TWO AEROBIC EXERCISE PROGRAMS IN MANAGEMENT OF BACK PAIN AMONG MIDDLE-AGED OBESE WOMEN: A RANDOMIZED CONTROLLED STUDY

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ABSTRACT

Purpose. Back pain is a frequent symptom in the obese. The purpose of the study was to compare the effects of two training programs on the reduction of back pain among obese women. **Methods.** The study included 30 obese women who reported back pain within 3 months preceding enrollment. The subjects were randomly allocated to endurance or endurance/resistance physical exercise. The intensity of the exercise was adjusted to 50–80% of HRmax. Back pain intensity, muscle strength of knee flexors and extensors, body balance and body composition were measured before and after training. **Results.** Both the endurance and endurance/resistance training exerted positive effect on back pain ($p < 0.05$). Similarly, in both training groups the significant increase in the strength of knee flexors and marked reduction of body fatness ($p < 0.001$ for all) was documented. However, the interventions' efficacies in selected groups did not differ. **Conclusions**. Both endurance and combined endurance/resistance training exert positive effect in decreasing back pain and improving functional fitness of obese women. Therefore, both forms of training may be recommended for individuals dealing with the abovementioned problems.

Key words: aerobic exercise, back pain, obesity

Introduction

Most back pain-related problems are non-specific [1, 2], and a small percentage (5 to 10%) of people suffering from back pain develops chronic pain. Heavy physical strain, repetitive lifting, age, gender, smoking, static positioning, previous history of pain, physical fitness, and genetics have also been well-documented risk factors for back pain [3]. Hue et al. has also reported on different spinal pathology-associated problems in obese persons [4].

The relation between obesity and functional impairment of the spine, secondary to weakness and stiffness of muscles, leading to back pain while performing such daily activities as standing up, walking, getting up, and running was already observed [5–8]. A significant positive association between Body Mass Index (BMI) and risk of low back pain was found in analyses adjusted for age, education, work status, physical activity at work and in leisure time, smoking, blood pressure, and serum lipid levels [9]. Also Payne et al. [10] indicated that physical fitness (muscle strength and endurance) and participating in physical activity were significantly higher among people with no history of low back pain than among those who suffered from this condition.

The multitude of potential causes of back pain inspires research on various forms of its prevention and treatment. Regular physical exercise and good mental health both have a protective effect. Physical exercise helps to keep the musculoskeletal system in shape and maintain psychological well-being [11]. Physical exercises may, in some aspects, be particularly important for women. Groessl et al. observed that exercising women had larger decreases in depression and pain and larger increases in energy than men [12].

The issues related to the rehabilitation of the spine were also studied by Demirel et al. [13], Sorensen et al. [14], and Lewandowski et al. [15], who suggested that physical exercise accompanied by other therapeutic methods, e.g. education or physiotherapy, can markedly reduce the demand for pharmacotherapy. As noted by Oldervoll et al. [16], increased body awareness is one of the consequences of programs designed to promote physical fitness, which may be of therapeutic importance in the treatment of every type of pain [17]. On the other hand, some authors have failed to find any effect of physical exercise on musculoskeletal pain [18–20]. Still, it is difficult to determine which specific components are the most important for back pain reduction.

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Grønningsæter et al. [18] did not find any correlation between pain reduction and increased aerobic fitness. This suggests that aerobic fitness has no important role in musculoskeletal pain management. On the other hand, Larivière et al. [21] claim that poor aerobic fitness is an important factor in the development of musculoskeletal pain. To the best of our knowledge, there are no studies comparing two different training programs aimed at reducing back pain in obese women.

The purpose of the present study was to compare the effects of two aerobic training programs on reduction in back pain among obese women. One exercise program was aimed exclusively at improving cardiovascular fitness (aerobic fitness), whereas the other was designed to improve both muscle strength and fitness. Thanks to the anticipated stronger effect of resistance exercise on muscle tone, it was possible to assume that this training program will be more effective in improving the functional ability of obese women than endurance exercise. Furthermore, strengthening the muscles should help reduce back pain.

