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The Effects of Eight Weeks of Rhythmic Exercises with Music on IGFBP-3 Levels, Insulin Resistance Index and Quality of Life in Women with Different Body Mass Indices

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ABSTRACT

Introduction: Inactivity and passive lifestyle have led to an increase in mortality and the incidence of chronic diseases such as hypertension, type 2 diabetes and obesity. The aim of this study was to investigate the effects of eight weeks of rhythmic exercises with music on IGFBP-3, insulin resistance index and quality of life in women with different body mass indices.

Methods: In this quasi-experimental study, 33 sedentary women were randomly divided into three groups: exercise + normal (body mass index [BMI] 20 to 24.9 kg/m^2) (n= 11), exercise + overweight (BMI 25 to 29.9 kg/m^2) (n=11), and exercise + obese (BMI 30 to 34.9 kg/m^2) (n=11). The rhythmic exercise program consisted of 8 weeks, three sessions per week and each session was performed for 45 to 60 minutes with an intensity equal to 60 to 70% HRmax. The paired t-test and one-way ANOVA with repeated measures were used to compare changes within and between groups.

Results: The results showed that the time interaction in the groups in terms of IGFBP-3, insulin, glucose, insulin resistance and quality of life was not statistically significant. The results of the comparison of within-group means showed that in the normal body mass index group, the overweight and obese groups, IGFBP-3 levels, quality of life have significantly increased. In the overweight and obese body mass index groups, serum insulin levels, glucose, and insulin resistance index significantly decreased.

Conclusion(s): Rhythmic exercise increased IGFBP-3 concentration and decreased fasting glucose, fasting insulin, insulin resistance index in all three groups.

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Introduction

Obesity and its prevalence as a global epidemic continue to rise in many developed and developing countries [1]. Study results indicating that obesity becomes more prevalent with age. This relationship between obesity and age can be partially attributed to a decrease in physical activity in both men and women as they grow older [2]. On the other hand, reduced metabolism aging process, especially in women after menopause, is another factor [3]. It appears that insulin levels, insulin-like growth factor binding protein-3 (IGFBP-3), and insulin-like growth factor-1 (IGF-1) are significant factors in fat metabolism, protein synthesis, and muscle hypertrophy. These factors may contribute to weight loss and muscle mass gain in obese individuals [4]. Levels of IGFBP-3 are regulated by various factors, including cytokines involved in insulin resistance, such as TNF-α. Studies have shown that overexpression of IGFBP-3 in transgenic mice leads to insulin resistance and impaired glucose tolerance. These findings support the role of IGFBP-3 in the pathogenesis of obesity and insulin resistance[5].

Furthermore, obesity and overweight can have a negative impact on quality of life. Regular physical activity and exercise, on the other hand, have been shown to improve psychological and mental health boost self-esteem, and increase overall life satisfaction [6]. Additionally, engaging in moderate-intensity physical activity has been shown to have positive effects on mental health and quality of life in women [7]. Recent meta-analytical studies provide support for the significant improvements in symptoms of anxiety and depression, reductions in fatigue, and enhancements in quality of life among both

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healthy individuals and those with chronic diseases who participate in physical activity [8]. Among the methods to combat obesity and overweight, engaging in physical activity and adopting appropriate dietary regimens are important. Promoting various forms of physical exercise and healthy nutrition is crucial for raising awareness about fitness in society. The Rhythmic exercises are a popular exercise model that improves all aspects of fitness and cardiovascular performance, increases balance and flexibility, and combines of aerobic, interval, and strength training. This combination accelerates calorie expenditure and improves cardiovascular system performance [9]. Research indicates that rhythmic exercises are a cost-effective and sustainable form of planned physical activity for enhancing both health and aesthetic appearance [10]. Furthermore, rhythmic exercises have been shown to positively impact changes in body composition [11], as well as improvements in health-related quality of life [12] and emotional well-being.

