ORIGINAL ARTICLE

Depressive symptoms, sleep quality, physical fitness, and fatigue among adult women with different obesity status

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Abstract

Purpose The aim of this cross-sectional study was to examine the association between depressive symptoms, sleep quality, objectively assessed physical fitness, and fatigue, among a sample of adult women with different obesity status.
Methods One hundred and ninety-four volunteer adult women (36.1 ± 11.1 years) participated in the study. Based on body mass index (BMI), the participants were allocated into three groups: normal weight ($n = 134$), overweight ($n = 32$), and obese ($n = 25$). Physical fitness-related parameters such as aerobic fitness, flexibility, lower limb explosive strength, isometric handgrip strength, and sprint performance were assessed with a battery of field tests. Total body fat and trunk fat levels were assessed by bioelectrical impedance analysis. Depressive symptoms were assessed using the Beck depression inventory, sleep quality was assessed using the Pittsburg sleep quality index, and fatigue levels were examined using the fatigue severity scale.
Results Obese women experienced a significantly worse score regarding depressive symptoms ($p < 0.05$). Similarly, the obese and overweight women were found to exhibit lower levels of aerobic fitness compared to women with normal BMI ($p < 0.05$). All examined body composition variables were shown to be inversely associated with the score on all physical fitness tests as well as with poor sleep, depressive symptoms, and fatigue levels ($p < 0.05$).
Conclusions Depressive symptoms and performance on various physical fitness tests were found to be significantly impaired in obese and overweight adult women indicating the negative impact of increased body weight in health and well-being.

Keywords Aerobic fitness · Total body fat · Trunk fat · Sleep quality

Introduction

Obesity and overweight are increasing worldwide and are considered to be one of the main public health concerns today [1]. High body weight and fat levels could increase the risk for a variety of diseases, including cardiovascular diseases, diabetes type II, cancer, and hypertension [2].

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Therefore, it is not surprising that obesity has been associated with all-cause mortality [3, 4].

Various factors have been blamed for the high obesity rates observed worldwide, including physical inactivity [5] and sedentary lifestyle [6], impaired sleep quality [7], low sleep efficiency [8], and unhealthy eating habits [9]. Interestingly, it seems that the prevalence of obesity is higher in women compared to men [1]. In women, elevated body fat and body weight levels are highly related with a sedentary lifestyle [6], impaired physical [10] and mental health-related parameters such as anxiety [11] and depression [12], all significant contributors to low quality of life levels [13].

Obesity has been reported to have a negative impact on physical fitness-related parameters such as cardiovascular fitness [14] and strength [15]. The low physical fitness levels and low daily energy expenditure that obese women experience may be explained by the low physical activity levels and sedentary lifestyle of women today [5]. The reduced physical fitness levels may explain the fact that obese

individuals experience impaired functional capacity and difficulty performing daily activities [16].

On the other hand, it is well known that exercise and physical activity could play an essential role in women's health and well-being through, among others, its beneficial effects on the physiological systems [17]. Physical activity and exercise have been shown to reduce insulin resistance and improve body composition [18], improve aerobic capacity, and reduce body mass index [19], improve sleep [20] and synchronize the circadian system [21], thereby reducing the risk for the development of chronic diseases and health problems.

In addition, published data, mainly derived from questionnaires and not from objective physical fitness measurements, reveal that low physical fitness levels appear to be inversely associated with depression [22] and anxiety in obese women [23], indicating the negative effects of physical inactivity on mental health. On the same wavelength, in a recent meta-analysis article, the authors indicated that physical activity and participation in systematic exercise training can be effective in improving depressive symptoms and anxiety in non-clinical populations [24] as well as in patients with chronic diseases [25]. Moreover, recent evidence reveals that obesity should be considered as a risk factor for depression [26]. It must be noted that depression is considered to be the most common mental disorder worldwide, whilst it seems that women are more likely to experience depressive symptoms compared to men [27].

Sleep loss could lead to hormonal abnormalities, impaired glucose tolerance, and impaired insulin sensitivity, and behavioural changes such as nocturnal eating, all of which are significant contributors to abnormal metabolism and increased energy intake, resulting in increased risk for obesity and weight gain [28]. On the other hand, exercise and participation in physical activities are considered to be effective non-pharmacological methods in terms of improving sleep [20, 29, 30].

The interaction between mental- and physical-related parameters has many consequences when exploring the effects of chronic diseases and pathological conditions in overall health. To our knowledge, only a few studies have examined both physical- and mental-related parameters related to obesity in women in a single study.

The aim of the current multidisciplinary cross-sectional study was to examine the relationship between depression symptoms, sleep quality, objectively measured physical fitness, and fatigue among a sample of adult women of different obesity status. The inclusion in a single study of both physical- and mental-related parameters could be very useful to extract safer conclusions in regards to the overall effect of obesity in inactive adult women population. It was hypothesized that the obese and overweight women would exhibit worse performance on the various physical fitness tests, experience impaired sleep quality, higher depression score, and greater fatigue levels compared to women with normal BMI.
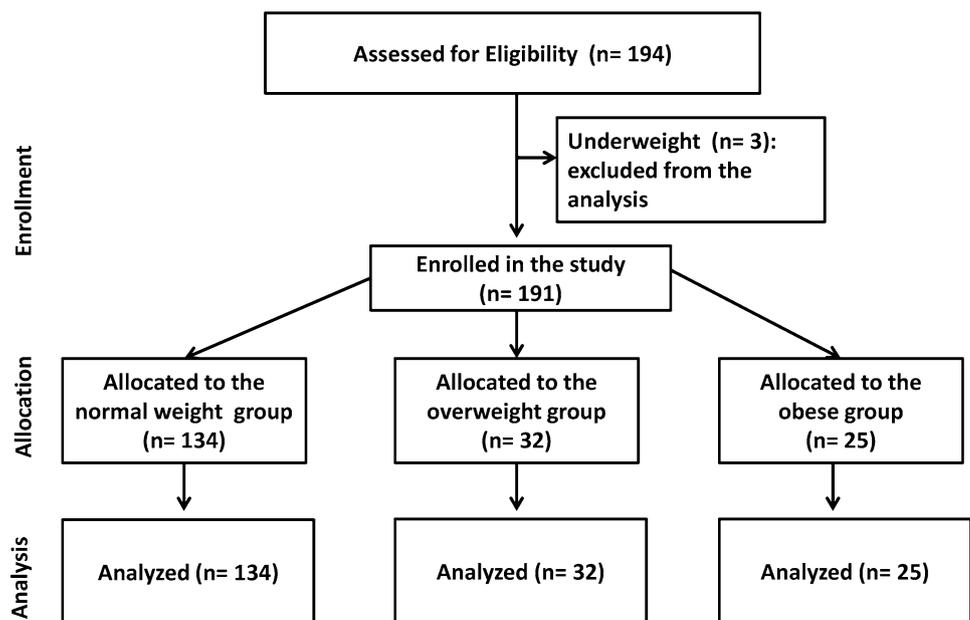
Materials and methods

