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Original article

Effect of the Whole-Body Vibration *versus* Treadmill Training on Liver Function in Obese Adults

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There is a lack of awareness of the efficacy of whole-body vibration and treadmill training on liver function in obese adults in Libya. The study aimed to show the difference in the whole-body vibration and treadmill training on liver function in obese adults. Forty obese adults of both genders (21 women and 19 men) were enrolled in this study; they were recruited from the relatives of the patients in Libya. Their age ranged from 35 - 45 years with body mass index (BMI) between 30-34.9 kg/m2 (Class I obesity), the waist/hip ratio less than one, and they were assigned randomly into two equal-sized groups of equal number (A and B). Group (A) includes 20 obese adults who received diet advices (to prevent increasing weight) and treadmill training while group (B) received includes 20 obese adults who received the same diet advices of group (A) and whole-body vibration exercises (vibration frequency was set to 30 Hz then increased gradually to 35 Hz, then the subject took about 20 minutes to fulfill a training session). The participating subjects in this study were assessed by liver enzyme tests and anthropometric measurements. They were evaluated before and after the treatment program, about three sessions per week for eight weeks. The obtained results revealed significant differences in all measured variables before and after treatment in the two groups. Statistically significant difference was also found in post-treatment values of all measured variables when compared between the two groups in favor of group (A). Treadmill training and whole-body vibration exercise can be added to the physical therapy program.

Introduction

Overweight and obesity are defined as abnormal or excessive fat accumulation. In adults, the World Health Organization (WHO) defines obesity as a Body Mass Index (BMI) greater than or equal to 30 kg/m2, and for children aged between 5-19 years, obesity is considered two standard deviations above the WHO Growth Reference median (1). Approximately 340 million children and adolescents worldwide were classified as overweight or obese in 2016, and the prevalence is dramatically increasing (2). Obesity has also been associated with a spectrum of cancer types (colon, breast, endometrium, kidney, esophagus, stomach, pancreas, gallbladder, and liver function diseases) and, together with insulin resistance, represents a risk factor for developing hepatocellular carcinoma (2,3).

Whole body vibration (WBV) is a novel exercise modality that has previously been shown to improve muscle strength and mass via a mechanical stimulus generated by a vibrating platform, stimulating muscle spindle activity and, consequently, increasing muscle mass and strength (4). Improvements in muscle strength have been observed in young overweight/obese women after WBV training (WBVT) 3 times a week for 6 weeks, as well as 2 times a week for 10 weeks (5). The WBV is a training modality, has emerged as a useful exercise method for improving overall health. Previous studies have reported that WBVT alone improves body composition, muscular strength, and cardiovascular health concurrently. Also, WBVT is suitable for special populations such as the elderly and diseased populations who cannot perform traditional resistance or aerobic exercise training (6).

Physical exercise is an effective method to promote health. Recently, an increased prevalence of obesity has been reported. Several undesirable health consequences are linked to that augmented adiposity, making obesity a major health risk. Regular physical exercise and diet control are the main factors that help to reduce weight and improve lipid metabolism (7). Treadmill training relies primarily on skeletal muscles' utilization of oxygen through aerobic respiration to produce energy, in the form of adenosine tri-phosphate or Adenosine triphosphate (ATP) (8). Treadmill training causes strengthening of the heart and improves circulation, lowers blood pressure, and helps to control blood sugar and weight (9). The study aimed to assess the difference in the whole-body vibration and treadmill training on liver function in obese adults.

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Methods

Study design and participants:

Forty obese adults were enrolled in this study; their age ranged from 35 - 45 years and were recruited from the relatives of the patients in Libya. The study design was a comparative study, and the time length of this study was from November 2023 to March 2024. The participating subjects in this study were assessed by liver enzyme tests and anthropometric measurements, and were evaluated before and after the treatment program, about three sessions per week for eight weeks.

Eligibility criteria

The participating subjects were enrolled based on the following inclusion and exclusion criteria: Forty obese adults aged between 35-45 years, and all participants would be clinically and medically stable, and the BMI of all participants was more than 30- 34.9 kg/m^2 (Class I obesity). While we excluded patients with recent myocardial infarction, complex ventricular arrhythmia or heart block, cerebro-vascular disease, visual and/or auditory defects, significant tightness and/or fixed deformity of lower limbs, neurological disorders that affect balance or mentality (e.g., epilepsy), congenital or acquired lower limb deformities in the lower limbs, and cardiopulmonary dysfunction.

