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Zumba Exercise Training in the Management of Body Composition and Insulin Resistance in Sedentary Obese Women

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Abstract

Obesity is a pathophysiologic component of type 2 diabetes (T2D) and is typically linked to insulin resistance (IR). However, incorporating regular physical exercise into one's daily schedule is an effective approach to managing IR, blood sugar levels, and general health. The study's goal is to assess the feasibility of the Zumba fitness program and its effects on body composition and IR indicators. It is a quasi-experimental design for a single-group pre- and post-Zumba dancing intervention at a fitness center in Al-Ahsa Governorate, Saudi Arabia. Sixty-two sedentary obese women (body mass index [BMI]: 37.55 ± 3.99 kg/m2) 32.5± 0.56 years, completed a 16-week intervention attending moderate to vigorous Zumba dancing sessions 5 d/week, 60 min/class. Study instruments were structured by anthropometric measurements, body composition analysis, and some biochemical markers. After implementing the Zumba exercise program, the results show a substantial improvement in BMI, body fat composition, and IR when compared to before the program. According to body fat position, the reduction in fat composition ranged from 3.7 to 9.71%, while BMI decreased on average by around 6.31%. Significant variations have also been noted in fasting blood glucose levels of 28.04%, in leptin levels of 13.75%, in insulin levels of 28.27%, and IR levels of 8.83%. Further, decrease in total cholesterol, triglycerides, very-low-density lipoprotein cholesterol, and low-density lipoprotein cholesterol were between 2.18% and 4.91%, and the increase in high-density lipoprotein was 5.22%. Total bilirubin, total protein, and total albumin did not vary significantly between the pre- and post-program periods, though aspartate aminotransferase, alkaline transaminase, and alkaline phosphatase did. In conclusion, the program demonstrated strong feasibility and adherence, and it had a favorable impact on body weight, BMI, body fat composition, lipid profiles, and IR parameters, which can improve insulin sensitivity and stop women from developing T2D in the future.

Keywords: *Obesity, Insulin Resistance, Zumba Dance, Body Composition, Blood Glucose*

Introduction

Obesity is considered present when a person's body mass index (BMI) exceeds 30, and unfortunately, the number of obese persons worldwide is growing [1]. The caloric imbalance that causes obesity is influenced by numerous genetic, behavioral, and environmental variables; early weaning, eating disorders, damaged family relationships, and modern lifestyles have led to new, insufficient eating patterns. Further, the availability of a variety of inexpensive, tasty products with high energy contents and low nutritional value is an additional variable contributing to the rising rate of obesity. Increased physical inactivity is also noted, something encouraged by technological advancements, including television, computers, and video games. In 2016, 27.5% of individuals worldwide failed to engage in the recommended amount of physical activity each week, which is at least 150 min of moderate exercise or 75 min of vigorous exercise. Further, women are more likely than men to be insufficiently active (32% versus 23%) [2]. A major risk factor for the increased incidence of obesity and noncommunicable illnesses, including diabetes, cardiovascular disease (CVD), hypertension, and several malignancies, is the absence of physical exercise [3]. The authors in [4] argue that this impacts psychological factors, such as behavioral problems, sadness, agony, low self-esteem, and guilt.

Obesity, or an excess of body fat, is a condition that affects people with type 2 diabetes (T2D) and is linked to IR. The authors in [5] share that the global prevalence of IR among adults ranges from 15.5% to 46.5%, and under these circumstances, insulin plays a crucial role in controlling the switch from nutrition synthesis to storage. Following dietary ingestion, plasma glucose levels rise to a critical point, triggering pancreatic β cells to secrete insulin. Under typical conditions, insulin encourages the absorption of carbohydrates in key areas for storage and consumption, such as skeletal muscle and adipose tissue, where they remain as

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lipids. The authors in [6] note that typical sedentary habits disturb this mechanism and can result in major health issues, including IR. It is regarded as the pathogenic cause of many contemporary illnesses, such as weight gain, metabolic syndrome, non-alcoholic fatty liver disease, atherosclerosis, and T2D. Further, it is described medically as a condition of diminished sensitivity in insulin-targeting tissues to elevated physiological insulin concentrations. Thus, to achieve regular insulin needs, it is first necessary that non-physiologic increases in plasma glucose levels occur [7], causing persistent hyperinsulinemia and hyperglycemia-induced cell death. As such, expanded visceral adipose tissue (in abdominal obesity) affects the metabolism of insulin as free fatty acids are let out to the portal circulation. This can, in some circumstances, decrease hepatic insulin clearance to expand visceral fat stores, and is linked to a higher risk of T2D, IR, and hyperinsulinemia development [8].