Participants

One hundred and ninety-four volunteer adult healthy women (36.1 ± 11.7 years) participated in this cross-sectional study. Based on body mass index (BMI), the participants were allocated into four groups: underweight ($n = 3$, BMI < 18.5), normal weight (G1, $n = 134$, BMI 18.5–25 mean BMI: 21.6 ± 1.8), overweight (G2, $n = 32$, BMI 25–30, mean BMI: 26.7 ± 2.1), and obese (G3, $n = 25$, BMI > 30, mean BMI: 35.1 ± 5.1). The underweight group was not used in the statistical analysis due to the very small number of subjects (Fig. 1). Fitness measurements were taken during the morning hours (9–11 am) at an accredited fitness center. Exclusion criteria were inability to perform the fitness testing as well as inability to fill in the questionnaires due to cognitive impairment or mental disorder. All participants refrained from food and fluid consumption for a 3-h period prior to body composition measurements. All volunteers were given a full explanation of the purpose and the procedures of the study and gave their written consent. The study was approved by the National Bioethical Committee (No.: ΕΕΒΚ/ΕΠ/2015/34). Data were analysed in blind fashion without the researchers knowing the characteristics of the participants.

Questionnaires

The interview method was used to complete all questionnaires. The participants' depressive symptoms were assessed using the Beck depression inventory (BDI) [31]. BDI measures key symptoms of depression and it consists of 21 questions. Conventional cut-off points were 0–9 for normal range, 10–18 for mild-to-moderate depression, 19–29 for moderate-to-severe depression, and 30–63 for severe depression. Subjective sleep quality was assessed using the Pittsburg sleep quality index (PSQI) [32]. The questionnaire consists of 19 items and seven clinically relevant domains of sleep difficulties: subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction. A global score of overall sleep quality can be calculated by adding up the single scores of these dimensions, producing scores ranging from 0 to 21. A PSQI global score greater than five indicates poor sleep quality. Finally, fatigue levels were assessed using the fatigue severity scale (FSS) [33]. FSS is a self-report instrument assessing the physical aspects of fatigue and their

Fig. 1 Participant recruitment flow diagram. Disposition of the participants into the three groups according to obesity status as follows: the normal-weight group, the overweight group, and the obese group

Assessed for Eligibility (n= 194)

Underweight (n= 3): excluded from the analysis

Enrolled in the study (n= 191)

Enrollment

Allocated to the normal weight group (n= 134)

Allocated to the overweight group (n= 32)

Allocated to the obese group (n= 25)

Allocation

Analyzed (n= 134)

Analyzed (n= 32)

Analyzed (n= 25)

Analysis

impact on the patient's daily function. The FSS consists of nine statements for evaluating the impact of fatigue. Subjects were asked to rate the severity of fatigue symptoms using a numeric scale ranging from 1 (strong disagreement with the statement) to 7 (strong agreement with the statement). The total score was calculated by averaging the scores of each item.

Physical fitness assessment

Physical fitness-related parameters were assessed with a battery of field tests. In particular, aerobic fitness was assessed using the 20 m multi-stage shuttle run test, flexibility with the sit-and-reach test, lower limb explosive strength with the squat jump (SJ), and the countermovement jump (CMJ) tests, 20 m sprint time using photocells, and handgrip strength with a digital dynamometer. The detailed explanation of the physical fitness tests used in the study is given below.

Aerobic fitness assessment

Aerobic fitness was assessed using the 20 m multi-stage shuttle run test [34]. Participants started running a back and forth over a distance of 20 m at an initial speed of 8.5 km h^{-1}, and speed increased by 0.5 km h^{-1} every minute. The pace was given by a sound signal from an audio tape. Each stage of the test was made up from several shuttle runs. Participants were instructed to keep pace with the signals for as long as they could and were informed that they would be withdrawn from the test if they were more than two strides away from the turning point on two consecutive shuttles.

For each participant, the number of shuttles completed was recorded and was used as an index of their aerobic fitness levels.

Flexibility assessment

The sit-and-reach test was used to measure flexibility levels of hamstrings muscles and lower back, using a sit-and-reach box. The participants were asked to remove their shoes, assume the sitting position facing the box and place their feet against the side of the box. Feet were shoulder width apart and both knees held straight. The palms of the participant's hands were facing down. The participants were asked to reach as far forward as they could, and hold for 2 s. The distance on the box was recorded in cm.

Lower limb explosive strength assessment

Lower limb explosive strength was assessed using the SJ and CMJ tests. Each participant performed three squats with 1 min rest between jumps. All participants had been taught the correct technique and became familiar with the SJ and CMJ at least 1 week prior to the tests. Jumps were measured in cm by the Optojump electronic device (Microgate, Bolzano-Bozen, Italy), which measured flight time. For the SJ, participants got into a squat position and jumped as high as they could and returned back to start position. No movement or swing was allowed before take-off. For the CMJ the participants started from an upright standing position, making a downward move by flexing the knees and hips and then immediately extending the knees and hips to jump vertically off the ground. In both jumps, the participants were advised

to keep their hands on their hips throughout the jump for avoiding external force and interference with jump height.

