

This study aimed to compare the BMI, WHR, PA, and appetite between women with MT and PM. In addition, this study assessed the relationship between lifestyle PA, purposeful exercise, and appetite, and their correlation with body composition during the MT and PM phases.

The findings of this study indicated that in PM women, the BMI and WHR, especially when adjusted for age, were higher, whereas appetite and lifestyle PA were lower than in MT women. A positive correlation was observed between PA and appetite in the MT group. Appetite and

Table 1. Descriptive characteristics of the participants ($N = 101$).

Parameter	Menopausal transition ($N = 57$)		Post menopause ($N = 44$)	
	Active women ($n = 39$)	Inactive women ($n = 18$)	Active women ($n = 14$)	Inactive women ($n = 30$)
Age (years), mean (SD)				
Each group	47.2 (3.63)	46.8 (4.40)	53.3 (3.59)	54.8 (4.56)
Total	47.12 (3.85)		54.31 (4.26)	
Appetite(score), mean (SD)				
Each group	16.92 (1.40)	15.05 (2.33)	15.50 (1.22)	14.53 (1.77)
Total	16.33 (1.94)		14.84 (1.66)	
BMI (kg/m^2), mean (SD)				
Each group	28.16 (3.36)	29.35 (4.28)	29.75 (3.75)	30.70 (3.42)
Total	25.83 (3.68)		30.40 (3.51)	
WHR, mean (SD)				
Each group	0.82 (0.04)	0.84 (0.43)	0.88 (0.44)	0.90 (0.37)
Total	0.83 (0.04)		0.90 (0.04)	
Total physical activity (score), mean (SD)				
Each group	8.15 (1.05)	5.31 (0.870)	7.30 (1.100)	4.96 (0.78)
Total	7.21 (1.66)		5.70 (1.41)	
Marital status (married), frequency (percentage)				
Each group	52 (91.23)		40 (90.90%)	
Total	92 (92.92%)			
Education, number (percentage)				
Each group				
Diploma	29 (50.88%)		21 (47.72%)	
Undergraduate	25 (43.86%)		22 (50%)	
Postgraduate	3 (5.26%)		1 (2.27%)	
Total				
Diploma	50 (49.50%)			
Undergraduate	47 (46.53%)			
Postgraduate	4 (3.96%)			
Economic status more than average, number (percentage)				
Each group	39 (68.42%)		30 (68.18%)	
Total	69 (68.31%)			
Obesity, number (percentage)				
Each group				
Obese or over weight	46 (80.7%)		42 (95.45%)	
Normal weight	11 (19.30%)		2 (4.55%)	
Total				
Obese or over weight	88 (87.13%)			
Normal weight	13 (12.87%)			

Variables were defined for each subgroup of active and inactive women, and the total in the menopausal transition and postmenopausal women groups.
BMI, body mass index; WHR, waist-to-hip ratio.

lifestyle PA were significant predictors of BMI and WHR during PM, and lifestyle PA was the most important predictor of WHR during PM.

Considering the higher WHR in the PM group than in the MT group with a large effect size ($np^2 = 0.24$) and the statistically similar BMI in the PM and MT groups with a small effect size ($np^2 = 0.024$) when adjusted for age, it can be concluded that menopause can increase abdominal obesity regardless of age. The higher abdominal obesity in PM women compared to pre-menopausal women was confirmed by previous studies.[24] Similar to our findings, a previous study reported a higher rate of abdominal obesity compared to general obesity in PM women.[25] Estrogen can increase the use of lipids as an energy source and reduce abdominal fat, which can be through increasing fat oxidation in the muscle and inhibiting lipogenesis in the liver and muscle mediating by peroxisome proliferator-activated receptor γ and lipoprotein lipase expression.[26] Therefore, lower estrogen during PM could be the cause of higher WHR or abdominal obesity.

Table 2. Hierarchical regression analysis predicting the BMI and WHR.