Therapy for IR and obesity should concentrate on interdisciplinary approaches that tackle physiological and metabolic issues. To accomplish deliberate weight reduction, first-line treatment calls for the application of lifestyle changes, notably frequent exercise [9]. In the literature, a diet and exercise regimen combined with a reduction in weight is shown typically to produce favorable modifications in body composition, such as a decrease in abdominal adiposity. This can postpone or prevent the onset of IR, metabolic syndrome, and diabetes [10]; [11]. Nevertheless, some research has shown that physical activity without a restricted diet is still beneficial for lowering obesity, decreasing IR, and decreasing waist circumference (WC) [12]; [13]. Thus, the notion that exercise plays a secondary role to calorie restriction in weight control has begun to dissipate [14].

Consistent physical activity can lengthen one's life, enhance mental health and mood, and lower the risk of several common illnesses linked to obesity, as well as aids in promoting the growth of bones, joints, and muscles [15]. Notwithstanding the numerous advantages of living a physically demanding life, many individuals struggle to maintain exercise as a part of their daily schedule. Diverse forms of aerobic exercise may be more effective to sustain exercise and boost motivation, as certain circumstances may lead to individuals skipping physical activity. Exercise's long-term impact on physiological reactions can be assessed based on participant satisfaction [16]; [15]. Due to this, most people will engage in physical activities like Pilates, Zumba, and spin classes [17].

The most popular dance fitness program in recent years, particularly with young women, has been Zumba, constituting an enjoyable and accessible intervention. The array of Latin dance arrangements and upbeat music, which generate an inviting environment and allow participants to forget they are training, distinguish Zumba fitness classes by sustaining interest and providing ongoing activity. Zumba incorporates elements of salsa, samba, cumbia, and other Latin American dances to form the basis of the aerobic routines, while incorporating other dances, like hip-hop and belly dance [15]. As indicated by [18], Zumba exercises often fall into the vigorous-intensity category of exercise and can burn 600–1,000 calories per hour. Zumba mixes a variety of simple athletic moves that work out many of the body's muscles, activate the heart and lungs, improve general fitness, and speed up circulation. In addition, it boosts the flow of oxygen to the body's muscles and organs [15].

Zumba exercise training, with its high-intensity cardio and resistance elements, can significantly affect obesity by burning calories and promoting weight loss. It targets visceral fat, reducing its accumulation around organs and thereby decreasing the risk of IR. Zumba's aerobic nature also enhances insulin sensitivity, aiding in blood sugar regulation. In addition, the exercise's rhythmic movements may reduce inflammation by improving receptor sensitivity and promoting metabolic health [19]. Further, Zumba's Latin and world music beats can increase adherence to exercise rates, energize individuals in-class, and encourage repeated participation [15]. Therefore, this study aims to investigate the potential efficacy of Zumba as an enjoyable and accessible intervention in the management of body composition and IR among sedentary obese women. The study hypothesizes that participation in regular Zumba exercise sessions will lead to favorable changes in body composition parameters, such as reductions in body fat percentage and increases in lean muscle mass, as well as improvements in insulin sensitivity, in sedentary obese women over a specified duration of the intervention.

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Methods

Participants

The Raosoft online calculator was used to determine the sample size for this study [20]. With an accepted margin of error of 10%, confidence level of 90%, and response distribution of 50%, the sample size required was 65 (with a margin error of 10.18%), though three participants were lost to follow up after the intervention.

Using local ads, the study recruited 65 inactive, apparently healthy women aged 25–40 years who were at risk of developing IR (BMI >35 kg/m^2) to participate in the study. A state of inactivity was decided as less than 1 h of consistent physical exercise per week over the most recent 6-month period. The exclusion criteria included pregnancy, smoking, CVD, diabetes, or liver, pulmonary, adrenal, pituitary, or thyroid diseases, as well as any prior musculoskeletal injuries that would have a detrimental impact on involvement. Those already following an established eating pattern or exercise regimen or who were using daily medication were excluded from the study. Before participating in the study, every individual completed an informed consent form in writing.