20-m sprint time assessment

Twenty-meter sprint performance was measured with an electronic photocell timing system (Microgate Timing Systems, Microgate, Bolzano-Bozen, Italy). The participants were told to run for 20 m as fast as they could. Women participating started from an upright position, behind the starting line. A photocell camera was used to calculate and record speed time in seconds to the nearest one hundredth of a second.

Isometric handgrip strength assessment

Handgrip strength (in kg) was measured using a digital dynamometer (T.K.K. 5401 Grip-D; Takey, Tokyo, Japan). Both arms were relaxed, in the neutral position by the side of the body. For each arm, participants were asked to squeeze and hold for about 3 s. No other body movement was allowed. The measurement was performed on both arms.

Total body and trunk fat assessment

Total body fat percentage was measured using bioelectrical impedance analysis (BIA) (Tanita body composition analyser, TBF-300). Participants were asked to remove their shoes and socks and stand on the platform with bare feet. They were also asked to avoid any fitness activity or eating for 3 h before the test, as activity and food intake tend to interfere with the impedance. Trunk fat along with abdominal circumference were measured with the use of a portable

BIA system (Tanita, Viscan AB 140) specialized for central adiposity measurement in healthy adults [35].

Statistical analysis

The normality of data was assessed by the Kolmogorov–Smirnov test. For normally distributed data, one-way analysis of variance (ANOVA) was used to compare differences in the independent variable among groups. Post hoc tests were performed using Bonferroni correction. Non-normally distributed data were analysed using the Kruskal–Wallis test. The effect size was determined by partial eta squared (η^2). The Pearson correlation test was used to assess the relationship between the examined variables. All data are presented as mean $\pm$ SD and the level of statistical significance was set at $p < 0.05$. All analyses were carried out using the SPSS Statistical Package version 19.

Results

In this cross-sectional study, 16.5% of the women were overweight (32 out of 194), 13% were obese (25 out of 194), 69% had normal BMI (134 out of 194), and a very small amount was categorized as underweight (3 out of 194; 1.5%—not included in the statistical analysis due to the small sample size).

The ANOVA analysis of body composition parameters revealed significant differences in abdominal circumference ($F_{3,168} = 19.960$; $p < 0.001$; $\eta^2 = 0.263$) and visceral fat ($F_{3,168} = 40.857$; $p < 0.001$; $\eta^2 = 0.442$) when comparing women with normal BMI, overweight, and obese (Table 1). The ANOVA analysis showed also that depressive symptoms score was significantly worse in the obese group compared

Table 1 Anthropometry and body composition data presented as pool data and divided into three groups according to obesity status

Variable	Pool data BMI: 23.8 ± 5.7	Normal weight BMI: 21.6 ± 1.8	Overweight BMI: 26.7 ± 2.1	Obese BMI: 35.1 ± 5.1
Age	36.1 ± 11.1	35.3 ± 10.8	39.1 ± 10.7	39.1 ± 12.2
Weight (kg)	62.3 ± 15.1	56.9 ± 6.5[a]	68.9 ± 6.5[a]	90.5 ± 16.3[a]
Height (cm)	161.6 ± 6.1	162.0 ± 6.4	160.5 ± 5.7	160.3 ± 4.6
Total fat (%)	29.2 ± 9.4	25.1 ± 5.6[a]	33.9 ± 7.2	43.9 ± 4.3[c]
Abdominal circumference (cm)	84.6 ± 14.4	80.5 ± 8.6	89.3 ± 12.0[b]	103.0 ± 26.3[c,d]
Visceral fat (%)	29.2 ± 9.9	25.4 ± 6.6	35.5 ± 6.4[b]	43.7 ± 11.4[c,d]
BMI	23.8 ± 5.7	21.6 ± 1.8	26.7 ± 2.1[b]	35.1 ± 5.5[c,d]

All data are mean values ± SD

BMI body mass index

[a]Significant differences between all groups of the subjects

[b]Significant differences between the women of the normal-weight group and the overweight group

[c]Significant differences between the women of the obese group and the overweight group

[d]Significant differences between the women of the normal-weight group and the obese group

Table 2 Sleep quality, depression score, and fatigue level data presented as pool data and divided into three groups according to obesity status

Variable	Pool data BMI: 23.8 ± 5.7	Normal weight BMI: 21.6 ± 1.8	Overweight BMI: 26.7 ± 2.1	Obese BMI: 35.1 ± 5.1
PSQI	5.3 ± 3.4	5.1 ± 3.1	5.7 ± 3.8	6.5 ± 4.5[a]
BDI	16.7 ± 7.2	15.9 ± 6.7	17.4 ± 7.8	21.4 ± 7.6[a,b]
FSS	3.2 ± 1.3	3.2 ± 1.2	3.4 ± 1.4	3.6 ± 1.7[a]

All data are mean values ± SD

BMI body mass index, *PSQI* Pittsburgh sleep quality index, *BDI* Beck depression inventory, *FSS* fatigue severity scale

[a]For data without normal distribution, a Kruskal–Wallis test was performed
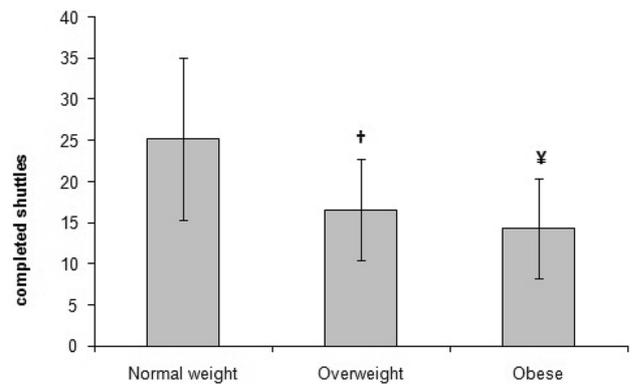
[b]Significant differences between the women of the normal-weight group and the obese group
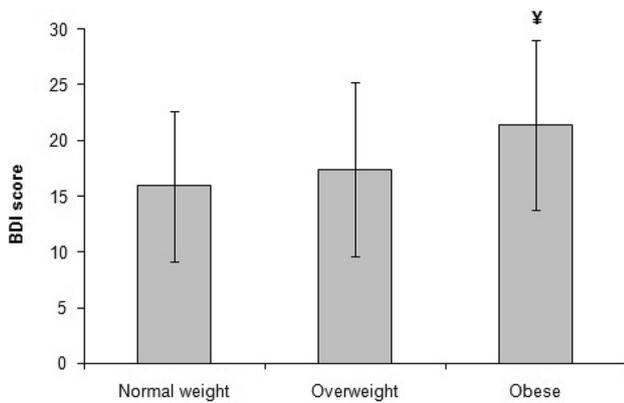
Fig. 2 Depressive symptoms divided into three groups according to obesity status. *BDI* Beck depression inventory. [¥]Significant differences between the women of the normal group and the obese group