Material and methods

Informed written consent was obtained from all subjects, and the study was approved by the Ethics Committee of Poznan University of Medical Sciences, registered as case no. 1077/12 with supplement (no. 753/13). The privacy rights of human subjects were observed. The study was carried out in accordance with the revised Declaration of Helsinki of 1975 and the Uniform Requirements for Manuscripts Submitted to Biomedical Journals. The study included 30 subjects aged 37 to 62 years (mean 49.8). We identified women who had reported obesity (BMI above 30 kg/m^2) and had incidence of back pain during the last 3 months prior to the beginning of study (Table 1). The participants were randomly assigned to Group E – with endurance intervention (N = 15) or Group M – mixed, endurance with resistance exercises (N = 15).

Measurements

Measurements of muscle strength of the knee flexors and extensors were taken on a UPR-02 A/S chair with Moment II by Sumer software (Sumer, Opole, Poland) [22, 23]. The study was performed in a sitting position, with stabilization of the thighs and trunk. Isometric knee extension torque was measured in both settings, with a knee joint angle of 90° (0° full extension) and a hip angle of 85° (0° supine position).

Balance was measured by having the subject stand on one leg with eyes open (balance with feet fixed). The subject stood on one leg for as long as she could, or until she was told to stop. Timing started when the foot was lifted, and stopped when the foot was placed on the ground, a hand touched a chair/table, the foot moved, or 30 seconds have passed.

Fat mass (%) was determined by impedance analysis using a Bodystat analyzer (1500 MDD; Bodystat, Isle of Man, UK).

Procedure

The 3-month intervention consisted of a physical exercise program including 3 sessions of training per week (on Mondays, Wednesdays, and Fridays). A total of 36 training sessions were carried out in each group. Training was performed under the supervision of a qualified fitness instructor and at least one investigator in a professional training room. Subjects were divided randomly into two groups (E – endurance and M – mixed) based on the type of training. Group E underwent endurance training on cycle ergometers (Schwinn Evolution, Schwinn Bicycle Company®, Boulder, Colorado, USA). Training sessions consisted of a 5-minute warm-up (stretching exercises) of low intensity (50–60% of maximum heart rate); 45-minute training, at an intensity between 50–80% of maximum heart rate; 5-minute cycling without load, and 5-minute closing stretching and breathing exercises of low intensity. Group M underwent endurance–resistance training which consisted of

Table 1. Baseline characteristics of the study subjects

Parameters	Group	$\bar{x}$	M	Min.	Max.	SD	F	p
Height (cm)	E	160.8	161	152	170	5.3	2.43	0.130
	M	162.8	164	151	173	6.3		
Weight (kg)	E	94.3	90	74	155	20.2	0.01	0.904
	M	93.2	93	72	117	13.9		
BMI (kg/m^2)	E	36.2	34	31.4	52.1	5.4	0.24	0.626
	M	35.3	34.7	30.1	42.7	3.8		
Fat (%)	E	47.8	45.8	40.5	62.9	5.4	0.85	0.362
	M	46.5	46.2	37.5	55.8	5.11		

BMI – body mass index

a 5-minute warm-up (stretching exercises) of low intensity (50–60% of maximum heart rate), a resistance component, an endurance component, cycling without load, and closing exercises. The resistance component involved 20 minutes of resistance exercise with a neck barbell and stability ball. To allow muscle power to regenerate, the resistance component was variable and repeated regularly every week. On Mondays, upper limb exercises were performed with a neck barbell; Wednesday sessions involved spine-stabilizing exercises, deep muscle strenghening exercises, and balance-adjusting exercises with a stability ball; on Fridays, lower limb exercises with a neck barbell were carried out. The exercises were repeated in series. The number of repetitions of each exercise in the series was dependent on the subjects' muscle strength and was equal to the number of repetitions performed correctly. The number of repetitions was systematically increased with increasing subjects' muscle strength. Between the series of resistance exercises, 10–15 second regeneration pauses were taken, during which subjects performed isometric exercises. Directly after the resistance exercises, subjects underwent 25 minutes of endurance exercise on cycle ergometers (Schwinn Evolution, Schwinn Bicycle Company®, Boulder, Colorado, USA) of intensity between 50–80% of maximum heart rate, 5 minutes of cycling without load, and 5 minutes of closing stretching and breathing exercises of low intensity. Heart rate during training was monitored with a Suunto Fitness Solution® device. Both training programs were comparable in exercise volume, and varied only in the nature of the effort.