Study Design

From September to November 2023, local fitness centers in Saudi Arabia's Al-Ahsa Governorate served as the research site. This study used a quasi-experimental pre–posttest design. In the research, 62 obese, inactive, seemingly healthy women worked out in moderate to vigorous Zumba exercise training for 60 min, five times per week for four consecutive months. Over the course of the trial, participants were instructed to continue with their regular eating routines. Women who met the initial admission requirements for the study were given the opportunity to attend a familiarization session where the project's specifics were discussed, human subject consent papers were completed, and personal and medical history data were gathered.

A Zumba dancing instructor with a license taught the courses. As research participants were obese and previously inactive, the instructor increased the workout intensity gradually during weeks 1 through 3. The trainer led the participants through each song's steps before having them perform the routines in order, which gave intensity to the sessions. By the third week, all involved had grown accustomed to replicating the exercises, which prevented any pauses in the flow of the program and raised the level of difficulty. The exercise intensity of the sessions was assessed by the rating perceived exertion (RPE) Borg scale, which ranged from 0 to 10 [21]. The intensity changes during the training session were indicated by the instructor to ensure that no one made strenuous efforts and that everyone maintained moderate-to-vigorous-intensity physical activity (6–8 on the Borg scale).

Recruitment rates, subject retention, and adherence were used to gauge feasibility. Participation in the sessions was monitored by the research staff, and the ratio of the total number of classes taken to the total number of classes provided was used to compute percentage adherence. All anthropometric and body composition measures, blood pressure (BP) readings, and blood analyses were assessed prior to and following the treatment by skilled nursing personnel in a private hospital. During the trial, participants were instructed to continue with their regular eating routines. The fitness center gave written consent for the research to be conducted, and the Research Ethics Committee of King Faisal University granted ethical permission for this study (KFU-REC-2023-SEP-ETHICS 1196).

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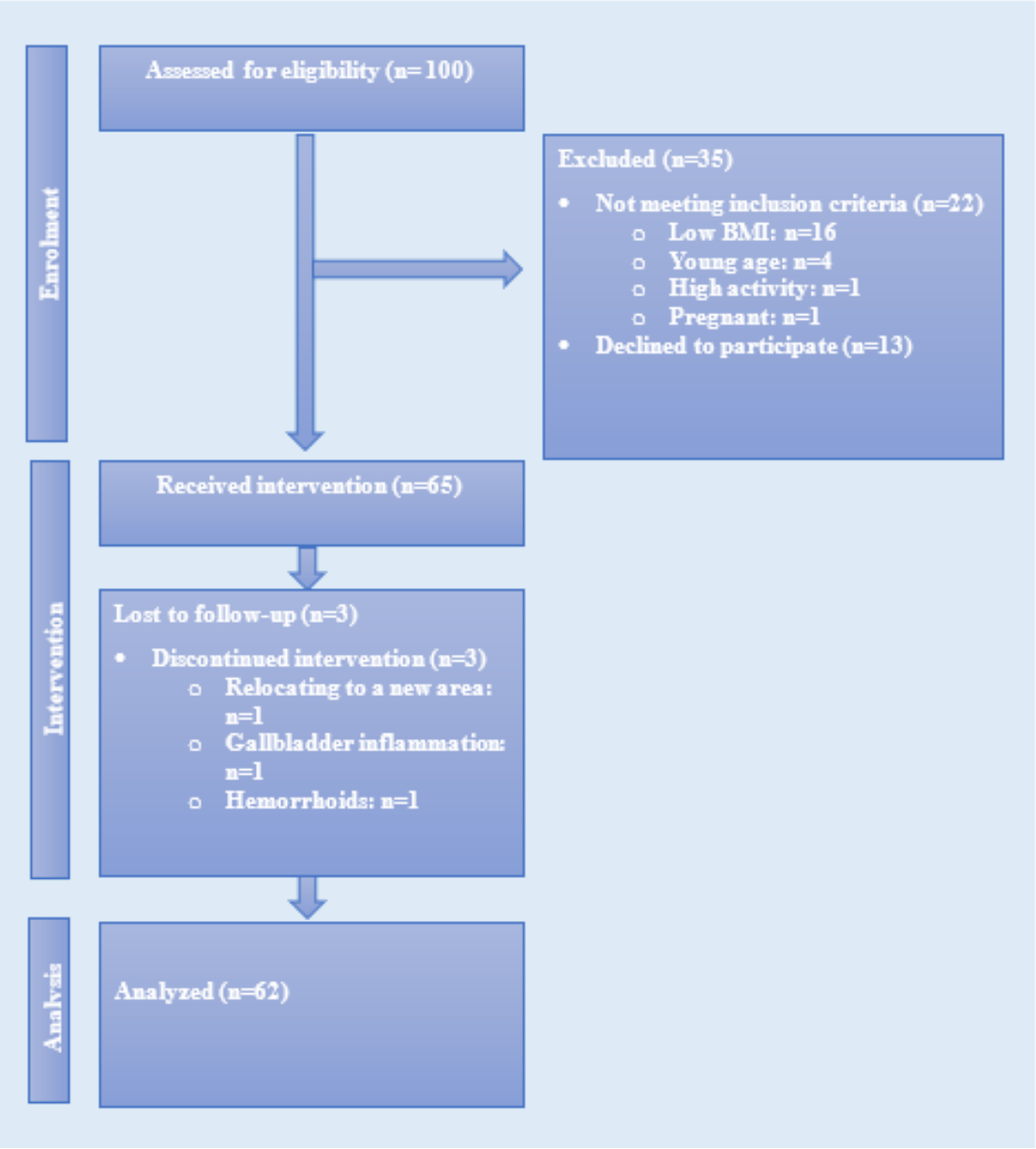