Fig. 3 Aerobic fitness divided into three groups according to obesity status. [¥]Significant differences between the women of the normal group and the obese group. [†]Significant differences between the women of the normal group and the overweight group. For data without normal distribution, a Kruskal–Wallis test was performed

to the normal-weight group ($F_{3,190} = 5.189$; $p = 0.004$; $\eta^2 = 0.076$) (Table 2; Fig. 2).

In addition, performance in both the SJ ($F_{3,160} = 4.629$; $p = 0.004$; $\eta^2 = 0.080$) and the CMJ test ($F_{3,160} = 6.714$;

$p = 0.042$; $\eta^2 = 0.112$) as well as in the 20 m shuttle run test was significantly worse in the obese and overweight group compared with the normal BMI group ($F_{3,126} = 12.322$;

Table 3 Physical fitness data presented as pool data and divided into three groups according to obesity status

Variable	Pool data BMI: 23.8 ± 5.7	Normal weight BMI: 21.6 ± 1.8	Overweight BMI: 26.7 ± 2.1	Obese BMI: 35.1 ± 5.1
Flexibility (cm)	17.7 ± 8.8	18.9 ± 8.6	17.1 ± 7.3	13.7 ± 8.9
Handgrip R (kg)	24.1 ± 6.0	24.0 ± 5.7	23.8 ± 5.2	24.5 ± 7.2[b]
Handgrip L (kg)	23.5 ± 5.3	23.3 ± 5.1	23.5 ± 3.8	24.5 ± 7.3[b]
SJ (cm)	15.1 ± 5.0	16.0 ± 4.7	14.1 ± 4.9[a]	11.2 ± 5.5[c]
CMJ (cm)	17.4 ± 5.8	18.7 ± 5.7	15.6 ± 4.2[a]	12.7 ± 6.0[c]
20 m sprint (s)	3.4 ± 2.3	3.4 ± 2.0	3.7 ± 1.8	3.9 ± 2.0
20 m shuttle run test (no. of shuttles)	22.4 ± 10.1	25.2 ± 9.9	16.6 ± 6.2[a]	14.3 ± 6.1[b,c]

All data are mean values ± SD

BMI body mass index, *R* right, *L* left, *SJ* squat jump, *CMJ* counter movement jump

[a]Significant differences between the women of the normal weight group and the overweight group

[b]For data without normal distribution, a Kruskal–Wallis test was performed

[c]Significant differences between the women of the normal-weight group and the obese group

$p < 0.001$; $\eta^2 = 0.227$ (Fig. 3). No significant differences were observed between the groups in regards to handgrip strength ($F_{3,168} = 2.008$; $p = 0.983$; $\eta^2 = 0.001$) (Table 3).

The analysis using the Pearson correlation test showed that performance in the SJ ($r = -0.216$, $p = 0.006$), CMJ ($r = -0.282$, $p = 0.000$), and 20 m shuttle run ($r = -0.363$, $p = 0.000$) were inversely correlated with total body fat levels.

Visceral fat inversely correlated with the 20 m shuttle run test ($r = -0.490$, $p = 0.000$), SJ ($r = -0.374$, $p < 0.001$), and CMJ ($r = -0.366$, $p < 0.001$).

BMI inversely correlated with performance in the 20 m shuttle run test ($r = -0.460$, $p < 0.001$), positively correlated with FSS ($r = 0.233$, $p = 0.001$) and PSQI ($r = 0.248$, $p = 0.001$), positively correlated with BDI score ($r = 0.281$, $p < 0.001$) and FSS ($r = 0.233$, $p = 0.001$), whereas it was inversely correlated with flexibility score ($r = -0.174$, $p = 0.024$) (Fig. 4).

Positive correlation among FSS was found with total body fat ($r = 0.179$, $p = 0.013$), visceral fat ($r = 0.206$, $p = 0.007$), and PSQI score ($r = 0.233$, $p = 0.001$).

BDI score positively correlated with body fat ($r = 0.214$, $p = 0.003$), BMI ($r = 0.281$, $p < 0.001$), visceral fat ($r = 0.236$, $p = 0.002$), and PSQI score ($r = 0.474$, $p < 0.001$). A positive connection with PSQI score was also seen between total body fat ($r = 0.157$, $p = 0.029$) and BMI ($r = 0.248$, $p = 0.001$).

Age positively correlated with BMI ($r = 0.198$, $p = 0.006$) and total body fat ($r = 0.295$, $p < 0.001$), whereas age inversely correlated with SJ ($r = -0.275$, $p < 0.001$) and the 20 m shuttle run test ($r = -0.212$, $p = 0.015$).

Discussion

Prevalence of overweight and obesity is increasing worldwide [1]. A number of reasons are responsible for the increase of obesity, with physical inactivity and, therefore, low physical fitness been one of the most evident [5]. The findings of the present study confirm the high rate of excessive body weight in adult women, which is associated with low physical fitness levels. Most importantly, however, the current study adds to the knowledge that obesity may be associated with impaired sleep quality and mental state (i.e., depressive symptoms), which, in turn, affect quality of life and well-being in adult women. However, the findings of the present study do not provide conclusive proof of causality and, therefore, should be interpreted with caution.