Evaluations

The tests used to check liver enzymes in obesity are [Alanine transaminase (ALT) (SGPT) and Aspartate aminotransferase (AST) (SGOT) (u/l)] (10). The body anthropometric measurements include [Waist circumference (cm), Hip circumference (cm), and Waist/hip ratio] (11).

B) Treatment:

Raatz et al., (12), stated that diet advice would be instructed to prevent any methods that may increase liver enzymes or total body weight, and follow up with those adults weekly by phone. The advice includes: 1) Eat a variety of vegetables. 2) Eat a variety of fresh fruits. 3) Include whole grains. 4) Eat a variety of protein foods. 5) Choose low-fat dairy products. 6) Drink a lot of water.

Also, it was other foods would be limited, including: 1) Vegetables with added fat. 2) Fruit with added sugar. 3) Carbohydrates are high in fat and sugar. 4) Protein foods with added fat. 5) High-fat protein foods. 6) High-fat dairy products. 7) Unhealthy fats.

Forty obese adults who met the previous criteria would be randomly assigned into two equal-sized groups of equal number (A and B) according to the following:

Group (A)

This group includes 20 obese adults who received diet advice and treadmill training in the form of treadmill training about 3 times per week for 8 weeks with an intensity of 1.5 Kilometers/hour (13). The subject completed treadmill training under three conditions in 1-minute training cycles. For 15s of each minute, the subject could hold on to the railings with both hands, for the next 15s with one hand, and finally with no hands on the handrails for 30 s. Each subject repeated this procedure for 30 min (14).

Group (B)

This group includes 20 obese adults who received the same diet advice as group (A) and whole-body vibration exercises about 3 times per week for 8 weeks (13). The total body vibration exercise session is about 30 minutes; it started with an initial 5-minute warming-up phase, and then subjects exercised on a horizontal swinging platform with an amplitude of 2 mm (Viberogym professional). Vibration frequency was set to 30 Hz, then increased gradually to 35 Hz, then the subject took about 20 minutes to fulfill a training session, and the vibration frequency was decreased gradually from 35 Hz to 30 Hz as a cooling down at the ending 5 minutes at the end of the training session. During the vibration session, the subjects were barefoot to eliminate any damping of the vibration caused by footwear. They were positioned on the platform with their knee slightly flexed, with their feet placed apart on the board. Subjects were encouraged to work isometrically against the swinging platform (15).

Statistical analysis

The gender distribution was determined using the Chi-square test. Means as well as standard deviations were utilized to display all of the study's data. The Shapiro-Wilk test was used to verify that the data followed a normal distribution. To examine whether or not there was homogeneity in the variances between groups, Levene's test was carried out. Unpaired t-tests were used to compare study variables among groups, while paired t-tests were used to examine study variables before and after treatment within each group. In this

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study, a p-value of less than 0.05 is considered significant. All statistical analysis was carried out using the statistical package for social studies (SPSS) version 22 for Windows (IBM SPSS, Chicago, IL, USA).

Results

Demographic data of the subjects in groups (A and B)

There were no substantial differences among groups (A and B) in mean age, height, weight, and BMI ($p > 0.05$) (Table 1).

Table 1. Mean values of age, height, weight, and BMI of groups (A and B).

Variable	Groups	$\bar{X} \pm$ SD	t-value	p-value
Age (years)	Group (A)	37.01 ± 3.11	0.32	0.719 NS
	Group (B)	38.4 ± 3.38		
Height (m)	Group (A)	1.72 ± 0.02	1.24	0.326 NS
	Group (B)	1.69 ± 0.04		
Weight (km)	Group (A)	83.6 ± 3.85	0.67	0.512 NS
	Group (B)	84.42 ± 4.49		
BMI (kg/m²)	Group (A)	33.32 ± 1.26	0.31	0.728 NS
	Group (B)	34.27 ± 1.38		

$\bar{X}$: Mean. SD: Standard Deviation. t-value: Paired and Unpaired t-test value. p-value: Probability value. S: Significant.