Figure 1. Flow of Participants Through the Trial.

Anthropometric Measurements

Weight was taken in kilograms (kg) using a beam balance (Beurer BG42) scale requiring minimal garments and the absence of footwear. Subjects were asked to stand barefoot while having their height measured using a stadiometer to the closest 1.0 cm [22]. Underweight (BMI <18.5kg/m^2), normal weight (BMI 18.5–24.9kg/m^2), overweight (BMI 25–29.9kg/m^2), obese class 1 (BMI 30–34.9kg/m^2), obese class 2 (BMI 35–39.9kg/m^2), and morbidly obese (BMI ≥40kg/m^2) were the categories used to classify BMI, based on criteria published by the World Health Organization (WHO) [23]. Bioelectrical Impedance Analysis InBody 170 was used to record body composition, which includes body fat percentage, visceral fat, body water percentage, bone mass, body muscle percentage, basal metabolic rate, and physique rating [24]. Utilizing a common tape measure, the WC a good indication of abdominal obesity was determined over light clothes to the closest 0.1 cm [23]. A skilled technician took all the measures both prior to and following program implementation.

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Blood Pressure

Utilizing an automated sphygmomanometer (HEM-7113 INT; Omron Corp., Kyoto, Japan), the systolic blood pressure (SBP, mmHg) and diastolic blood pressure (DBP, mmHg) of subjects at rest were calculated.

Zumba Exercise Program

The program was a moderate-to-vigorous Zumba dancing intervention comprised of monitored exercise sessions held for 60 min, five times per week for four consecutive months. The local fitness center hosted the Zumba program, and it was directed by a certified Zumba instructor. To avoid vigorous steps for a group consisting of obese participants, Zumba choreographies were created using movements that put lighter demand on the skeletal muscular system. Every workout consisted of three phases: a 10-min warm-up, a 45-min main exercise period (which comprised 20 min of aerobic activity and 25 min of resistance exercise), and a 5-min cool-down.

Blood Sample Analysis

In a secure hospital lab, blood analyses were conducted. Following a 12-h fast, blood samples were taken and promptly sent to an analytical facility to determine blood glucose using the methodology of [25]. The techniques of [26], [27], [28], and [29] were also used to assess serum triglycerides, serum cholesterols, serum HDL cholesterols, and serum LDL-cholesterols, respectively. Considering the recommendations of [30] and [31], such liver elements as alkaline phosphatase (ALP), alanine transferase (ALT), aspartate transferase (AST), and gamma-glutamyl transferase (GGT) were also measured. Further, leptin and insulin levels were determined in accordance with [32] and [33], respectively. As such, the following formula was used to determine the homeostatic model assessment of insulin resistance (HOMA-IR) (marker of IR): fasting insulin (mU/L) × fasting glucose (mg/dl)/405 [34].

Statistical Analysis

The statistical packages for the social sciences (SPSS) version 17.0 (Chicago, Illinois, USA) software were used to enter and analyze all the data. Each tool's material was examined, grouped, and coded. Means and standard deviations for quantitative variables were used to display data using descriptive statistics. Comparisons between the different study groups were carried out using student t-test for Mean ± Standard Deviation. The level of significance in this study was ($p \leq 0.05$); high significant at ($P<0.01$) while $p \leq 0.001$ was considered very highly statistically significant (HS) [35].