Despite the physical fitness impairments, the outcomes of the current study reveal also an association between body composition parameters and depressive symptoms score, confirming the previous studies [11, 12, 36]. Research has indicated that elevated BMI is associated with anxiety and, particularly, appearance-based social anxiety [37].
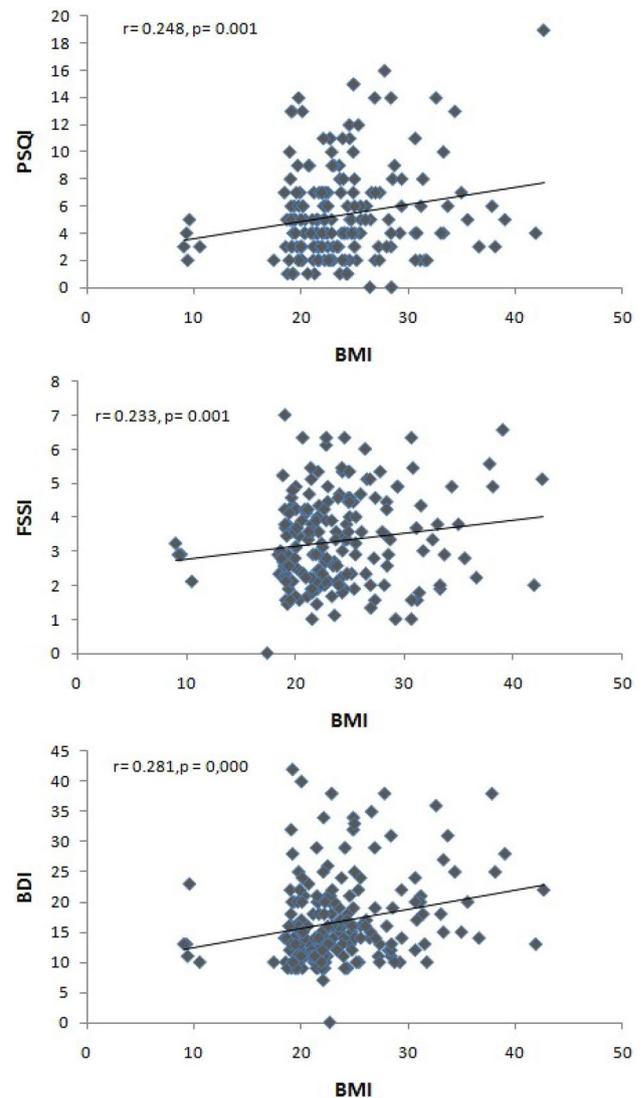
Fig. 4 Correlations between body mass index and fatigue, sleep quality, and depressive symptoms. *BDI* Beck depression inventory, *BMI* body mass index, *FSSI* fatigue severity scale index, *PSQI* Pittsburgh sleep quality index

Moreover, an increase in visceral fat may potentially increase a person's susceptibility towards depression [38]. This can be explained by the fact that visceral fat is associated with increased inflammation [38] and endocrine abnormalities, [39] which could contribute to brain chemistry changes and depressive-like behaviour. Interestingly, both obesity and depression may share common pathogenesis. A dysregulation of the hypothalamic–pituitary–adrenocortical system has been reported in both depressed and obese patients supporting the hypothesis of the interconnection between depression and obesity [40]. On the other hand, there is evidence in the literature regarding the positive effects of exercise training in terms of reducing depression symptoms [41], whilst other studies have shown a significant amelioration

of depressive symptoms following surgically induced weight loss [42]. Interestingly, low aerobic fitness levels (seen also in the current study in the obese group) have been reported to be associated with depression in both men and women [43]. Obese women should be encouraged to participate in systematic exercise and physical activity interventions to lose weight and reduce potential depressive symptoms and mental health.

The results of the current study reveal that overweight and obesity may, indeed, be associated with significant impairments on aerobic fitness, confirming the existing literature [44, 45]. Aerobic fitness has been reported to be inversely related to cardiovascular risk factors such as aortic stiffness in adult women with high visceral fat levels [46], as well as with insulin resistance and impaired blood lipid profile in adult overweight women [47]. In the study of Kim and colleagues [48], both visceral fat and aerobic fitness were found to be associated with metabolic syndrome in overweight and obese adults. Interestingly, the results of the previous study showed that adults with normal visceral fat and low aerobic fitness exhibit significantly greater risk for metabolic syndrome compared with adults with high visceral fat but with high levels of aerobic fitness. Obese and overweight women should be encouraged to participate in exercise and physical activity programs to improve their aerobic fitness levels and, therefore, reduce the risk for developing cardiovascular disease and improve their quality of life levels and well-being.

Obese individuals may be vulnerable to significant impairments in muscle and skeletal system physiology and functionality [15]. An inverse relationship between BMI and SJ as well as CMJ was found in the present cross-sectional study, confirming the previous findings [49]. Moreover, it is well known that muscle mass, strength, and power decrease with advancing age, leading to significant impairments in daily living and quality of life [50]. In the current study, an inverse relationship was found between age and performance in lower extremities explosive strength (assessed by the jump tests). Furthermore, BMI inversely correlated with flexibility, as measured using the sit-and-reach test. Obesity is also considered to be one of many reasons that lead to low back pain [51] which, in turn, could impair flexibility levels. According to the literature, both muscle strength and flexibility should be improved through specific exercise training programs in obese women [52, 53].

Fatigue is another common complaint in overweight and obese people [54] and is associated with impaired quality of life [55]. Alam and Rahman reported that, in obesity, mitochondrial dysfunction occurs [56], which causes increased fatigue and muscle weakness [57]. Moreover, overweight individuals carry an increased amount of body mass, experience low physical fitness levels, and sleep disturbances, all significant contributors to the development of fatigue [7]. Indeed, significant correlations between BMI, visceral fat, and sleep quality were also observed in the current study. Exercise training could effectively reduce fatigue and increase feelings of energy in sedentary individuals [58].