Gender distribution

There were no substantial differences between groups (A and B) ($p > 0.05$) (Table 3).

Table 3. Comparison of gender distribution between the two groups (A and B)

Gender distribution	Gender distribution N (%)		X^2	p-value	Level of significance
	Group (A)	Group (B)			
Women	11 (55%)	10 (50%)	0.1	0.75	NS
Men	9 (45%)	10 (50%)			

$\bar{X}$: Mean. SD: Standard Deviation. X^2: Chi-squared value.
p-value: Probability value. NS: Non-Significant.

Measured variables

Before treatment, among groups (A and B):

Comparison between the pre-treatment $\bar{X}$ ± SD values, non-substantial differences of all measurable variables were revealed among the 2 groups ($p > 0.05$) (Table 4).

Before and after treatment for groups (A and B):

Comparison between the before and after treatment $\bar{X}$ ± SD values, substantial differences of all measurable variables were revealed among the 2 groups ($p < 0.05$) (Table 4).

After treatment, comparison between groups (A and B):

Comparison between the after-treatment $\bar{X}$ ± SD values, substantial differences of all measurable variables were revealed among the 2 groups ($p < 0.05$) (Table 4).

Table 4. Liver enzyme tests and anthropometric measurements for the 2 groups (A and B)

Liver enzyme tests		Group (A) $\bar{X}$ ± SD	Group (B) $\bar{X}$ ± SD	p-value
Alanine transaminase (ALT) (SGPT) (u/l)	Before treatment	57.9 ± 4.44	57.85 ± 4.9	0.973^{NS}
	After treatment	31.01 ± 4.37	35.55 ± 3.93	0.001^{S}
	p-value	0.0001^{S}	0.0001^{S}	

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Aspartate aminotransferase (AST) (SGOT) (u/l)	Before treatment	175.4 ± 6.04	174.4 ± 8.53	0.671[NS]
	After treatment	120.45 ± 4.35	124.8 ± 6.14	0.014[S]
	p-value	0.0001[S]	0.0001[S]	
Waist circumference (cm)	Before treatment	98.2 ± 3.27	99.4 ± 3.57	0.275[NS]
	After treatment	86.35 ± 3.15	92.4 ± 4.64	0.0001[S]
	p-value	0.0001[S]	0.0001[S]	
Hip circumference (cm)	Before treatment	112.45 ± 3.35	114.01 ± 3.26	0.146[NS]
	After treatment	105.01 ± 3.08	107.5 ± 3.64	0.025[S]
	p-value	0.0001S	0.0001S	
Waist/hip ratio	Before treatment	0.87 ± 0.01	0.86 ± 0.01	0. 677[NS]
	After treatment	0.82 ± 0.02	0.85 ± 0.2	0.0001[S]
	p-value	0.0001[S]	0.001[S]	

$\overline{X}$: Mean. SD: Standard Deviation. t-value: Paired and Unpaired t-test value.
p-value: Probability value. NS: Non-Significant. S: Significant.

Discussion

Regular exercise, along with physical activity and diet, is well documented as the most effective intervention for the preventive and therapeutic treatment of chronic and adult diseases (16). Exercise exerts different effects depending on not only individual characteristics such as age, gender, and disease, but also exercise characteristics such as frequency, intensity, type, and time (17). However, exercise is an intervention without side effects and cost burden for chronic diseases, and the effects of exercise are mainly positive (18).

When comparing between the pre- and post- treatment results of group (A) revealed a significant difference that comes in agreement with Hallsworth et al., (19) who stated that treadmill training exercise has been shown to increase intramyocellular triacylglycerol synthesis, while decreasing the accumulation of fatty acid metabolites and suppressing the proinflammatory state associated with insulin resistance. Subjects with a BMI ≥ 25 kg/m^2, treadmill training is more efficient in reducing body weight, waist circumference, and fat mass as well as in increasing $VO_{2\,max}$ uptake when compared to resistance training, respectively (20).