Results

Anthropometric Parameters, Body Composition, And Blood Pressure Of Participants Pre- And Post-Intervention

The advertising drew responses from 100 individuals, of whom 35 were unable to begin the program because they either did not match the criteria for participation or they refused to take part (Figure 1). In total, 62 women participated, with a mean age of roughly 32.5 years. Anthropometric, body composition, and BP data are shown in Table 1 for the initial and 12-week intervention periods. There was a significant difference for body weight ($P<0.001$) and significant for body mass index ($P<0.05$) before and after the Zumba fitness program. The percentage of weight and BMI reduction was about 6.31%. The results also showed significant reduction ($P<0.05$) in CRT, CLT, RMAC, LAMC as compared to their values before planned program. Additionally, substantial decreases in visceral fat, fat mass, and body fat percentage ($P<0.05$) were noted, while water, bone and muscle levels were significantly ($P<0.05$) increased; the reduction was between 3.7 to 9.71% while the improvement was between 3.3 to 9.5 %. Furthermore, the results recorded high significant changes ($P<0.01$) in WC, metabolic age and fat free mass and very high significant changes in basal metabolic rate ($P<0.001$). Whereas the findings indicated that decrease in SBP (1.07%) and DBP (1.08%) were not significant.

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Table 1. Anthropometric Parameters, Body Composition and Blood Pressure of Participants Pre- and Post-Intervention

Anthropometric measurements	Before program	After program	P value
Age (y)	32.5± 0.21	32.5± 0.13	0.076
Height (cm)	1.60± 0.15	1.60± 0.31	0.132
Weight (kg)	96.13± 2.83	90.07± 1.32	0.01**
BMI (kg/cm²)	37.55 ± 2.03	35.18± 1.96	0.05*
Waist circumference (cm)	97.06±2.41	92.01± 1.84	0.01**
Fat Range (%)	33.13± 5.77	30.09± 1.64	0.05*
Fat Mass (Kg)	38.67± 2.66	34.99± 7.32	0.05*
Visceral Fat (Level)	12.87± 1.34	11.62± 1.55	0.05*
Metabolic Age (years)	48.54± 5.32	44.02± 1.67	0.01**
Fat Free Mass / (Kg)	35.06± 3.87	31.88± 2.85	0.01**
Total Body Water / TBW (Kg)	30.08± 4.03	32.77± 2.43	0.05*
Muscle Mass /PMM (Kg)	29.95±2.76	32.93± 1.74	0.05*
Bone Mass	3.95± 1.65	4.08± 1.89	0.05*
Rate Physique Rating %	15.11± 1.93	16.01± 0.35	0.05*
Basal Metabolic Rate (KJ)	5007.09± 13.92	5410.19± 13.5	0.001***
SBP (mmHg)	131.2 ± 3.6	129.8 ± 2.1	0.507
DBP (mmHg)	83.5 ± 2.2	82.6 ± 2.1	0.130

Statistically significant at P <0.05; highly significant at P <0.01; very high significant at P<0.001

Lipid Profiles of Participants Pre- and Post-intervention

Table 2 indicates how the program altered obese women's lipid profiles. When compared to their values before the treatment, it was discovered that low and very low lipoprotein levels, total triglycerides, and total cholesterol all dropped. However, none of these alterations were statistically significant, except for low lipoprotein levels (P<0.05). Nevertheless, compared to before the program, the high-density lipoprotein level was significantly (P<0.05) improved. Total triglycerides, total cholesterol, low and very low lipoproteins all reduced by 2.91, 2.18, 4.91, and 2.18%, respectively, while HDL improved by 5.22%.

Table 2. Lipid Profiles of Participants Pre- and Post-intervention

Lipid profile	Before program	After program	P value
Total Serum Cholesterol	267.11± 2.76	259.34± 4.81	0.142
Serum Triglycerides	275.05± 7.21	269.05± 3.01	0.105
Serum HDL-c	37.91± 7.54	39.89± 3.88	0.05*
Serum LDL-c	174.19± 6.43	165.64± 2.85	0.05*
VLDL-c	55.01± 3.93	53.81± 4.99	0.163

Statistically significant at P <0.05

Liver Function Markers of Participants Pre- and Post-intervention

Table 3 displays the average values of liver enzymes and other functional indicators. A significant (P<0.05) decreasing in ALT (5.9%) and AST (7.1%) values and high significant decreasing (P<0.01) in ALP (6.23%)

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value was found after applying the program. The remaining blood liver functions such as total bilirubin, serum globulin, albumin, and total protein showed improved values; however, the changes were statistically insignificant. Compared to pre-program, the reduction levels were 2.97%, 5.15%, 3.12%, and 3.97%, respectively.