The outcomes of the current study reveal a positive correlation between increased BMI/body fat and impaired sleep quality, confirming the previous studies also reporting a link between obesity and impaired sleep quality [7, 59]. In addition, a number of studies emphasizes that increased BMI and high body fat cause sleep disturbances probably due to stress-induced hormone reactivity [60], sleep problems such as sleep apnea symptoms [61], and generally obstruction of the upper airway causing respiratory problems [59].

A positive correlation between age and body composition indices, such as BMI and body fat, was also seen in the current study. Based on the literature, increasing age is associated with considerable changes in body composition [62]. Many factors could explain this including aging-related changes in the endocrine system [63] as well as alternations in eating habits that contribute to weight gain [64].

The current study has some limitations which have to be pointed out. Sleep was assessed by the PSQI instead of more objective measures such as actigraphy or polysomnography. In addition, chronotype was not assessed, which has been reported to affect both physical activity behaviour, physical fitness, physiological and psychological variables, and sleep [65–69].

Conclusion

Overweight and obese adult women in the present study were found to experience significant impairments on physical fitness and increased depressive symptoms compared with women of normal BMI. Moreover, high body fat levels were associated with significant impairments in various physical fitness parameters, as well as sleep and depression. Therefore, obese and overweight adult women should be encouraged to perform both physical fitness and body composition testing to ascertain their physical performance levels and make stronger bonds with sport and exercise scientists to obtain better consultation and services. Measures such as increased physical activity should be taken for combating obesity to improve health and quality of life of adult women. As such, motivating participation of adult women in exercise and physical activity programs should bear high importance for the society and health-care providers.

Compliance with ethical standards

References

1. NCD Risk Factor Collaboration (2016) Trends in adult body-mass index in 200 countries from 1975 to 2014: a pooled analysis of 1698 population-based measurement studies with 19.2 million participants. Lancet 387(10026):1377–1396
2. Baumgartner RN, Heymsfield SB, Roche AF (1995) Human body composition and the epidemiology of chronic disease. Obes Res 3(1):73–95
3. Britton KA, Massaro JM, Murabito JM, Kreger BE, Hoffmann U, Fox CS (2013) Body fat distribution, incident cardiovascular disease, cancer, and all-cause mortality. J Am Coll Cardiol 62(10):921–925
4. Masters RK, Reither EN, Powers DA, Yang YC, Burger AE, Link BG (2013) The impact of obesity on US mortality levels: the importance of age and cohort factors in population estimates. Am J Public Health 103(10):1895–1901
5. Lee IM, Djousse L, Sesso HD, Wang L, Buring JE (2010) Physical activity and weight gain prevention. JAMA 303(12):1173–1179
6. Blumel JE, Chedraui P, Aedo S, Fica J, Mezones-Holguin E, Baron G, Bencosme A, Benitez Z, Bravo LM, Calle A, Flores D, Espinoza MT, Gomez G, Hernandez-Bueno JA, Laribezcoa F, Martino M, Lima S, Monterrosa A, Mostajo D, Ojeda E, Onatra W, Sanchez H, Tserotas K, Vallejo MS, Witis S, Zuniga MC (2015) Obesity and its relation to depressive symptoms and sedentary lifestyle in middle-aged women. Maturitas 80(1):100–105
7. Mesarwi O, Polak J, Jun J, Polotsky VY (2013) Sleep disorders and the development of insulin resistance and obesity. Endocrinol Metab Clin North Am 42(3):617–634
8. Roveda E, Montaruli A, Galasso L, Pesenti C, Bruno E, Pasanisi P, Cortellini M, Rampichini S, Erzegovesi S, Caumo A, Esposito F (2018) Rest-activity circadian rhythm and sleep quality in patients with binge eating disorder. Chronobiol Int 35(2):198–207
9. Qi Q, Chu AY, Kang JH, Huang J, Rose LM, Jensen MK, Liang L, Curhan GC, Pasquale LR, Wiggs JL, De Vivo I, Chan AT, Choi HK, Tamimi RM, Ridker PM, Hunter DJ, Willett WC, Rimm EB, Chasman DI, Hu FB, Qi L (2014) Fried food consumption, genetic risk, and body mass index: gene–diet interaction analysis in three US cohort studies. BMJ 348:g1610
10. Pataky Z, Armand S, Muller-Pinget S, Golay A, Allet L (2014) Effects of obesity on functional capacity. Obesity 22(1):56–62
11. Bjorngaard JH, Carslake D, Lund Nilsen TI, Linthorst AC, Davey Smith G, Gunnell D, Romundstad PR (2015) Association of body mass index with depression, anxiety and suicide—an instrumental variable analysis of the HUNT study. PLoS One 10(7):e0131708
12. Martin-Rodriguez E, Guillen-Grima F, Auba E, Marti A, Brugos-Larumbe A (2016) Relationship between body mass index and depression in women: a 7-year prospective cohort study. The APNA study. Eur Psychiatry 32:55–60
13. Jia H, Lubetkin EI (2005) The impact of obesity on health-related quality-of-life in the general adult US population. J Public Health (Oxf) 27(2):156–164
14. Ortega FB, Tresaco B, Ruiz JR, Moreno LA, Martin-Matillas M, Mesa JL, Warnberg J, Bueno M, Tercedor P, Gutierrez A, Castillo MJ (2007) Cardiorespiratory fitness and sedentary activities are associated with adiposity in adolescents. Obesity (Silver Spring) 15(6):1589–1599
15. Tomlinson DJ, Erskine RM, Morse CI, Winwood K, Onambele-Pearson G (2016) The impact of obesity on skeletal muscle strength and structure through adolescence to old age. Biogerontology 17(3):467–483
16. Backholer K, Wong E, Freak-Poli R, Walls HL, Peeters A (2012) Increasing body weight and risk of limitations in activities of daily living: a systematic review and meta-analysis. Obes Rev 13(5):456–468
17. Roberts CK, Barnard RJ (2005) Effects of exercise and diet on chronic disease. J Appl Physiol 98(1):3–30
18. Bruno E, Roveda E, Vitale J, Montaruli A, Berrino F, Villarini A, Venturelli E, Gargano G, Galasso L, Caumo A, Carandente F, Pasanisi P (2018) Effect of aerobic exercise intervention on markers of insulin resistance in breast cancer women. Eur J Cancer Care 27(2):e12617
19. Galasso L, Montaruli A, Bruno E, Pesenti C, Erzegovesi S, Ce E, Coratella G, Esposito F (2018) Aerobic exercise training improves physical performance of patients with binge-eating disorder. Sport Sci Health 14(1):47–51
20. Roveda E, Vitale JA, Bruno E, Montaruli A, Pasanisi P, Villarini A, Gargano G, Galasso L, Berrino F, Caumo A, Carandente F (2017) Protective effect of aerobic physical activity on sleep behavior in breast cancer survivors. Integr Cancer Ther 16(1):21–31
21. Vitale JA, Lombardi G, Weydahl A, Banfi G (2018) Biological rhythms, chronodisruption and chrono-enhancement: the role of physical activity as synchronizer in correcting steroids circadian rhythm in metabolic dysfunctions and cancer. Chronobiol Int 35(9):1185–1197
22. Suija K, Timonen M, Suviola M, Jokelainen J, Jarvelin MR, Tammelin T (2013) The association between physical fitness and depressive symptoms among young adults: results of the Northern Finland 1966 birth cohort study. BMC Public Health 13:535
23. Mollaoglu H, Ucok K, Kaplan A, Genc A, Mayda H, Guzel HI, Sener U, Uygur E, Ozbulut O (2012) Association analyses of depression, anxiety, and physical fitness parameters in Turkish obese adults. J Back Musculoskelet Rehabil 25(4):253–260
24. Rebar AL, Stanton R, Geard D, Short C, Duncan MJ, Vandelanotte C (2015) A meta-meta-analysis of the effect of physical activity on depression and anxiety in non-clinical adult populations. Health Psychol Rev 9(3):366–378
25. Mitrou GI, Grigoriou SS, Konstantopoulou E, Theofilou P, Giannaki CD, Stefanidis I, Karatzaferi C, Sakkas GK (2013) Exercise training and depression in ESRD: a review. Semin Dial 26(5):604–613
26. Olvera RL, Williamson DE, Fisher-Hoch SP, Vatcheva KP, McCormick JB (2015) Depression, obesity, and metabolic syndrome: prevalence and risks of comorbidity in a population-based representative sample of Mexican Americans. J Clin Psychiatry 76(10):e1300–e1305
27. Kuehner C (2017) Why is depression more common among women than among men? Lancet Psychiatry 4(2):146–158
28. Beccuti G, Pannain S (2011) Sleep and obesity. Curr Opin Clin Nutr Metab Care 14(4):402–412
29. Vitale JA, Montaruli A, Michielon G, Scurati R, Alberti G, Carandente F, Roveda E (2017) Sleep quality and cytokine