In summary, Research on the effects of rhythmic exercises accompanied by music on IGFBP-3 levels, insulin resistance index, and quality of life in women with different body mass indices is limited, despite the high prevalence of overweight and obesity in the female population. There is a need for studies focusing on early diagnosis and treatment of obesity-related diseases to prevent undesirable consequences. Additionally, the importance of exercise in improving IGFBP-3, insulin resistance index, and quality of life in women with varying body mass indices has not been thoroughly explored. Therefore, the purpose of this research is to answer the question of how participating in rhythmic exercises with music affects the levels of IGFBP-3, insulin resistance indices and quality of life in women with different body mass profiles (normal, overweight, and obese).

Methods

Study Design and Participants

The current study is of an applied nature and utilizeda semi-experimental pre-post test design with three comparison groups. The statistical population for this research comprised inactive women with varying body mass indices, including obese, overweight, and normal weight. These classifications for BMI are in use by the NIH and the World Health Organization (WHO) for white, Hispanic, and black individuals. The BMI number and classifications are listed below. Severely underweight - BMI less than 16.5kg/m^2, Underweight - BMI under 18.5 kg/m^2, Normal weight - BMI greater than or equal to 18.5 to 24.9 kg/m^2, Overweight – BMI greater than or equal to 25 to 29.9 kg/m^2, Obesity – BMI greater than or equal to 30 kg/m^2, Obesity class I – BMI 30 to 34.9 kg/m^2, Obesity class II – BMI 35 to 39.9 kg/m^2, Obesity class III – BMI greater than or equal to 40 kg/m^2 (also referred to as severe, extreme, or massive obesity). Thirty-three inactive women between the ages of 34 and 40 were randomly divided into three equal groups: exercise + normal body mass index (20 to 24.9 kg/m^2) (n= 11), exercise + overweight body mass index (25 to 29.9 kg/m^2) (n=11), and exercise + obese body mass index (30 to 34.9 kg/m^2) (n=11). The participants were randomly selected for this research. The characteristics of the samples, including mean age, height, weight, and body mass index, are presented in Table 1.

In the initial phase, participants were provided with a briefing on the collaboration process, potential benefits, and risks of participating in the study. It was emphasized that they could withdraw from the study at any stage if they did not wish to continue. Additionally, all collected information was treated as confidential, and the researchers only published general and group results without including any names or identifying information. The inclusion criteria for the study involved being inactive (engaging in less than 120 minutes of moderate to vigorous physical activity per week), being in good health (not taking any medication or any medication causing water retention), having a body mass index between 20 and 34.9 kg/m^2, not being an athlete, and not regularly participating in physical activity in the six months before the exercise program.

Table 1. The characteristics of the samples taken from the pre-test results

Variable	Age (years)	Height (cm)	Weight (kg)	Body mass index (kg/m2)
Normal body mass index	36.27 ± 6.13	161.54 ± 7.52	60.22 ± 5.47	23.08 ± 1.11
Overweight body mass index	34.18 ± 6.64	161.04 ± 4.99	71.08 ± 4.89	27.29 ± 1.40
Obese body mass index	35.27 ± 5.12	159.09 ± 5.35	82.11 ± 6.60	32.48 ± 1.76

Table 2. Comparison of within and between group mean changes in serum IGFBP-3levels and glycemic markers in women with different BMI

Variables	Groups	Stages			Within and between group mean changes			
		Pre-test M±SD*	8th Week M±SD*	Percentage of changes	P-Value**	Time P-Value	Group P-Value	Time × Group P-Value
IGFBP-3 (mg/ml)	Normal	3.36±0.79	4.33±0.97	22.40	0.001	0.001	0.095	0.602
	Overweight	4.04±0.73	4.46±0.97	15.12	0.001			
	Obese	4.12±0.72	5.05±0.91	18.41	0.001			
Glucose (mmol/L)	Normal	5.42±0.24	5.24±0.36	-3.43	0.081	0.001	0.053	0.60
	Overweight	5.32±0.33	4.98±0.40	-6.82	0.001			
	Obese	5.55±0.21	4.73±0.44	-17.33	0.001			
Insulin (Microunit/L)	Normal	90.36±4.12	87.45±6.05	-3.32	0.09	0.001	0.051	0.601
	Overweight	88.54±5.20	82.54±5.61	-7.26	0.001			
	Obese	95.00±2.79	86.45±7.11	-9.89	0.001			
HOMA-IR	Normal	21.81±1.96	20.48±2.97	-6.49	0.101	0.002	0.048	0.678
	Overweight	21.07±2.61	18.38±2.72	-14.63	0.001			
	Obese	23.45±1.30	18.21±2.37	-28.77	0.001			
Quality of Life	Normal	30.81±4.46	37.27±5.17	17.35	0.001	0.001	0.868	0.559
	Overweight	31.81±5.68	37.90±2.87	16.06	0.001			
	Obese	30.09±5.48	38.27±2.57	22.55	0.001			