Table 3. Liver Function Markers of Participants Pre- and Post-intervention

Liver functions	Before program	After program	P value
Aspartate transferase (AST) (U/L)	55.95± 2.64	51.99± 4.96	0.05*
Alanine transferase (ALT) (U/L)	59.34± 3.41	55.86± 2.98	0.05*
Alkaline Phosphatase (ALP) (U/L)	103.76± 3.85	97.29± 1.98	0.01**
Total Bilirubin (mg/dl)	1.01± 0.08	0.98± 0.22	0.117
Globulin (g/dl)	2.33± 0.76	2.21± 0.07	0.102
Serum Albumin (mg/dl)	3.21± 0.99	3.11± 0.09	0.216
Total protein (g/dl)	5.54± 0.38	5.32± 0.41	0.124

Statistically significant at P <0.05; highly significant at P <0.01

Blood Glucose, Leptin Hormones, and Insulin Resistance Levels of Participants Pre- and Post-Intervention

Table 4 illustrates how the Zumba program affected obese women with IR regarding fasting glucose levels, insulin hormones, IR, and leptin hormones. Zumba dancing was shown to significantly lower fasting blood glucose (28.04%), (P <0.001), and leptin hormones (13.75%) (P <0.01). As for IR as measured by HOMA analysis there was a significant change (8.83 %) (P <0.05), after applying the program.

Table 4. Blood Glucose, Leptin Hormones, Insulin Hormones, and Insulin Resistance (HOMA-IR) Levels of Participants Pre- and Post-intervention

Parameters	Before program	After program	P value
Blood glucose (mg/dl)	180.65±1.43	129.99±3.76	0.001***
Insulin hormones (IU/ml)	7.11±0.23	9.12±1.64	0.001***
Insulin resistance (HOMA-IR)	3.17±0.81	2.89±0.93	0.05*
Leptin hormones(ng/mL)	26.54±2.86	22.89±3.86	0.01**

Statistically significant at P <0.05; highly significant at P <0.01; very high significant at P <0.001

Discussion

This study is one investigation among the minimal existing research on the impact of Zumba activity on weight reduction, body fat loss, and IR markers. The program was conducted with 62 individuals having an average age of 32.5 years.

As stated by [36], the feasibility and effectiveness of a workout program may often be determined by whether it meets the requirements for recruitment, protocol adherence, retention of screened individuals, adherence, safety, or positive changes in medical results. One finding of this research is that the treatment

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appears feasible regarding the procedure of assessing and creating future interventions. In this research, of 100 adults who answered the telephone eligibility screening, 71 (71%) qualified for a clinical screening visit. Of these 71, 68 went on to meet eligibility criteria, 65 (95.59%) started Zumba classes, and 62 (95.38%) finished the intervention. The mean attendance was 82.5%, which equates to 66 classes of a total 80. Just three individuals (4.62%) left the investigation because of sickness (unconnected to the treatment) or moving to a different location (Figure 1). This research's comparatively satisfactory results can be ascribed to the qualified instructor, the pleasurable Zumba dancing techniques, and the safe approach.

The workouts with music beats were conducted with the help of the instructor in a team setting, which was crucial for workout compliance. The responsibility of establishing a collaborative environment, which has been shown to improve cohesion [37], was thus given to the skilled instructor, who employed motivational techniques, including encouragement and commendation to promote compliance. The authors in [38] emphasized the ability of the fitness instructor to inspire participants by giving them the confidence to believe they would succeed with exercise, leading to improved exercise compliance. Obese people who frequently reported experiencing exhaustion were at times deterred from exercising due to an absence of desire [39]. However, the minimal dropout rate and high compliance rate in the research show that the treatment itself is feasible. When a minimum of 80% of participants finished the intervention, structured adherence was deemed good [40]. However, it has not yet been determined how well this demographic adheres to the Zumba workout program over an extended period.

