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RESEARCH ARTICLE

Baseline Body Mass Index Influences the Responses to Exercise Training on Quality of Life in Women with Obesity

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ABSTRACT
Purpose: Exercise has been documented as a critical strategy for improving physical and mental health. However, the impact of exercise training (ET) on quality of life (QoL) among obese is controversial. The present study aims to evaluate the impact of a 20-week ET program in women with obesity and the influence of baseline weight status on QoL responses to the ET program.
Methods: This secondary analysis from a quasi-experimental study included 40 obese women (BMI $\geq$30 kg/m^2) aged between 18 and 65 years old (20 interventions and 20 controls). The intervention group participated in a moderate-to-vigorous intensity ET thrice a week, nutritional guidance, and psychological support. The control group received the same activities of nutritional guidance and psychological support but did not perform the ET. Measurements of QoL (WHOQOL-Bref) were performed at baseline and after 20- week follow-up.
Results: No significant impact of 20-week ET on QoL among obese women was observed. However, greater improvements in physical health, psychological, social relationship, and environment domains were observed for every increase in 1 unit of baseline BMI, except for the overall QoL score.
Conclusions/Recommendation: We can speculate that the better QoL responses to ET among those with higher BMI at baseline may be explained by the fact that individuals with more severe obesity are more impacted by functional limitations, stigmatization, discrimination, and social isolation; therefore, presenting worse QoL.

Keywords: Mental health; Exercise; Obesity; Quality of life

Introduction

Obesity – a major public health problem worldwide – is associated with several chronic diseases, such as diabetes mellitus (DM) and cardiovascular diseases (CVDs)[1]. Moreover, the prevalence of obesity has dramatically increased over the last decades and their consequences, beyond the increased risk of premature deaths or comorbidities associated to DM and CVDs, are the decrease of physical function and the elevated risk for development of mental health problems[2,3].

In Brazil, data from a large national survey (Vigitel) demonstrates that between 2006 and 2019, obesity increased from 11.8% to 20.3%, an average increase of 0.6% a year, a trend observed in both sexes and across all age groups and educational levels. However, a slightly higher increase of obesity prevalence was observed among women in comparison to men during this period (8.8% increase for women vs 8.1% increase for men)[4].

Obesity is commonly associated with mental disorders. This association can be found in both directions, with mental disorders favoring the development of obesity, as well as, obesity increasing the incidence of mental disorders. These associations might differ among different populations with varied sociodemographic and clinical characteristics[5,6].

For women, obesity negatively affects endocrine control of menstrual function and fertility[7], which together with the stigma and discrimination suffered by obese individuals in different settings of their lives, can impair them physically and psychologically, worsening their quality of life (QoL)[8–10]. A deleterious impact of obesity on physical and psychological QoL domains was already demonstrated, with normal weight adults presenting better QoL compared to obese and morbidly obese individuals[11]. Moreover, the degree of obesity seems to influence QoL, since it is worse in morbidly obese individuals in comparison to those with non-morbid obesity[12].

As a pivotal therapeutic strategy to improve physical and mental health, exercise training (ET), including aerobic, strength, stretching, and balance exercises ameliorates QoL in the general population[13], being consistently ranked among the top health and fitness trends[14,15]. Similar health benefits from ET are usually observed among overweight and obese adults, facilitating weight loss and improving lipid profile and glucose metabolism[16]; however, its impact on the QoL of obese individuals is still controversial, with some studies demonstrating positive results[17,18] and others showing null effects[19–21]. These conflicting results can be attributed to differences across study populations, especially regarding their weight status, with studies including patients ranging from overweight to morbid obesity.

The present study aimed to evaluate the impact of a 20-week ET program in obese women. The influence of baseline weight status on QoL responses to a 20-week ET program was also evaluated. We hypothesized that ET would improve QoL among obese women with a greater impact on those with higher body mass index (BMI) at baseline.

Methods

The present study is a secondary analysis from a quasi-experimental study including 40 obese women (20 interventions and 20 controls) aiming to investigate the influence of an ET program on QoL among women submitted to a weight loss program for 20 weeks. The full description and the main results can be found elsewhere[22].