† A significant level P<0.05 *Data presented as mean ± standard deviation ** P- Value within group

The exclusion criteria included non-participation in two exercise sessions, having a history of or currently having metabolic diseases such as cardiovascular, renal, hepatic, cancer, stroke, or musculoskeletal diseases, having neuromuscular disability that prevents performing exercise, a history of smoking, and being pregnant. The participants voluntarily took part in the research based on the research conditions and signed an informed consent form. It is important to note that the principles of the Helsinki Declaration and the opinions of the research ethics committee were followed throughout the research. Additionally, the experimental stages were approved by the research ethics committee of Hakim Sabzevari University with the code IR.HSU.REC.1402.021. All exercise sessions were supervised by anexercise physiology specialist.

At the beginning and after the eight-week intervention, the participants were evaluated. Body weight (kg) and height (cm) were measured using a digital scale and a stadiometer, respectively. The body mass index was calculated by dividing the weight (kg) by the square of the height (m) using the formula 1.

Formula 1: Body Mass Index (kg/m^2) = Weight (kg) / Height (m)^2

Quality of life refers to how an individual percelives their health and satisfaction with their overall well-being. The World Health Organization Quality of Life 36-item questionnaire (WHOQOL-BREF) is a tool used to measure an individual's general quality of life. This questionnaire consists of four subscales and an overall score. These subscales assess physical health, psychological health, social relationships, and general health, with 7, 6, 3, and 8 questions respectively. Participants rate their statususing a 5-point Likert scale.

The beginning (24 hours before the first training session) and the end of the eight weeks (48 hours after the last training session). The participants were required to fast for 10-12 hours before each blood sample collection. Additionally, they were instructed to refrain from engaging in intense physical activity or taking any medication for 24 hours before the test. The collected samples were placed into tubes containing K2EDTA and left undisturbed for 15 minutes before analysis.

The serum was separated by centrifugation at 3000 RPM for 10 minutes and then stored at -80°C until measurement. Serum IGFBP-3 levels were measured using the ELISA method and a commercial kit from Casabayo company made in Japan. The kit had a sensitivity of 0.06 ng/mL. Blood glucose was estimated using the Pars Azmoon kit (from Iran) wihich utilized an enzymatic method. The kit's sensitivity was less than 2 mg/dL and the intra-assay coefficient of variation was less than 1.82%. Insulin levels were measured using the ELISA method and the Saman Tejharat Noor kit (CAT: K2B158, Tehran, Iran). The HOMA-IR index was calculated using the equation HOMA-IR = [glucose (mmol/L) × insulin (μU/mL)]/22.5 [13].

The exercise program lasted for a total of eight weeks, with three sessions (lasted for a total of eight weeks, with three sessions per week scheduled each week, resulting in a total of 24 sessions. All participants completed their training sessions simultaneously. Each rhythmic training session had a duration of 45 to 60 minutes and consisted of awarm-up, main exercise, cool-down, and stretching. The warm-up phase lasted for 8 to 10 minutes and involved gradual movements accompanied by rhythmic music. The main exercise session was performed at an intensity of 60 to 70% the maximum heart rate. The duration of the exercise varied throughout the program: 5 minutes in the first and second week, 6 minutes in the third and fourth week, 7 minutes in the fifth and sixth week, and finally 8 minutes in the seventh and eighth week. Two-minute rest intervals were provided between sets. The cool-down phase, which was the final part of the exercise, lasted for 5 to 10 minutes Participants engaged in light exercises while listening to relaxing music in order to gradually decrease their heart rate and achieve mental and psychological relaxation. The exercise intensity was assessed using a Polar heart rate monitor [14].