Numerous health issues, including as IR, total visceral fat, abdominal visceral fat, and intramuscular fat, are more prevalent in women and grow worse with age and as weight increases [16]. A persistent disparity between energy consumed and expended (which results in weight gain) is a common contributor to obesity, and multiple investigations have linked obesity and several chronic disorders, including T2D, cancer, CVD, hypertension, stroke, dyslipidemia, reproductive issues, and IR [9]. IR is a complicated disorder whereby the human body cannot react properly to the hormone insulin, which is generated by the pancreas and is crucial for controlling blood sugar levels. [42] believe peripheral IR is characterized by a poor physiologic reaction to the insulin stimulation of peripheral target tissues, specifically the liver, muscles, and adipose tissue. To address obesity, behavioral therapy and lifestyle interventions often use a multifaceted stepwise approach [43]. Thus, to understand better how the Zumba fitness program (one hour, five times a week for three months) affects obesity and IR, the present study investigated this topic.

Zumba invokes the large muscle groups, which help transport glucose to the cells for utilization and, therefore, lead to an improvement in insulin sensitivity. Numerous physiological nature studies confirm that regular Zumba exercises decrease IR, primarily via insulin improvements, including enhanced pathways signaling and the positive facilitation of GLUT-4 translocation to cell membranes, where glucose is transported to the cells through parallel pathways of signaling [44]; [45]. Zumba's high intensity interval training (HIIT) imparts a quick-paced burst of energy that promotes lipolysis and cuts abdominal fat. A euphoric cycle takes place during and in the immediate wake of HIIT, where there is improved fat oxidation, which results in reduced visceral fat. This effect is also connected to the finding that Zumba interventions lead to visceral fat reductions and a decreased waistline, accordingly [46]. Furthermore, this heart method also has favorable effects on cardiovascular health, so it can reduce the risk of cardiovascular diseases. Aerobic exercise and resistance training are involved with Zumba to enhance cardiovascular endurance, decrease blood pressure, and improve lipid profiles. In this regard, such side effects jointly lead to a lower risk of cardio-metabolic disease, including heart ailments and T2D [47].

There is a substantial relationship between BMI and IR concerning increased liver enzymes, and this link has been partially mediated by inflammation and endothelial dysfunction [48]. Increased energy intake is the primary factor underlying abnormal weight gain, which results in obesity. According to the outcomes, the participants' weight and BMI decreased by 6.31% due to Zumba dancing. Similarly, [19] notes that dancing activities focusing on fat burning for 6 weeks can help overweight and obese women reduce their percentage of body weight and IR. It links increased energy expenditure to a decrease in overall body fat, a rise in muscle mass, and a reduction in total fat mass. In addition, despite the Polycystic Ovary Syndrome group not losing a large amount of weight, improvements in IR, visceral fat, and triglycerides were observed with exercise training [49]. In contrast, [50] found that in postmenopausal overweight inactive women, a

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12-week Zumba fitness program may be insufficient to enhance body composition or cardiorespiratory fitness significantly. Nevertheless, it aids in enhancing quality of life in relation to weight and reducing obstacles in sports. Further, there are still limits, even though the current study had a positive impact on lowering the percentage of body fat in obese women. One of these restrictions is that the researcher has less control over the subjects' everyday routines and diets, and the absence of a control group makes it difficult to draw firm conclusions from the data.

To improve the rate of calories burned by the dance program, the metabolic age was lowered from around 48 to about 40 years. Adjustments in activity led to an improved body composition, represented by a drop in body fat and IR, particularly in obese people. In line with existing studies, an abundance of visceral fat causes the IR to emit the protein known as retinol-binding protein 4 (RBP4), which has been proven to enhance IR and T2D. Increased triglyceride levels in circulation brought on by belly fat trigger the generation of inflammatory hormones that lead to IR [42]. Meanwhile, WC provides a more accurate depiction of how fat is distributed, and a growing WC, particularly visceral fat is closely associated with metabolic syndrome, as well as to both T2D and IR when exceeding 85 cm in women [51]. Angiotensin II (Ang II) and aldosterone, which have vasopressor and anti-natriuretic effects, may be formed because of sympathetic activity linked to WC and molecules generated by hypertrophied fat cells, respectively. Meanwhile, human adipose tissue possesses a local renin-angiotensinogen system (RAS), which may function independently of the plasma RAS, meaning adipose tissue that is connected to IR has all the RAS elements (angiotensinogen [AGT], Ang II type 1 [AT1] receptor, and angiotensin-converting enzyme, but not renin and AT_2 receptor) [52]; [53].