Participants were women aged between 18 and 65 years old with BMI $\geq$30 kg/m^2 that were recruited to participate in a weight loss program including ET. Only women who were not enrolled in any other exercise program for a minimum period of six months before this study, and who did not have any diseases associated with overweight, such as DM, CVDs, cancer, or any other limitation that prevented the regular practice of physical exercise, were allowed to participate in this study.

All procedures were in accordance with the ethical guidelines[23]. This research project adhered to the international ethical policies and was approved by the local Ethics Committee (1157-CEP/HUPE - CAAE: 0031.0.228.000-05). Only women who signed the informed consent form were included in the study.

The sample size was only calculated for the primary study (insulin sensitivity), but not for this secondary analysis, aiming to achieve a reduction of -2.42 (standard deviation = 1.07) in HOMA-IR values among individuals undergoing the exercise intervention in comparison to controls[24]. Assuming $\alpha = 0.05$ and $\beta = 0.20$ and increasing the sample size by 20% to account for losses to follow-up, at least 10 women were necessary for each group.

The intervention group participated in ET, nutritional guidance, and psychological support activities. The control group received the same activities of nutritional guidance and psychological support but did not perform the ET. The weight loss program had only 20 spots for ET; therefore, the intervention group comprised the first 20 women enrolled in the program, while the control group consisted of another 20 women who were referred to the waiting list due to the lack of spots to ET during the study period.

The ET included activities developed in three weekly sessions of 60 minutes. Each ET session was divided into three parts: 1) warm-up (10 minutes) including activities that gradually increase exercise intensity, joint mobility exercise, and stretching; 2) main activity (40 minutes) including calisthenics exercises, walking and jogging, sports initiation activities, recreational activities, and resistance exercise (6 exercises including sit-ups, push-ups, and pull-ups, 1 set of 10 to 12 repetitions) 3) cool-down (10 minutes) to allow a gradual transition to a resting state, including recreational, slow walk, and stretching.

The physical training program was divided into two phases: 1) adaptation phase, lasting eight weeks, which involved aerobic activities of moderate-intensity (60–70% peak heart rate) and resistance exercise at moderate intensity in a self-reported rating of perceived exertion; 2) physical conditioning phase, which consisted of aerobic activities of moderate to vigorous intensity (70–85% peak heart rate) and resistance exercise at moderate to vigorous intensity in a self-reported rating of perceived exertion. Peak heart rate was obtained through a maximal treadmill exercise test using the Bruce protocol performed during the initial evaluation before the beginning of the study. The exercise intensity during aerobic activities was self-monitored by each participant three times during the exercise sessions using the manual palpation method at the wrist. Participants were advised to count the beats for 15 seconds and the value obtained was multiplied by 4 to obtain the heart rate per minute. To adequately obtain this measure, patients were trained before starting the ET program by placing two fingers (tip of the index and third fingers) between the bone and the tendon over the radial artery (located on the thumb side of your wrist).

The nutritional intervention included monthly appointments with a dietician that prescribed a hypocaloric diet (caloric restriction of approximately 500 kcal per day) with a balanced distribution of macronutrients (50 to 60% of carbohydrates, 25 a 30% of lipids, and 15 to 20% of proteins). Furthermore, biweekly group-based psychological sessions were performed based on cognitive behavioral therapy. Cognitive-behavioral therapy is a psychological intervention that helps the participant identify and change destructive or disturbing patterns that negatively influence their behavior and emotions. Group sessions can strengthen the relationship among individuals who present similar difficulties and conflicts, finding in the group the mutual support that may act as a trigger for their treatment, improving adherence, and facilitating a change in their attitude towards eating habits.