Statistical analysis

Statistical analyses were performed using Statistica 10 software (StatSoft Inc, Krakow, Poland) and statistical significance was defined as $p < 0.05$. ANOVA was used to determine the significance of differences between groups E and M, and for the analysis of variation between pre-test and post-test results. The analysis with two levels of the first factor (within-subject factor: "training" – pre-test, post-test) and two levels of the second factor (between-subject factor: "group" – endurance or endurance-resistance training) was performed. For interaction effects, the Eta^2 (η^2) effect size was calculated. Eta^2 can be defined as the proportion of variance associated with or accounted for by each of the main effects, interactions, and error in an ANOVA study. It was also used to calculate the power of significant effects. Pearson chi-square statistics were used to identify the potential differences between the kinds of training and changes in back pain.

Results

Changes in the well-being of the studied women represented important response to training. Both types of training, endurance and endurance/resistance, exerted beneficial effect on back pain ($p < 0.05$). Similarly, in both training groups the significant increase in the strength of knee flexors and marked reduction in body fatness ($p < 0.001$ for all) was documented. However, the interventions' efficacies in selected groups did not differ. As many as 70% of women participating in the training reported a lack of pain during the three months of the program, and 30% still complained of back pain (Table 2).

Neither of the two types of training caused significant changes in the strength of knee joint extensors (Figure 1 and 2). Furthermore, we did not observe significant intergroup differences with regard to this variable. In contrast, the significant ($p < 0.01$) increase in the strength of knee flexors (Figures 3 and 4) was documented in both training groups (F = 23.30, $p = 0.001$, $\eta^2 = 0.45$ for the left, and F = 18.48, $p = 0.001$, $\eta^2 = 0.39$ for the right leg). Therefore, the effect of the training proved to be strong but limited to muscles which are usually considered as weaker, i.e. the knee flexors rather than the extensors.

Participants from groups E and M did not differ significantly in terms of training-induced changes.

No significant results of the training were documented in body balance measured during the single stance test. The time of standing on both left (Figure 5) and right (Figure 6) leg did not change significantly in response to either training regimen. Moreover, we did not observe significant differences in body balance response to endurance and endurance/resistance training.

The fact that participation in both training programs was reflected by marked reduction in body fatness (F = 25.90, $p = 0.001$, $\eta^2 = 0.48$) and BMI (F = 33.12, $p = 0.001$, $\eta^2 = 0.55$) should be considered positive, as baseline analysis of body composition revealed high values of this parameter in the studied women. However, the results of the training in groups E and M proved equally positive (Figure 7 and 8).

Table 2. Changes in back pain after different kinds of training

Group	Pre		Post			
	Pain	Lack of pain	Pain	Lack of pain	Chi^2	p
Group E ($N = 15$)	100% ($N = 15$)	0% ($N = 0$)	66.7% ($N = 10$)	33.3% ($N = 5$)	19.1	$p < 0.05$
Group M ($N = 15$)	100% ($N = 15$)	0% ($N = 0$)	73.3% ($N = 11$)	26.7% ($N = 4$)	22.03	$p < 0.05$
Total	100% ($N = 30$)	0% ($N = 0$)	70.0% ($N = 21$)	30.0% ($N = 9$)		
p	$p > 0.05$	$p > 0.05$	$p > 0.05$	$p > 0.05$		

Main effect: F=3.88, p=0.058, η^2=0.12
Interaction effect: F=0.45, p=0.503, η^2=0.02
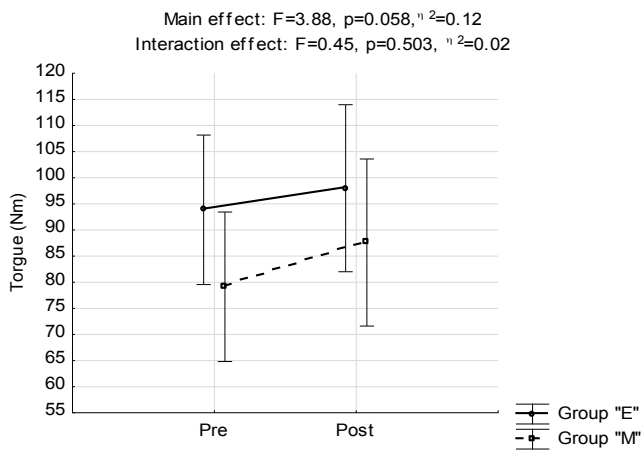
Figure 1. Changes in the muscle strength of the left knee extensors among women from "E" and "M" groups