Variable	Groups	*R*	R^2	*p*	*f*	*t*	*p*	β
BMI (kg/cm^2)	Menopausal transition							
	PA	0.387	0.16	0.07	5.43	−2.71	0.009	−0.38
	Appetite					−2.97	0.004	0.42
	Post menopause							
	PA	0.29	0.4	0.16	1.91	−1.30	0.2	−0.2
	Appetite					−1.05	0.29	0.16
WHR	Menopausal transition							
	PA	0.35	0.16	0.02	3.77	−2.29	0.02	−0.33
	Appetite					−0.16	0.87	0.02
	Post menopause							
	PA	0.38	0.15	0.03	3.60	−1.95	0.03	−0.29
	Appetite					−1.24	0.17	0.18

BMI, body mass index; PA, physical activity; WHR, waist-to-hip ratio.

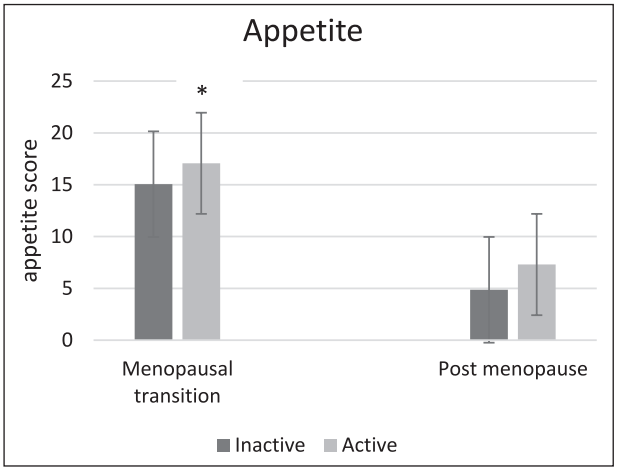

Figure 1. Comparison of appetite between the active and inactive women in the menopausal transition and postmenopausal groups.
*Significant difference between the active and inactive women groups.

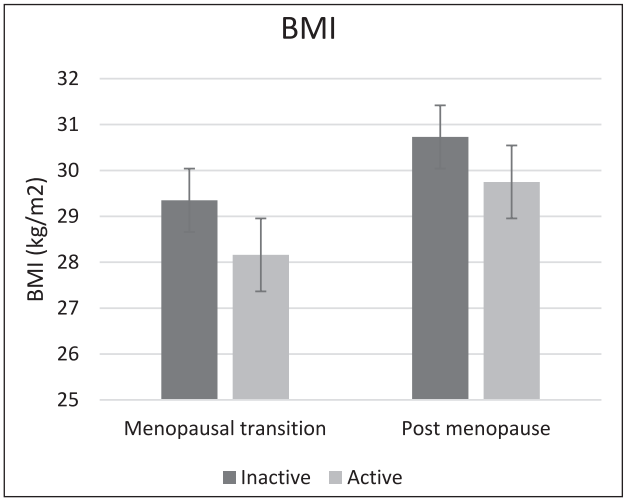

Figure 2. Comparison of the BMI between the active and inactive women in the menopausal transition and postmenopausal groups.
BMI, body mass index.

Regarding the higher BMI and WHR, and lower appetite and lifestyle PA in the PM group than in the MT group, it can be estimated that higher obesity during menopause can be related to lower lifestyle PA, including daily and recreational activities and sports. Increased weight gain during menopause and its association with cardiovascular disease have been reported in some studies.[27] Aging, along with estrogen level reduction, may lead to visceral obesity, which leads to a decrease in energy expenditure.[28] In contrast to our findings, another study reported that body obesity increased before MT and did not change at the start of MT.[29] Dosi et al. demonstrated that PM women, compared to premenopausal women, had considerably higher BMI and WHR values.[30] Ambikairajah et al. also stated that BMI and WHR significantly increased between the MT period and menopause owing to hormonal changes that occur during midlife, which is when women have a greater androgen-to-estradiol ratio.[31] Another main problem with PM is the lower basal metabolic rate[32]; hence, even in the absence of increasing appetite, BMI can still increase. Reduced basal metabolic rate (BMR) is induced by a lack of estrogen.[6] However, the reasons for menopausal obesity and the relationship between lifestyle, PA, body composition indices, and appetite have been investigated.