Baseline body weight, height, and circumferences (waist and hip) were measured by a single non-blinded evaluator, according to the criteria proposed by Lohmann et al.[25]. Functional capacity was assessed through a maximal symptom-limited exercise test on a treadmill using the Bruce protocol performed by a trained physician. The duration of the exercise test, which is the primary variable used to estimate maximum oxygen consumption through specific formulas, was used as the main parameter of functional capacity since it was not possible to perform a direct analysis of the gas exchange during the test. QoL was assessed using the World Health Organization Quality of Life questionnaire – Bref (WHOQOL-Bref) validated for the Brazilian population[26] that consisted of 24 questions divided into four domains (physical, psychological, social relationships, and environment) and two other general questions (overall). The questions are based on the Likert Scale, with five response options. Each answer receives from one to five points that determine the perception of each subject in each of the four domains, in which higher scores indicate a better QoL perception. The overall and domain-specific scores were transformed on a scale ranging from 0 to 100 using the following formula: transformed score= (score-4) x (100/16)[27]. This transformation converts the lowest and highest scores to 0 and 100, respectively. Scores between these values represent the percentage of the total possible score achieved. The WHOQOL-Bref questionnaire was self-responded with no interference from the researchers on the participant's responses. Anthropometric and QoL measurements were performed at baseline and after 20- week follow-up by the same single non-blinded evaluator.

Data were expressed as the mean and standard deviation. Changes for QoL domains between groups over time were evaluated using linear mixed models that included the interaction term time X treatment (represented as beta coefficient), adjusted for age and the respective QoL domain at baseline. To evaluate the influence of baseline BMI on the response to ET, linear mixed models including an interaction term time X treatment X baseline BMI, adjusted for age and the respective QoL score at baseline, were also fitted.

All participants were considered in the statistical analysis, regardless of compliance or loss to follow-up, characterizing an intention-to-treat analysis. A per-protocol analysis including only those participants that completed the 20-week follow-up was also performed. Residual plots of all models were also examined and showed no major deviations from regressions assumptions. The statistical analysis was performed using Stata 13.0 statistical software (College Station, TX, StataCorp LP. 2013) and the significance level was ≤ 0.05.

Results

Of the 40 obese women (20 control and 20 exercise groups) that initiated the study, 30 (13 control and 17 exercise groups) completed the 20-week follow-up (Figure 1).