expression after an exhaustive exercise: influence of ACE polymorphism I/D. Sleep Biol Rhythm 15(1):31–37

30. Sakkas GK, Giannaki CD, Karatzaferi C, Maridaki M, Koutedakis Y, Hadjigeorgiou GM, Stefanidis I (2015) Current trends in the management of uremic restless legs syndrome: a systematic review on aspects related to quality of life, cardiovascular mortality and survival. Sleep Med Rev 21:39–49

31. Beck AT, Guth D, Steer RA, Ball R (1997) Screening for major depression disorders in medical inpatients with the Beck depression inventory for primary care. Behav Res Ther 35(8):785–791

32. Buysse DJ, Reynolds CF 3rd, Monk TH, Berman SR, Kupfer DJ (1989) The Pittsburgh sleep quality index: a new instrument for psychiatric practice and research. Psychiatry Res 28(2):193–213

33. Krupp LB, LaRocca NG, Muir-Nash J, Steinberg AD (1989) The fatigue severity scale. Application to patients with multiple sclerosis and systemic lupus erythematosus. Arch Neurol 46(10):1121–1123

34. Leger LA, Mercier D, Gadoury C, Lambert J (1988) The multistage 20 metre shuttle run test for aerobic fitness. J Sports Sci 6(2):93–101

35. Browning LM, Mugridge O, Chatfield MD, Dixon AK, Aitken SW, Joubert I, Prentice AM, Jebb SA (2010) Validity of a new abdominal bioelectrical impedance device to measure abdominal and visceral fat: comparison with MRI. Obesity (Silver Spring) 18(12):2385–2391

36. Hryhorczuk C, Sharma S, Fulton SE (2015) Metabolic disturbances connecting obesity and depression. Front Neurosci 7:177

37. Titchener K, Wong QJ (2014) A weighty issue: explaining the association between body mass index and appearance-based social anxiety. Eat Behav 16:13–16

38. Murabito JM, Massaro JM, Clifford B, Hoffmann U, Fox CS (2013) Depressive symptoms are associated with visceral adiposity in a community-based sample of middle-aged women and men. Obesity (Silver Spring) 21(8):1713–1719

39. Hryhorczuk C, Sharma S, Fulton SE (2013) Metabolic disturbances connecting obesity and depression. Front Neurosci 7:177

40. Stunkard AJ, Faith MS, Allison KC (2003) Depression and obesity. Biol Psychiatry 54(3):330–337

41. Silveira H, Moraes H, Oliveira N, Coutinho ES, Laks J, Deslandes A (2013) Physical exercise and clinically depressed patients: a systematic review and meta-analysis. Neuropsychobiology 67(2):61–68

42. Dixon JB, Dixon ME, O'Brien PE (2003) Depression in association with severe obesity: changes with weight loss. Arch Intern Med 163(17):2058–2065

43. Sui X, Laditka JN, Church TS, Hardin JW, Chase N, Davis K, Blair SN (2009) Prospective study of cardiorespiratory fitness and depressive symptoms in women and men. J Psychiatr Res 43(5):546–552