The findings of the present study indicate a significant positive relationship between appetite and lifestyle PA in the MT group. However, there was no significant association between appetite and lifestyle PA in the PM group. The positive relationship between appetite and PA in the MT group is consistent with the results reported in previous studies, indicating that an increase in appetite was due to the compensation of energy used in PA.[33] Dorling et al. indicated that appetite and hunger were greater in

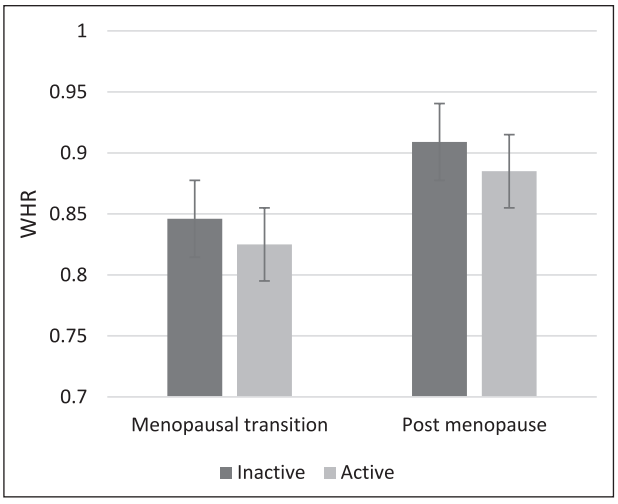

Figure 3. Comparison of the WHR between the active and inactive women in the menopausal transition and postmenopausal groups.
WHR, waist-to-hip ratio.

middle-aged women who were more physically active than in those who were inactive.[13] Van Walleghen et al. also found that active individuals had higher energy and protein intake than inactive individuals.[34] Notably, appetite is not an indicator of food intake. Duval et al. stated that appetite increases but food intake decreases during MT.[5] Clegg and Godfrey indicated that increased PA is associated with improved appetite in elderly women.[35] In contrast, Beaulieu et al. stated that PA modifies appetite through satiety signaling.[36] Lurati showed that PA suppresses appetite and increases ghrelin levels.[37] Therefore, PA increases energy expenditure or causes physiological changes associated with an increase in appetite, although defining the exact mechanisms require further investigation.

Hormonal fluctuations may mediate the relationship between PA and appetite. In the present study, no significant relationship was observed between PA and appetite in PM women. The average appetite score of PM women was lower than that of the MT group, whereas their BMI and WHR were higher than those of the MT group. Two possible reasons include decreasing energy expenditure related to lifestyle PA and basal metabolic rate, and not increasing eating, even in the case of increasing appetite. Our findings indicate a lower lifestyle PA score in the PM group, which may be a cause of the higher BMI and WHR compared with the MT group. Reduced resting energy expenditure in PM women has been found.[32] Estrogens have been found to play a role in the regulation of energy balance and suppression of appetite by acting on the central nervous system. Consequently, it can be assumed that abrupt reduction of these hormones would significantly increase appetite in the MT group.[8] Age-related appetite loss can be caused by factors, such as low metabolism and reduced PA.[35] Most studies indicate that older adults have slower gastric emptying than younger adults, which is a possible mechanism for appetite reduction during aging.[38] However, there are several discrepancies in the findings regarding the hormones that regulate appetite, which makes it difficult to describe how sex and PA affect hormonal responses to exercise. Mani et al. reported that exercise might increase ghrelin levels and decrease appetite, which is inconsistent with the findings of the current study.[39] In summary, increasing PA may be superior to appetite control in the PM phase for reducing obesity indices.