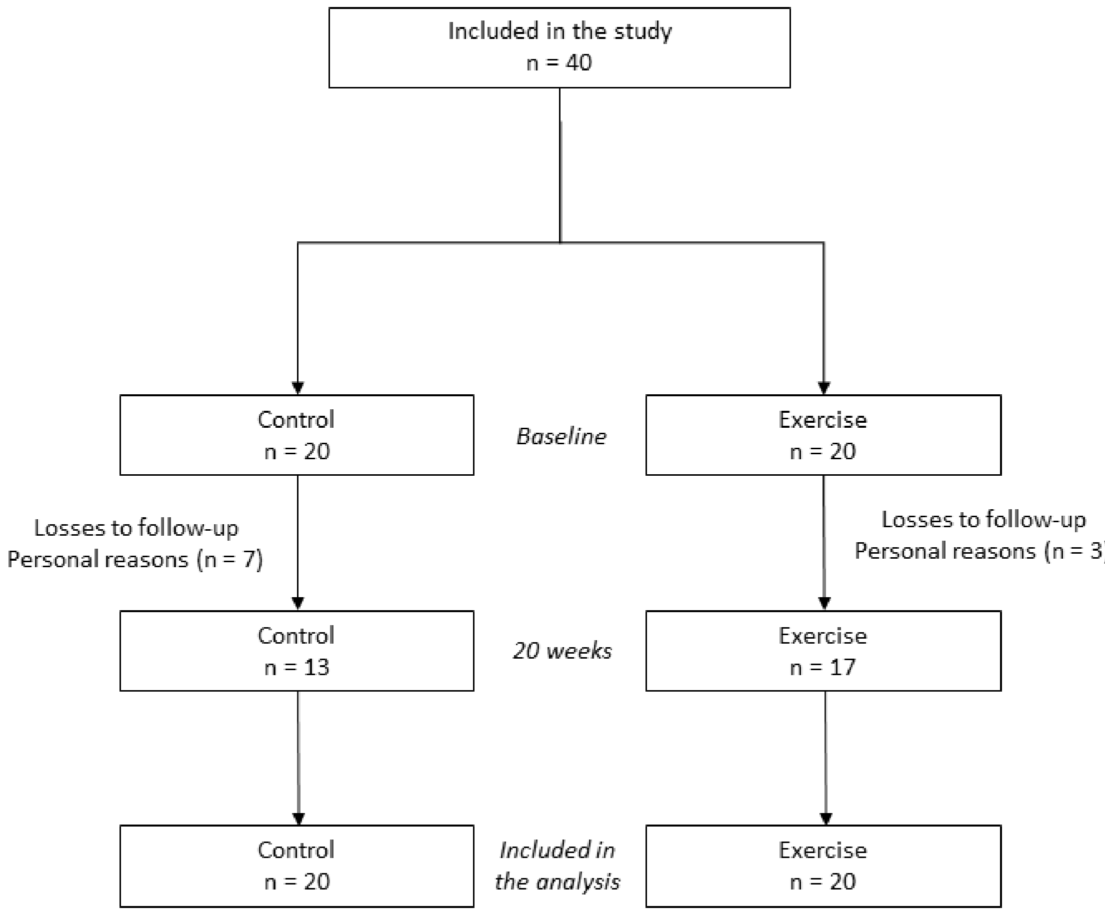

Figure 1- Flowchart of participants included in the study (n=40).

Baseline clinical characteristics of participants in each group are depicted in Table 1. Overall, no major differences between groups were observed at baseline, except for age and some QoL domains (physical health, psychological, environment, and overall QoL), in which those in the ET group were more likely to be older and with greater QoL scores. Of the 40 women that initiated the study, 30 (75%) completed the 20-week intervention (17 in the exercise [85%] and 13 in the control [65%]). Those who dropped out from the study reported personal reasons (lack of time, work commitments, and family obligations) not related to the ET protocol. No differences were observed for the baseline characteristics between completers vs dropout participants (Supplemental Table). Compliance rates for the activities proposed in the study were greater than 75% for participants that completed the 20-week follow-up.

Table 1 – Baseline characteristics of participants included in the study (n=40)

Variables	Control (n=20)	Exercise (n=20)	*p-value*ᵗ
	Mean (Standard Deviation)		
Age (years)	40.8 (12.1)	49.7 (9.6)	0.01
Weight (kg)	99.1 (15.4)	94.2 (12.4)	0.28
Height (m)	1.57 (.06)	1.58 (.07)	0.61
BMI (kg/m^2)	39.9 (6.2)	37.7 (5.2)	0.23
Waist (cm)	102.4 (10.7)	101.2 (8.6)	0.70
Hip (cm)	126.3 (11.3)	124.1 (10.8)	0.53
Waist-to-hip ratio	0.81 (0.05)	0.81 (0.05)	0.71
Exercise capacity (min, Bruce protocol)	7.6 (2.3)	7.8 (1.7)	0.68
Physical health QoL	49.4 (16.3)	65.0 (20.3)	0.01
Psychological QoL	44.9 (18.3)	58.7 (16.9)	0.02
Social relationship QoL	58.7 (19.9)	61.2 (21.3)	0.72
Environment QoL	36.9 (13.7)	50.4 (11.7)	0.002
Overall QoL	40.7 (17.5)	56.2 (22.0)	0.02

Kg: kilograms; m: meters; cm: centimeters; min: minutes; QoL: quality of life
QoL was measured using WHOQOL-Bref questionnaire
ᵗ Two-sample t-test
QoL – Quality of Life

The longitudinal effects of ET on QoL are depicted in Table 2. There were no significant improvements in any QoL domains and the overall score during the follow-up. No significant differences for changes in the time of exercise test were observed between groups at the end of follow-up (+0.14 vs +0.62 minutes for control and exercise, respectively; p=0.07). Similar results for QoL were observed for the analysis considering only those that completed the 20-week follow-up in a per-protocol analysis (Table 3).