The results of group (A) are accepted with Angulo (21), who stated that a reduction of 5% or more of original weight by diet control and regular exercise for 3 months was associated with improvement in total cholesterol and ALT levels. He also reported that calorie restriction and regular aerobic exercise for 30 minutes a day for 3 months resulted in normalization of liver biochemistry (ALT and AST) in patients with nonalcoholic steatohepatitis. Also, a 1% reduction in body weight can improve ALT by 8.1 %. Also, Wong et al., (22) found that weight reduction in obese patients of 10% from the baseline weight has been shown to reduce ALT levels and hepatomegaly. However, weight loss should be gradual, as losing more than 1.6 kg per week has been shown to potentially worsen steatohepatitis and result in gallstones. Weight loss may be achieved through an exercise and diet program; treadmill training exercise improves insulin resistance independent of weight loss, while calorie-restricted diets reduce weight, and diets low in saturated fat and high in fiber reduce insulin resistance.

The results of the present study in group (A) are confirmed with Croniger (23), who stated that liver markers are an effective way to assess the accumulation of fat in the liver, and by far the most commonly used of these methods. ALT values correlate positively with liver fat proportions. ALT appears to have associations with both hepatic insulin resistance and later decline in hepatic insulin sensitivity.

When comparing between the pre- and post- treatment results of group (B) revealed a significant difference that comes in agreement with Liu et al., (24) who demonstrated that the hepatic effects of WBV were correlated with reductions in sterol regulatory element binding protein 1c (SREBP1c), a transcription factor that regulates genes involved in cholesterol metabolism. Although the effects of WBV on glycemic control and hepatic lipids might be mediated by a shared mechanism, this possibility remains speculative and will require targeted manipulation of SREBP1c and other pathways associated with WBV effects on the liver (25). The WBV can positively affect body composition by reducing body fat accumulation and serum leptin (5). It was reported that WBV combined with endurance training could significantly increase resting energy expenditure for the improvement of body composition (26). Vibration exercise has attracted a lot of attention as an exercise modality, which elevates metabolic rate and activates muscular adaptation that could be a

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potential method for weight reduction (27). The physical performance regarding vibration exercise was focused on neuromuscular functions or strength evaluation (28).
The results of the present study on group (B) are accepted with Oh et al., (29) who stated that WBV improve systemic glucose, fatty acid metabolism, and adipokines to cause adipose tissues in the liver to contribute to hepatic steatosis producing energy to, in turn, reduce ectopic fat deposition in the liver. WBV also alleviates hepatic stiffness and inflammatory effects when applied in the study on hepatic steatosis and its underlying pathophysiology in 25 patients with NAFLD. Seventeen patients with NAFLD were designated as a control group. After WBV exercise, body weight in the study group decreased by only 2.5% compared with the control group.
The results of group (B) agree with Oh et al., (30), who evaluated WBV results in obese patients with non-alcoholic fatty liver disease by analyzing physical condition, liver and metabolic function, liver fat content, skeletal muscle, and quality of life in relation to health. The results found were that WBV reduced body adiposity, showing a significant reduction in liver fat and lipid content, and on the occurrence of abnormalities were observed in the results of liver function tests. Also, WBV combined with a hypocaloric diet improved body composition, insulin resistance, glucose regulation, and adiponectin levels to a greater extent compared with dieting alone (31). When comparing the post-treatment means values between groups (A and B), the results are significant in the form of group (A), that are confirmed by Bhat et al., (32), who found that lifestyle modification adapted by previously sedentary patients resulted in improvement in ALT levels after 3 months. There was a significant correlation between the decline of ALT and improvement of insulin resistance, which shows the causal relation of insulin resistance in NAFLD. This proves that exercise improves insulin sensitivity, resulting in a decline in ALT levels. Also, the significant results of our study in the form of group (A) agree with Udristioiu and Cojocaru, (33), who proved that when compared between aerobic training and resistance training groups and found that aerobic training decreases both body weight and fat mass significantly more than does resistance training. While the two modes of exercise produced statistically similar changes in body fat percentage, these changes were driven by different mechanisms, where resistance training increased lean body mass and aerobic training decreased fat mass. In the present study, the null hypothesis was rejected, which stated that there would be no effectiveness of the whole-body vibration and treadmill training on liver function in obese adults.

Conclusion
It was concluded that treadmill training and whole-body vibration exercise can be added to the physical therapy program, and treadmill training was more effective than whole-body vibration in enhancing liver function in obese adults.

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Informed consent
Informed consent has been obtained from all individuals included in this study.

Disclosure statement
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Conflict of interest
The authors state no conflict of interest.

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