This study also found that appetite and PA were significant predictors of BMI and WHR in the MT group, and PA was the most important predictor of WHR. In the PM group, only PA predicted WHR. These findings emphasize the important role of PA in controlling obesity indices, especially WHR, in the MT and PM groups. There is evidence that regular PA may reduce weight gain and adverse changes in body composition that occur with aging and the transition to menopause.[40]

Purposeful exercise may have different effects on obesity; therefore, we compared regular participants in exercise and non-exercise groups. According to the present study, there was no significant difference between WHR and BMI in women who participated in purposeful exercise and in inactive women. This may indicate the prominent role of total lifestyle PA compared to exercise. Fenton also indicated that aging and a sedentary lifestyle are the main factors for weight gain during menopause.[41]

This study also found that PA was the most important predictor of WHR in PM women. Lifestyle PA was found to be inversely related to changes in waist circumference and weight, regardless of age or menopausal status; women who were less physically active experienced higher increases in weight and waist circumference.[42] Therefore, despite inevitable changes in weight, body composition, and fat distribution with age and menopause, PA may control these changes during menopause.

This study found that the lifestyle PA levels in the PM group were lower than those in the MT group. Ennour-Idrissi et al. demonstrated an inverse relationship between PA and estrogen levels during menopause.[43] The lack of sex hormones during menopause directly reduces skeletal muscle mass, which can lead to decreased PA.[14]

This study is the first to compare women with MT and PM, while considering the relationship between appetite, PA, BMI, waist circumference, and WHR. However, this study included some limitations, such as a small sample size, non-random recruitment of participants, not recording the dietary habits and practices of participants, and not measuring hormonal status, basal metabolism, and psychological stress, which may affect appetite. These limitations should be addressed and measured in future studies.

Conclusions

In summary, this study found that PM was associated with increasing obesity indices, especially WHR, reduction in

lifestyle PA, and decreased appetite compared to the MT phase. Lifestyle PA was superior to appetite in predicting obesity indices during the MT and PM phases, especially during PM. Although lifestyle PA is positively related to appetite, it can also improve body composition by influencing other factors such as metabolism, which requires further clarification. Lifestyle PA is more important than purposeful exercise for determining obesity. Therefore, increasing total lifestyle PA is recommended to reduce obesity. Regarding the possible effects of ethnicity and culture on the study variables, generalization of the present findings to other groups must be performed with caution.

Declarations

Ethics approval and consent to participate

The study procedures were approved by the Shiraz University Ethics Committee (date: 2023-04-18; registration number: SEP.1403.48.2408). Written informed consent was obtained from all participants before their participation in the study. All procedures were conducted in accordance with the ethical standards of the Institutional Research Committee and the Helsinki Declaration.

Consent for publication

Not applicable.

Author contribution(s)

Forough Andarzi: Conceptualization; Formal analysis; Methodology; Performance; Writing the original draft.
Maryam Koushkie Jahromi: Data analysis; Editing; Reviewing; Study design; Supervision; Writing.

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Competing interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Availability of data and materials

Data related to this article is available and will be provided upon reasonable request.

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Supplemental material

Supplemental material for this article is available online.