Table 2- Crude means (standard deviation) and adjusted beta values for longitudinal QoL changes after 20 weeks (n=40)

Variables	20 weeks		
	Mean (sd)*	β	*p-value***
Physical health			
Control	55.0 (19.1)	+ 0.11	0.97
Exercise	70.7 (15.4)		
Psychological			
Control	47.5 (22.2)	+ 2.36	0.59
Exercise	63.9 (16.6)		
Social relationship			
Control	54.1 (23.7)	+ 9.26	0.13
Exercise	68.7 (18.8)		
Environment			
Control	41.7 (15.7)	- 0.69	0.84
Exercise	54.5 (15.5)		
Overall			
Control	48.9 (18.8)	+ 2.80	0.56
Exercise	67.1 (19.2)		

β (exercise vs control)
* Control (n=13) and Exercise (n=17)
** Linear mixed models including the interaction term time X treatment (represented as beta coefficient), adjusted for age and the respective QoL domain at baseline

Table 3 - Crude means (standard deviation) and adjusted beta values for longitudinal QoL changes after 20 weeks among those that completed the study (n=30).

	Baseline Mean (sd)	*p-value**	20 week Mean (sd)	β	*p-value***
Physical health					
Control (n=13) Exercise (n=17)	52.1 (16.4) 66.4 (20.4)	0.05	55.0 (19.1) 70.7 (15.4)	+0.34	0.95
Psychological					
Control (n=13) Exercise (n=17)	43.1 (20.4) 58.6 (16.9)	0.04	47.5 (22.2) 63.9 (16.6)	+2.24	0.66
Social relationship					
Control (n=13) Exercise (n=17)	54.4 (20.9) 61.3 (21.6)	0.42	54.1 (23.7) 68.7 (18.8)	+8.14	0.26
Environment					
Control (n=13) Exercise (n=17)	35.5 (10.7) 50.9 (10.6)	0.001	41.7 (15.7) 54.5 (15.5)	-0.85	0.84
Overall					
Control (n=13) Exercise (n=17)	42.7 (17.2) 58.8 (20.1)	0.03	48.9 (18.8) 67.1 (19.2)	+2.92	0.61

β (exercise vs control)
* Two-sample t-test
** Linear mixed models including the interaction term time X treatment (represented as beta coefficient), adjusted for age and the respective QoL domain at baseline

The analysis considering the influence of baseline BMI on the responses to ET demonstrated significant greater responses in physical health (β = +1.72; p = 0.02), psychological (β = +1.60; p = 0.03), social relationship (β = +2.20; p = 0.04) and environment (β = +1.39; p = 0.02) domains for every increase in 1 unit of baseline BMI, except for the overall QoL score (β = - 0.26; p = 0.77) (Table 4). The same pattern of response was observed for the influence of baseline BMI on the QoL changes to ET in the analysis considering only those that completed the 20-week follow-up (Table 5). However, statistical significance was reached only for the environment domain (β = +1.45; p = 0.04), with physical health (β = +1.58; p = 0.07), psychological (β = +1.45; p = 0.10), and social relationship (β = +2.25; p = 0.09) reaching a borderline significance (Table 5).

Table 4 – Beta estimates for the influence of baseline BMI on longitudinal QoL changes to exercise training after 20 weeks (n=40)

Variables	β[ǂǂ]	95% CI	*p-value**
Physical health	+ 1.72	+ 0.27 to + 3.18	0.02
Psychological	+ 1.60	+ 0.08 to + 3.11	0.03
Social relationship	+ 2.20	+ 0.02 to + 4.37	0.04
Environment	+ 1.39	+ 0.21 to + 2.56	0.02
Overall	- 0.26	- 2.09 to + 1.55	0.77

[ǂǂ] For every increase in 1 unit of baseline BMI. CI: Confidence Interval.
* Linear mixed models including the interaction term time X treatment X baseline BMI, adjusted for age and the respective QoL score at baseline

Table 5 – Beta estimates for the influence of baseline BMI on longitudinal QoL changes to exercise training after 20 weeks among those that completed the study (n=30)