Statistical Analysis

After the data was collected and entered into SPSS software version 26, the raw data was analyzed. The normality of the data was confirmed using the Shapiro-Wilk test,and the equality of variances between groups was assessed using Levene's test. Within-group mean comparisons (pre- and post-tests) were conducted using paired t-tests, while between-group mean comparisons were done using one-way ANOVA with repeated measures.Pairwise comparisons between groups were evaluated using Benferoni's post hoc tests. A significance level of $p < 0.05$ was used for decision-making.

Results

The concentration of IGFBP-3 decreased significantly in all three-body mass index (BMI) groups compared to the pre-test: normal from 3.36 to 4.33 mg/mL (P = 0.001), overweight from 4.04 to 4.46 mg/mL (P = 0.001), and obese from 4.12 to 5.05 mg/mL (P = 0.001). Fasting glucose levels also decreased significantly in the overweight BMI group from 5.32 to 4.98 mmol/L (P = 0.001), and in the obese BMI group from 5.55 to 4.73 mmol/L (P = 0.001). Additionally, fasting insulin levels decreased significantly from 88.54 to 82.54 IU/mL (P = 0.001) in the overweight BMI group and from 95.00 to 86.45 IU/mL (P = 0.001).

The insulin resistance index decreased significantly from 21.07 to 18.38 (P = 0.001) in the normal BMI group and from 23.45 to 18.21 (P = 0.001) in the obese BMI group, respectively. However, there was no significant difference between the three groups in terms of the mean levels of IGFB-3, glucose, insulin, insulin resistance index and quality of life. Paired t-test results showed that the quality of life increased significantly in all three groups: normal from 30.81 to 37.27 (P = 0.001), overweight from 31.81 to 37.90 (P = 0.001), and obese from 30.09 to 38.27 (P = 0.001).

Discussion

The presentis study aims to compare the effects of eight weeks of rhythmic exercises onIGFBP-3 levels, insulin resistance index, and quality of life in women with different BMI categories. The researchfindings indicate a significant increase in concentration of IGFBP-3 in all three BMI groups: normal weight, overweight, and obese. Moreover, the percentage change in IGFBP-3 was higher in the obese BMI group when compared to the other two groups.

The results are consistent with the findings of Nishida et al. (2010) [15]. but they contradict the findings of Azadi et al. (2022) [16]. In their study, Nishida et al. (2010) examined the impact ofsix weeks of low-intensity exercise, five days a week, on the levels of IGF-I, IGFBP-1, and IGFBP-3 in sedentary men. They observeda 20% improvement in insulin sensitivity and a 13% decrease in fasting insulin levels. Additionally, the low-intensity aerobic exercise reduced to a 9% decrease in circulating IGF-I levels and a 16% increase in IGFBP-1 levels [15]. On the other hand, Azadi et al. (2022) reported that continuous exercise, which included 30 to 50 minutes of sustained running at 50-70% of heart rate reserve and intense interval exercises, did not lead to significant changes in IGF-1 and IGFBP3 concentrations in young men.however, it did increase GH levels in both groups [16]. The ponse of the hypothalamic-pituitary-adrenal axis to stress and exercise stimuli has been well documented. Other pituitary hormones, particularly growth hormone (GH), may also respond to stress. Plasma GH levels are associated with IGF-1 and are bound to carrier proteins (IGFBP-1 to IGFBP-6) [17]. Therefore, the free plasma level of IGF-1 depends not only on GH production but also on its binding to carrier proteins, especially IGFBP-3, which has been shown to respond to exercise-induced changes. The IGF-1/IGFBP3 ratio is also an important factor in evaluating IGF-1 and IGFBP3 [18].