References

1. Mohamed H, Lamadah S and Zamil LGA. Quality of life among menopausal women. *Int J Reprod Contracept Obstet Gynecol* 2014; 3: 552–561.
2. Fu Y, Yu Y, Wang S, et al. Menopausal age and chronic diseases in elderly women: a cross-sectional study in Northeast China. *Int J Environ Res Public Health* 2016; 13: 936.
3. Talaulikar V. Menopause transition: physiology and symptoms. *Best Pract Res Clin Obstet Gynaecol* 2022; 81: 3–7.
4. Opoku AA, Abushama M and Konje JC. Obesity and menopause. *Best Pract Res Clin Obstet Gynaecol* 2023; 88: 102348.
5. Duval K, Prud'homme D, Rabasa-Lhoret R, et al. Effects of the menopausal transition on energy expenditure: a MONET Group Study. *Eur J Clin Nutr* 2013; 67: 407–411.
6. Weidlinger S, Winterberger K, Pape J, et al. Impact of estrogens on resting energy expenditure: a systematic review. *Obes Rev* 2023; 24: e13605.
7. Hirschberg AL. Sex hormones, appetite and eating behaviour in women. *Maturitas* 2012; 71: 248–256.
8. Kozakowski J, Gietka-Czernel M, Leszczyńska D, et al. Obesity in menopause—our negligence or an unfortunate inevitability. *Prz Menopauzalny* 2017; 16: 61–65.
9. Baker JH, Eisenlohr-Moul T, Wu Y-K, et al. Ovarian hormones influence eating disorder symptom variability during the menopause transition: a pilot study. *Eat Behav* 2019; 35: 101337.
10. Biegon A, Alia-Klein N, Alexoff DL, et al. Relationship of estrogen synthesis capacity in the brain with obesity and self-control in men and women. *Proc Natl Acad Sci U S A* 2020; 117: 22962–22966.
11. Melanson EL, Gavin KM, Shea KL, et al. Regulation of energy expenditure by estradiol in premenopausal women. *J Appl Physiol* 2015; 119: 975–981.
12. Bondarev D, Finni T, Kokko K, et al. Physical performance during the menopausal transition and the role of physical activity. *J Gerontol A Biol Sci Med Sci* 2021; 76: 1587–1590.
13. Dorling J, Broom DR, Burns SF, et al. Acute and chronic effects of exercise on appetite, energy intake, and appetite-related hormones: the modulating effect of adiposity, sex, and habitual physical activity. *Nutrients* 2018; 10: 1140.
14. Bondarev D, Laakkonen EK, Finni T, et al. Physical performance in relation to menopause status and physical activity. *Menopause* 2018; 25: 1432–1441.
15. Grindler NM and Santoro NF. Menopause and exercise. *Menopause* 2015; 22: 1351–1358.
16. Sternfeld B, Bhat AK, Wang H, et al. Menopause, physical activity, and body composition/fat distribution in midlife women. *Med Sci Sports Exerc* 2005; 37: 1195–1202.