Main effect: F=0.79, p=0.379, η^2=0.02
Interaction efect: F=0.04, p=0.837, η^2=0.01
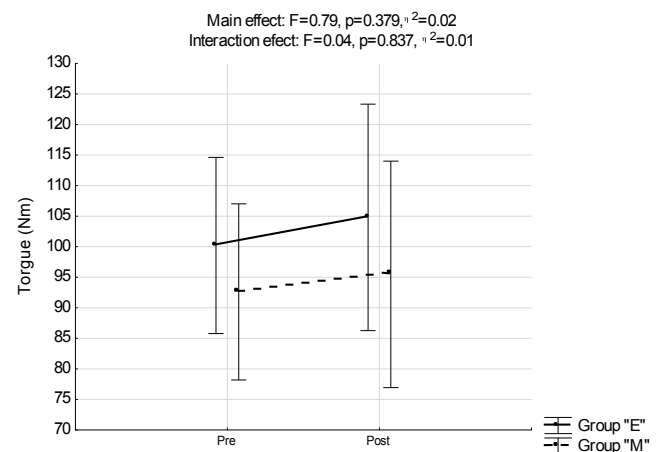
Figure 2. Changes in the muscle strength of the right knee extensors among women from "E" and "M" groups

Main effect: F=23.30, p=0.001, η^2=0.45
Interaction effect: F=0.01, p=0.917, η^2=0.01
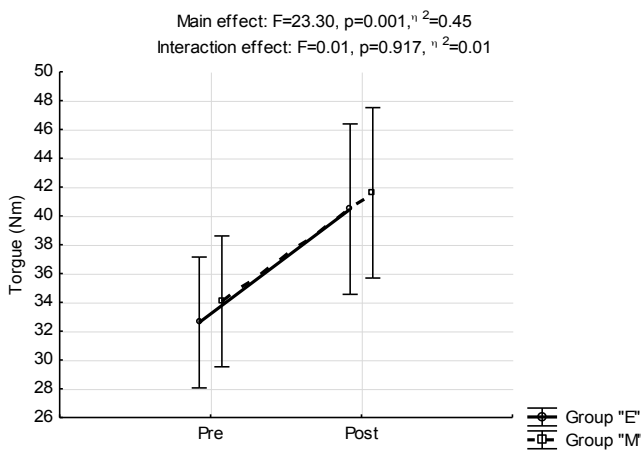
Figure 3. Changes in the muscle strength of the left knee flexors among women from "E" and "M" groups

Main effect: F=18.48, p=0.001, η^2=0.39
Interaction effect: F=2.54, p=0.12, η^2=0.08
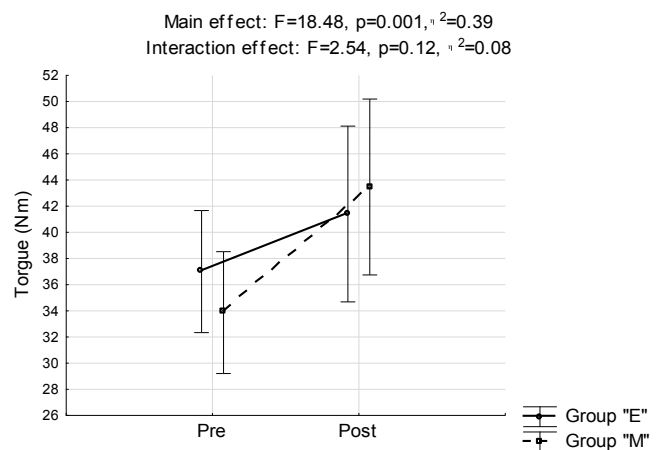
Figure 4. Changes in the muscle strength of the right knee flexors among women from "E" and "M" groups

Main effect: F=0.02, p=0.889, η^2=0.01
Interaction effect: F=0.22 p=0.636, η^2=0.01
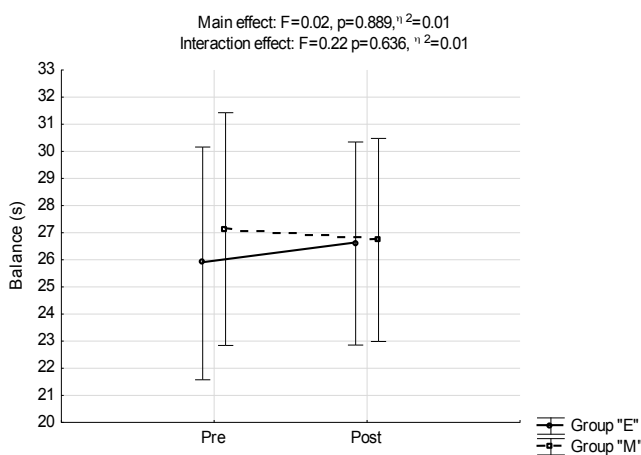
Figure 5. Changes in the body balance on left leg among women from "E" and "M" groups