Previous studies have shown that physical exercise affects circulating IGF-1 and IGFBP3, and this effect may depend on the intensity and type of exercise. In most studies, exercise interventions have resulted in an increase in the secretion of IGF-1 and IGFBP3 [19, 20]. However, some reports argue that exercise interventions have either caused a decrease in IGF-1, IGFBP3, and the IGF-1/IGFBP3 ratio, or have had no effect on them [19, 21]. Activation of the GH/IGF-1 axis, which is a desirable hormonal response, leads to increased anabolic activities. In this study, by performing rhythmic exercises, individuals may have experienced a significant increase in total serum IGF-1. Physical activity stimulates GH secretion in the circulation, resulting in a temporary increase in tissue production of IGF-1[22]. Since IGFBPs have a higher affinity for binding to IGF-1, Structural and functional changes that occur after translation are more likely to affect the binding of IGF-1 to IGFBP-3. Overall, the proteolysis of IGFBP-3 is regulated at a significant level [23]. Furthermore, variousproteases, such as serine proteases and matrix metalloproteinases, have been identified as cleaving IGFBP-3 at specific sites.This can result in variations in size and potentiallybinding to IGFs [24]. According tothe findings of this study, fasting insulin and the insulin resistance index significantly decreased in overweight and obese BMI groups. However, the percentage of changes in glucose, insulin and insulin resistance levels in the obese BMI group was greater compared to theother groups.

The results are consistent with the studies conducted byHaldrup et al. (2023) and Weng et al. (2023) [25, 26]. However, they do not correspond to the findings of Fairey et al. (2003) [27]. Haldrup et al. (2023) reported that 10 weeks of exercise in obese women resulted in increased levels of IGF-1 and IGFBP-3. Additionally, they observed an improvement in insulin resistance at the conclusionof the exercise intervention [26]. Weng et al. (2023) determinedthat exercise and cold exposure independently reduced HOMA-IR levels in obese mice. Exercise reduced serum FFA, while cold exposure did not effect them [25]. In contrast, Fairey et al. (2003) found no significant differences in fasting insulin, glucose, and insulin resistance between the exercise and control groups. However, they did observe variations in IGF-1 and IGFBP-3 levels [27]. The main factor in increasing liver IGF-I production is growth hormone, which stimulates IGF-I synthesis and is further enhanced by insulin. Since fasting insulin levels decrease after exercise intervention, it may potentially contribute to reducing IGF-I levels [15]. The reduction in fasting insulin, glucose, and insulin resistance due to exercise is biologically acceptable. Exercise may reduce hepatic and muscular insulin resistance and promote glucose release through various mechanisms, including increased insulin receptor signaling, increased glucose transporter protein, and mRNA, increased glycogen synthase and hexokinase activity, reduced free fatty acid release, and increased free fatty acid clearance. Additionally, exercise can lead to an increased delivery of muscle glucose due to increased muscle capillary density and changes in muscle composition that favor increased glucose release [28].

The decreasein insulin resistance may lead to lower levels ofcirculating insulin [29]. Consequently, which may result in a reduction inthe biological availability of IGF-1, as insulin-mediates changes in IGFBP concentration. These effects may suggest significant biological mechanisms related to exercise. However, it is important to approach the interpretation of the results with caution due to the limitations of this studyThese limitations include diverse diets, varied adaptive responses to physical activity, a few participants due to dropouts, and individual differences.

Conclusion

In general, rhythmic exercises resulted in a significant increase in IGFBP-3 concentration for all the three BMI groups: normal weight, overweight, and obese. Additionally, fasting insulin levels and insulin resistance index showed a significant decrease in the overweight and obese groups. Considering the significance of physical activity in preventing and treating -diseases related to obesity, experts strongly recommend exercise counseling as a means to reduce occurrence of associated conditions.

Furthermore, incorporating exercise into one's routine leads to enhanced strength and greater social participation among obese women.

Declarations

Acknowledgment

We would like to thank all the people who cooperated in this research.

Ethical Considerations

This study was approved by the Ethics Committee of Hakim Sabzevari University with the code IR.HSU.REC.1402.021.

Authors' Contributions

All authors equally contributed to preparing this article.

Conflict of Interest

The authors declared no conflict of interest.

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