Variables	β[‡‡]	95% CI	*p-value*[*]
Physical health	+1.58	-0.14 to +3.29	0.07
Psychological	+1.45	-0.34 to +3.24	0.10
Social relationship	+2.25	-0.37 to +4.86	0.09
Environment	+1.45	+0.06 to +2.83	0.04
Overall	-0.47	-2.60 to +1.67	0.67

[‡‡] For every increase in 1 unit of baseline BMI. CI: Confidence Interval.
* Linear mixed models including the interaction term time X treatment X baseline BMI, adjusted for age and the respective QoL score at baseline

Discussion

Contrary to our study hypothesis, the present study did not demonstrate a positive impact of a 20-week ET on QoL among obese women. However, greater improvements in physical, psychological, social relationship, and environment QoL domains were obtained according to weight status at baseline, with those obese women presenting higher BMI achieving greater QoL improvements from ET when compared to those with lower BMI. These results suggest that the degree of obesity may exert a differential impact on the QoL responses to ET.

The consequences of obesity to health are unquestionable, increasing the risk of several chronic diseases, mortality, stigmatization, and decreasing QoL[28]. Intervention strategies, including physical exercise, are urgently needed to prevent and treat cardiovascular and metabolic complications, to decrease stigmatization and improve well-being and QoL[29].

Previous studies demonstrated a positive effect of physical exercise on QoL in obese individuals[30]. A recent randomized clinical trial showed that either moderate or high-intensity exercise training programs promoted increases on QoL among obese adults[31]. Surprisingly, our study did not confirm these previous results. The lack of QoL improvements as a result of the ET intervention can be explained by the relatively short-term follow-up for this type of outcome since studies with a longer duration usually obtained positive responses[32–34]. For instance, in the Look AHEAD study, Williamson et al. evaluated the effects of a lifestyle intervention program including exercise ≥175 to 200 minutes/week at moderate intensity in overweight and obese adults and found important improvements in the physical component of QoL after 1-year follow-up[35]. In addition, the lack of improvements on functional capacity may have contributed to the null changes on QoL. One of the reasons that may have collaborated to the absence of significant changes in functional capacity was the prescription of physical training, which represented relatively low exercise volume. An 8-week randomized clinical trial involving women aged between 18 and 44 years, comparing the effect of a low volume high-intensity interval training versus a moderate-intensity continuous training program on QoL in women with overweight, did not show significant differences between groups in physical and mental components of QoL[36]. Similarly, Sperlich et al. investigated the effect of functional high-intensity circuit training alone or in combination with high-volume low-intensity exercise on QoL among women with overweight, and observed that physical and social functioning, vitality, role of emotional limitations, and mental health improved following both exercise groups. However, perception of physical pain was higher only after high-intensity circuit training alone, and perception of general health was increased only by the exercise combined group[37].

Compared to the general Brazilian population, women included in this study presented better scores for QoL domains at baseline, which may have contributed to the overall null impact of ET on QoL[38]. Moreover, despite most studies in the literature have demonstrated a positive influence of increased physical activity levels on QoL[39], the lack of association between physical activity and some QoL domains was previously demonstrated in different populations[40–42]. In obese individuals, some QoL domains are more affected among those with severe obesity (BMI≥40 kg/m^2)[43]. Thus, we can speculate that the better QoL responses to ET among those with higher BMI at baseline may be explained by the fact that individuals with more severe obesity are more impacted by functional limitations, stigmatization, discrimination, and social isolation; therefore, presenting worse QoL[44]. For those, ET seems to promote a cascade of direct and indirect benefits on physical and mental health, decreasing their functional limitations, improving their social relationships, and, consequently, increasing their QoL[20]. Freese et al. conducted a randomized clinical trial to determine the effect of 6 weeks of high-intensity interval training on perceived health among women at risk of metabolic syndrome. The authors showed that exercise effects on role-physical scores, vitality, general health, social functioning, and the total SF-36 scores were largest among those participants with poorer perceived health status at baseline[45].