44. De Schutter A, Lavie CJ, Milani RV (2014) The impact of obesity on risk factors and prevalence and prognosis of coronary heart disease—the obesity paradox. Prog Cardiovasc Dis 56(4):401–408

45. Kim TN, Park MS, Kim YJ, Lee EJ, Kim MK, Kim JM, Ko KS, Rhee BD, Won JC (2014) Association of low muscle mass and combined low muscle mass and visceral obesity with low cardiorespiratory fitness. PLoS One 9(6):e100118

46. Augustine JA, Yoon ES, Choo J, Heffernan KS, Jae SY (2016) The relationship between cardiorespiratory fitness and aortic stiffness in women with central obesity. J Women Health 25(7):680–686

47. Hunter GR, Chandler-Laney PC, Brock DW, Lara-Castro C, Fernandez JR, Gower BA (2010) Fat distribution, aerobic fitness, blood lipids, and insulin sensitivity in African-American and European-American women. Obesity (Silver Spring) 18(2):274–281

48. Kim S, Kim JY, Lee DC, Lee HS, Lee JW, Jeon JY (2014) Combined impact of cardiorespiratory fitness and visceral adiposity on metabolic syndrome in overweight and obese adults in Korea. PLoS One 9(1):e85742

49. Abidin NZ, Adam MB (2013) Prediction of vertical jump height from anthropometric factors in male and female martial arts athletes. Malays J Med Sci 20(1):39–45

50. Trombetti A, Reid KF, Hars M, Herrmann FR, Pasha E, Phillips EM, Fielding RA (2016) Age-associated declines in muscle mass, strength, power, and physical performance: impact on fear of falling and quality of life. Osteoporos Int 27(2):463–471

51. Grossschadl F, Freidl W, Rasky E, Burkert N, Muckenhuber J, Stronegger WJ (2014) A 35-year trend analysis for back pain in Austria: the role of obesity. PLoS One 9(9):e107436

52. Sarsan A, Ardic F, Ozgen M, Topuz O, Sermez Y (2006) The effects of aerobic and resistance exercises in obese women. Clin Rehabil 20(9):773–782

53. Lau C, Yu R, Woo J (2015) Effects of a 12-week Hatha yoga intervention on cardiorespiratory endurance, muscular strength and endurance, and flexibility in Hong Kong Chinese adults: a controlled clinical trial. Evid Based Complement Alternat Med 2015:958727

54. Impellizzeri FM, Agosti F, De Col A, Sartorio A (2013) Psychometric properties of the fatigue severity scale in obese patients. Health Qual Life Outcomes 11:32

55. Lasselin J, Laye S, Dexpert S, Aubert A, Gonzalez C, Gin H, Capuron L (2012) Fatigue symptoms relate to systemic inflammation in patients with type 2 diabetes. Brain Behav Immun 26(8):1211–1219

56. Alam MA, Rahman MM (2014) Mitochondrial dysfunction in obesity: potential benefit and mechanism of co-enzyme Q10 supplementation in metabolic syndrome. J Diabetes Metab Disord 13:60

57. Filler K, Lyon D, Bennett J, McCain N, Elswick R, Lukkahatai N, Saligan LN (2014) Association of mitochondrial dysfunction and fatigue: a review of the literature. BBA Clin 1:12–23

58. Puetz TW (2006) Physical activity and feelings of energy and fatigue: epidemiological evidence. Sports Med 36(9):767–780

59. Drager LF, Togeiro SM, Polotsky VY, Lorenzi-Filho G (2013) Obstructive sleep apnea: a cardiometabolic risk in obesity and the metabolic syndrome. J Am Coll Cardiol 62(7):569–576

60. Prather AA, Puterman E, Epel ES, Dhabhar FS (2015) Poor sleep quality potentiates stress-induced cytokine reactivity in postmenopausal women with high visceral abdominal adiposity. Brain Behav Immun 35:155–162

61. Kritikou I, Basta M, Tappouni R, Pejovic S, Fernandez-Mendoza J, Nazir R, Shaffer ML, Liao D, Bixler EO, Chrousos GP, Vgontzas AN (2012) Sleep apnoea and visceral adiposity in middle-aged male and female subjects. Eur Respir J 41(3):601–609

62. Xu W, Zhang H, Paillard-Borg S, Zhu H, Qi X, Rizzuto D (2016) Prevalence of overweight and obesity among chinese adults: role of adiposity indicators and age. Obes Facts 9(1):17–28

63. Mauvais-Jarvis F, Clegg DJ, Hevener AL (2013) The role of estrogens in control of energy balance and glucose homeostasis. Endocr Rev 34(3):309–338

64. Cao X, Xu P, Oyola MG, Xia Y, Yan X, Saito K, Zou F, Wang C, Yang Y, Hinton A Jr, Yan C, Ding H, Zhu L, Yu L, Yang B, Feng Y, Clegg DJ, Khan S, DiMarchi R, Mani SK, Tong Q, Xu Y (2014) Estrogens stimulate serotonin neurons to inhibit binge-like eating in mice. J Clin Invest 124(10):4351–4362

65. Vitale JA, Weydahl A (2017) Chronotype, physical activity, and sport performance: a systematic review. Sports Med 47(9):1859–1868

66. Rossi A, Formenti D, Vitale JA, Calogiuri G, Weydahl A (2015) The effect of chronotype on psychophysiological responses

during aerobic self-paced exercises. Percept Mot Skills 121(3):840–855

67. Bonato M, Agnello L, Galasso L, Montaruli A, Roveda E, Merati G, La Torre A, Vitale JA (2017) Acute modification of cardiac autonomic function of high-intensity interval training in collegiate male soccer players with different chronotype: a cross-over study. J Sports Sci Med 16(2):286–294

68. Vitale JA, Banfi G, La Torre A, Bonato M (2018) Effect of a habitual late-evening physical task on sleep quality in neither-type soccer players. Front Physiol 9:1582

69. Vitale JA, La Torre A, Baldassarre R, Piacentini MF, Bonato M (2017) Ratings of perceived exertion and self-reported mood state in response to high intensity interval training a crossover study on the effect of chronotype. Front Psychol 8:1232