Main effect: F=0.36, p=0.548, η^2=0.01
Interaction effect: F=0.53, p=0.468, η^2=0.02
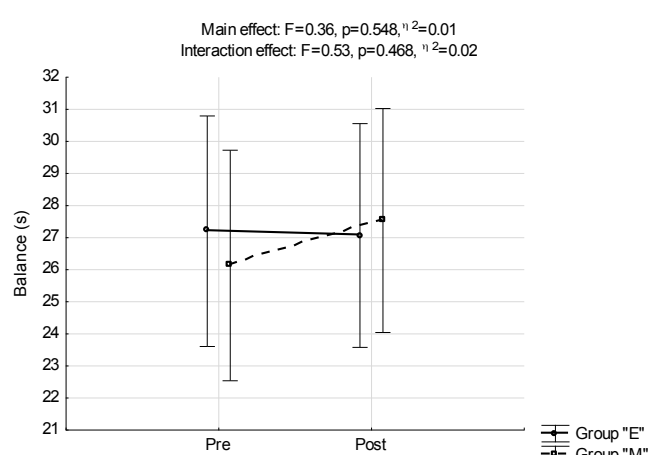
Figure 6. Changes in the body balance on right leg among women from "E" and "M" groups

Figure 7. Changes in the body fatness among women
from "E" and "M" groups
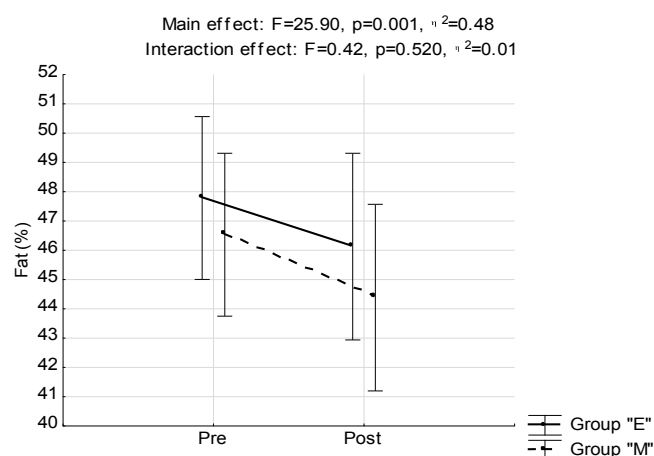

Figure 8. Changes in BMI among women
from "E" and "M" groups

Additional information was obtained by the use of multiple regression analysis. Because of the multifactorial determinants of back pain, attempts to introduce all measured variables to the regression equation were being undertaken. The most optimal model built to measure changes in back pain includes 9 variables, but only changes in these variables "the body balance on left leg before training", "pain on the left side before training", "BMI before training", "changing in strength of the right knee flexor after training" are, though rather small, statistically significant (Table 3). Correlation of changes in the dependent variable (pain) with the observed independent variables is small, on the verge of statistical significance ($R = 0.842$, $F = 2.98$, $R^2 = 0.709$, $p = 0.045$).