17. Knight MG, Anekwe C, Washington K, et al. Weight regulation in menopause. *Menopause* 2021; 28: 960–965.
18. Sotoudeh G, Niyazi E, Khosravi S, et al. Prevalence and determinants of obesity and overweight in pre-and postmenopausal women in Islamshahr: a population-based study. *Hayat* 2010; 16: 47–54.
19. Lachin JM. Introduction to sample size determination and power analysis for clinical trials. *Control Clin Trials* 1981; 2: 93–113.
20. Baecke JA, Burema J and Frijters JE. A short questionnaire for the measurement of habitual physical activity in epidemiological studies. *Am J Clin Nutr* 1982; 36: 936–942.
21. Sadeghisani M, Manshadi FD, Azimi H, et al. Validity and reliability of the Persian version of Baecke habitual physical activity questionnaire in healthy subjects. *Asian J Sports Med* 2016; 7: e31778.
22. Wilson MM, Thomas DR, Rubenstein LZ, et al. Appetite assessment: simple appetite questionnaire predicts weight loss in community-dwelling adults and nursing home residents. *Am J Clin Nutr* 2005; 82: 1074–1081.
23. Mohammadi MR, Akhondzadeh S, Keshavarz SA, et al. The characteristics, reliability and validity of the Persian version of Simplified Nutritional Appetite Questionnaire (SNAQ). *J Nutr Health Aging* 2019; 23: 837–842.
24. Toth MJ, Tchernof A, Sites CK, et al. Effect of menopausal status on body composition and abdominal fat distribution. *Int J Obes Relat Metab Disord* 2000; 24: 226–231.
25. Chen JL, Guo J, Mao P, et al. Are the factors associated with overweight/general obesity and abdominal obesity different depending on menopausal status? *PLoS One* 2021; 16: e0245150.
26. Tessier S, Riesco E, Lacaille M, et al. Impact of walking on adipose tissue lipoprotein lipase activity and expression in pre- and postmenopausal women. *Obes Facts* 2010; 3: 191–199.
27. Kodoth V, Scaccia S and Aggarwal B. Adverse changes in body composition during the menopausal transition and relation to cardiovascular risk: a contemporary review. *Womens Health Rep* 2022; 3: 573–581.
28. Birkhaeuser M and Genazzani A. Weight and body composition management after menopause. In: Lambrinoudaki I, Armeni E and Tsoltos N (eds.) *The effect of lifestyle modifications. pre-menopause, menopause and beyond*. Volume 5. Frontiers in Gynecological Endocrinology, Frontiers Media S.A. 2018, pp. 153–161.
29. Greendale GA, Sternfeld B, Huang M, et al. Changes in body composition and weight during the menopause transition. *JCI Insight* 2019; 4: e124865.
30. Dosi R, Bhatt N, Shah P, et al. Cardiovascular disease and menopause. *J Clin Diagn Res* 2014; 8: 62–64.
31. Ambikairajah A, Walsh E, Tabatabaei-Jafari H, et al. Fat mass changes during menopause: a metaanalysis. *Am J Obstet Gynecol* 2019; 221: 393.e50–409.e50.
32. Hodson L, Harnden K, Banerjee R, et al. Lower resting and total energy expenditure in postmenopausal compared with premenopausal women matched for abdominal obesity. *J Nutr Sci* 2014; 3: e3.
33. Blundell J, Gibbons C, Caudwell P, et al. Appetite control and energy balance: impact of exercise. *Obes Rev* 2015; 16: 67–76.
34. Van Walleghen EL, Orr JS, Gentile CL, et al. Habitual physical activity differentially affects acute and short-term energy intake regulation in young and older adults. *Int J Obes* 2007; 31: 1277–1285.
35. Clegg ME and Godfrey A. The relationship between physical activity, appetite and energy intake in older adults: a systematic review. *Appetite* 2018; 128: 145–151.
36. Beaulieu K, Hopkins M, Blundell J, et al. Does habitual physical activity increase the sensitivity of the appetite control system? A systematic review. *Sports Med* 2016; 46: 1897–1919.
37. Lurati AR. Effects of menopause on appetite and the gastrointestinal system. *Nurs Womens Health* 2018; 22: 499–505.
38. Soenen S, Rayner CK, Horowitz M, et al. Gastric emptying in the elderly. *Clin Geriatr Med* 2015; 31: 339–353.
39. Mani BK, Castorena CM, Osborne-Lawrence S, et al. Ghrelin mediates exercise endurance and the feeding response post-exercise. *Mol Metab* 2018; 9: 114–130.
40. Moradpour F, Jahromi MK, Fooladchang M, et al. Association between physical activity, cardiorespiratory fitness, and body composition with menopausal symptoms in early postmenopausal women. *Menopause* 2020; 27: 230–237.
41. Fenton A. Weight, shape, and body composition changes at menopause. *J Midlife Health* 2021; 12: 187–192.
42. Morris DH, Jones ME, Schoemaker MJ, et al. Body mass index, exercise, and other lifestyle factors in relation to age at natural menopause: analyses from the breakthrough generations study. *Am J Epidemiol* 2012; 175: 998–1005.
43. Ennour-Idrissi K, Maunsell E and Diorio C. Effect of physical activity on sex hormones in women: a systematic review and meta-analysis of randomized controlled trials. *Breast Cancer Res* 2015; 17: 139.