The present study has some limitations. Since this is a secondary analysis from a quasi-experimental study, the sample size was only calculated to detect changes in the primary outcome but not to evaluate changes in QoL. Therefore, the lack of effects from ET on QoL should be interpreted with caution, considering that our study may have been underpowered. However, even with the small sample size, we were able to detect improvements in some QoL domains according to the BMI status at baseline. Moreover, the linear mixed model is a powerful model to detect longitudinal changes over time since it considers the variance-covariance structure for repeated measures. The relatively high percentage of losses to follow-up (25%) may also be cited as a study limitation. However, the results demonstrated the same trend in the analysis considering only those that completed the 20-week follow-up period, despite the lack of statistical significance in some QoL domains. Another limitation was the lack of a random allocation of participants. However, the allocation procedure based on a waiting list was impartial and the baseline values of variables that were different at baseline were included in the longitudinal models to control for baseline unbalances. In addition, although the WHOQOL-Bref is the most used questionnaire to evaluate QoL in the general population, this is a generic instrument and some specific issues related to QoL in obese individuals may not be contemplated. To our knowledge, no specific questionnaire to evaluate QoL validated for the Brazilian population with obesity had been developed at the time of study conduction. Therefore, considering this context, we decided to use the WHOQOL-Bref to evaluate QoL during the study. The lack of information about habitual eating patterns regularly throughout the 20-week study period should also be mentioned as a limitation, precluding a more detailed analysis based on changes in food consumption over the follow-up. Moreover, the self-controlled exercise intensity may have hindered the appropriate control of exercise training parameters, even though the participants had been exhaustively trained for adequately self-monitoring.

Conclusions

Exercise training seems to positively affect QoL in those obese women with higher BMI. Large-scale intervention strategies including ET should be implemented for the treatment of obese individuals, especially among those with higher BMI in which benefits of ET on QoL seem to be higher. Studies with larger sample size and including different subgroups of obese individuals are still necessary and would help clinicians and researchers to better understand the impact of ET on perceived mental and physical health status in obese individuals.

Ethics approval & Consent to participate

The study was analyzed and approved by the Research Ethics Committee of Pedro Ernesto University Hospital (1157-CEP/HUPE - CAAE: 0031.0.228.000-05). Written informed consent was obtained from all participants before the beginning of the study

Availability of data and material

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request

Conflicts of Interest Statement

The authors have no conflicts of interest to declare

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MFFM designed and conducted the research; LGR, VBP, TRG, and MFFM analyzed the data; LGR, VBP, TRG, APD, LFRJ, JSOB, and MFFM wrote the paper; MFFM had primary responsibility for the final content. All authors read and approved the final manuscript.

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Supplementary Material

Supplemental Table – Comparison of baseline characteristics of participants that completed vs did not complete the 20-week follow-up study (n=40).

Variables	Completers (n=30)	Dropout (n=10)	*p-value*[ǂ]
	Mean (Standard Deviation)		
Age (years)	45.5 (12.2)	44.6 (10.9)	0.83
Weight (kg)	95.0 (11.1)	101.8 (20.6)	0.19
Height (m)	1.58 (0.07)	1.57 (0.05)	0.66
BMI (kg/m^2)	38.2 (5.3)	41.0 (7.1)	0.17
Waist (cm)	100.9 (8.6)	104.7 (12.4)	0.29
Hip (cm)	124.2 (9.6)	128.3 (14.7)	0.32
Waist-to-hip ratio	0.81 (0.05)	0.82 (0.06)	0.82
Exercise capacity (min, Bruce protocol)	7.9 (2.1)	7.2 (2.1)	0.31
Physical health QoL	60.5 (19.8)	48.6 (18.1)	0.10
Psychological QoL	52.2 (19.7)	51.7 (16.8)	0.94
Social relationship QoL	58.6 (21.2)	64.2 (18.4)	0.47
Environment QoL	44.9 (13.0)	41.9 (18.2)	0.58
Overall QoL	52.2 (20.3)	38.8 (21.6)	0.09

Kg: kilograms; m: meters; cm: centimeters; min: minutes; QoL: quality of life
QoL was measured using WHOQOL-Bref questionnaire
[ǂ] Two-sample t-test
QoL – Quality of Life