Discussion

Our findings raise hopes for better functioning of obese women with concomitant back pain. Although we expected significant differences between the effec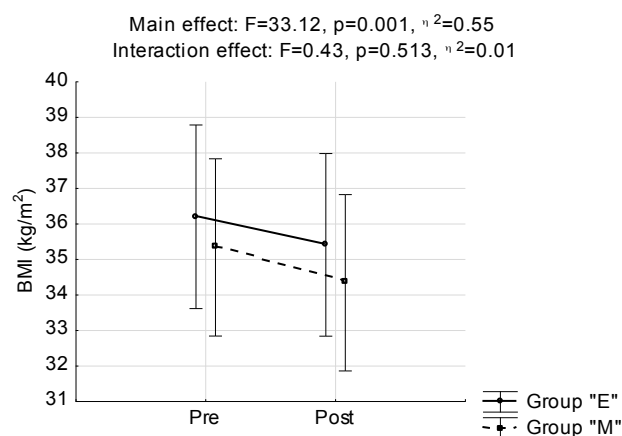ts of both training regimens on subjectively assessed back pain in women from groups E and M, marked improvement documented in most participants from both groups should be considered as a highly positive finding. We did not confirm the hypothesis that endurance training combined with resistance exercise exerts more favorable effects on functional fitness and reduction in back pain than purely endurance training. Nevertheless, women from groups E and M obtained higher well-being scores, better fitness and lower body fatness. It should be regarded as a positive determinant of their health [24]. As shown by Brown et al. [25], each reduction of body weight is associated with lower risk of headaches, back pain, difficulty in sleeping, as well as with higher scores in physical functioning and general health. On the other hand, high values of body mass index and prevalence of emotional problems may predispose women to both acute and chronic low back pain [26], and participation in physical exercise exerts positive effect in terms of stress reduction. The role of physical activity in mitigating back pain risk is shown to be considerable in the overweight and obese populations [27, 28].

Table 3. Most appropriate multiple regression model for the disappearance of back pain (Δ) among all women trainees.
Takes into account all the variables studied

Source	B	SEB	p
Constants	0.85	1.21	0.498
Body balance on left leg before training	0.02	0.01	0.011
Changing after training of the right knee extensor strength	0.01	0.01	0.134
Left knee extensor strength before training	0.01	0.01	0.409
Pain on the left side before training	0.75	0.28	0.023
BMI before training	0.16	0.06	0.019
Fat% before training	0.09	0.05	0.107
Changing after training of the right knee flexor strength	0.03	0.01	0.021
Right knee extensor strength before training	0.01	0.01	0.080
Changing after training of the left knee flexor strength before training	0.01	0.01	0.153
$R = 0.842$, $F = 2.98$, $R^2 = 0.709$ $p = 0.045$			

BMI – body mass index, SEB – standard error of coefficient, B – Beta coefficient

Therefore, the fact that 33.3% of overweight women from group E and 26.7% from group M declared the back pain had disappeared should be considered a positive effect of both types of training. However, the participation in the exercise programs might not have been the only factor that induced such positive changes among obese women. The increase of muscle strength in exercising women constitutes potential biological rationale for such interpretation. The changes were especially pronounced in the case of relatively weaker muscle groups, i.e. the knee flexors (F = 14.34, p = 0.001, η^2 = 0.26 for the left, and F = 11.78, p = 0.001 for the right leg). This is a very positive effect of the training since the imbalance between flexor and extensor strength can lead to improper muscle tonus, incorrect positioning of the lower limbs, and consequently pelvis and spine [29, 30]. Therefore, increased strength of these weaker muscles should be considered positive as it can be reflected by lower intensity of back pain. Dystonia muscle strength and concomitant disorders of balance can additionally predispose to decreased levels of everyday physical activity in obese individuals and be associated with back pain. Although we did not observe direct improvement of static balance, this aspect of functional fitness should be included in future experiments.

Taking into account the improvement of the frame of mind among obese women with back pain, we assumed that the proposed programs of training should enhance a reduction in body weight. The findings of Shiri et al. indicate that both obesity and a low level of physical activity are independent low back pain risk factors [31]. They suggest that a moderate level of physical activity is recommended for the prevention of low back pain, especially in obese individuals. Therefore, reduction in body fat was included among the endpoints of the present study. Although some researchers put into question the association between overweight, weight reduction, and back pain reduction. Garzillo and Garzillo [32] revealed a possible association between obesity and low back pain only in the upper quintile of obesity, and Brooks et al. [33] confirmed no evidence of a temporal relationship between changes in weight and low back pain. Nevertheless, our findings suggest that reduction in body weight is associated with decreased prevalence of back pain. Also Heuch et al. [9] observed a significant positive association between BMI and low back pain risk. Weight reduction is associated with decrease in low back pain [24]. The loss of every kilogram of body weight translates into lower load on the lower limbs and spine. This in turn facilitates maintaining correct posture during various activities of daily living.

Conclusions

It is to conclude that both endurance training and combined endurance/resistance training exert a positive effect leading to decreased back pain and improved functional fitness of obese women. Therefore, both forms of training may be recommended for individuals affected by the abovementioned problems.

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