In response, the capacity of participants to manage the Zumba routines integratively and harmoniously reduces subcutaneous fatty tissue, as body composition and IR influence the results obtained regarding a decrease in body fat percentage. According to research that supports our findings, common cardiovascular risk factors for sedentary women, such as body fat percentage, WC, blood pressure, blood glucose levels, insulin levels, and the homeostatic model assessment of insulin resistance (HOMA-IR) [17], may be improved by physical activity via Zumba classes. In [54], the findings show that using a dance aerobic approach for 12 weeks reduces skin folds, body fat percentage, and body mass by 3.7%, as well as increases muscle mass by 2.4% [55], particularly because more visceral than subcutaneous fat was lost.

It was found that low and very low lipoprotein levels, total triglycerides, and total cholesterol all dropped. However, the outcomes were not statistically significant except for low lipoprotein levels ($P<0.05$). Despite that, the high-density lipoprotein level was significantly ($P<0.05$) improved. Total triglycerides, total cholesterol, low and very low lipoproteins all reduced by 2.91, 2.18, 4.91, and 2.18%, respectively, while HDL improved by 5.22%. The results were consistent with meta-analyses conducted by [56] and [6], demonstrating that high-fat diets or a surplus of carbohydrates in a person's diet can impact systemic lipid metabolism, which in turn leads to the onset of dyslipidemia and the lipid triad: high plasma triglyceride levels, low HDL levels, and an increase in small, dense HDL proteins. The authors in [17] show that Zumba activity was more effective at reducing IR, which in turn reduced cholesterol and LDL cholesterol levels, and it was also more impactful at raising HDL cholesterol. Following 16 weeks of aerobic training or 12 weeks of aerobic exercise paired with yoga, [57] and [58] discovered that blood triglyceride levels decreased and HDL-C levels increased, helping people to lose excess weight and increase their heart and breathing rates.

Consuming excessive amounts of calorie-dense meals might hinder the liver's ability to function [59], and it can induce inflammation over time, which might eventually result in liver scarring (cirrhosis). Previous research has also discovered a connection among non-alcoholic fatty liver disease, IR, metabolic syndrome, and obesity. Further, researchers have demonstrated an association between serum albumin and HOMA-IR, leading to elevated enzyme levels of ALT, AST, and ALP in the liver. Moreover, the availability of circulating amino acids for protein synthesis, especially BCAAs, which are the main regulators of protein synthesis, is suppressed by insulin, which also plays a role in impeding protein catabolism [60]. This outcome was consistent with the obtained results; ALT and AST values were significantly ($P<0.05$) decreased while ALP value recorded high significant change ($P<0.01$) and the reduction levels were between 5.9 to 7.1%. However, compared to the levels before program administration, the other serum liver

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functions, including total bilirubin, serum globulin, albumin, and total protein, showed insignificant developments, with a reduction rate ranging from 2.97% to 5.15%. Engaging in aerobic activity for 6 weeks can help treat fatty liver disease, and it may also help to reduce AST and ALT blood levels and ALP enzymes [61]. In addition, [62] discovered that ALT, AST, and ALP levels change dramatically before and after exercise programs, whereas liver enzyme levels hardly change, presumably as a consequence of minor decreases in enzyme consumption or variations in body weight. According to [63] and [64], greater lymph flow during and following training could be the cause of a non-significant decline in albumin and total protein levels.

A calorie-dense diet can impede digestion and complicate proper insulin function. As noted by [59], such a diet raises fasting glucose levels and increases hepatic glucose production, causing IR in women to be more than or equal to 2.5. Nevertheless, Zumba can increase fitness, enhance insulin sensitivity, and aid in blood sugar control. It may even aid in weight loss while increasing muscle mass, which can improve metabolism [65]. The results of the present research are supported by [66], who discovered that the decrease in blood glucose values after exercise may be because said exercise lowers IR, rendering the muscles less resistant to insulin and allowing glucose to be used for energy production in the working muscles.

While Zumba training can significantly contribute to body composition management and IR, its effectiveness can be further enhanced through concurrent nutritional interventions. Providing sedentary obese women with personalized nutritional guidance and dietary counseling can complement the physiological benefits of Zumba exercise training, facilitating sustainable weight loss and metabolic improvement. In addition, encouraging long-term engagement and adherence to Zumba exercise training is essential for maintaining health benefits over time. Incorporating social support mechanisms, such as group accountability, buddy systems, and community events, can foster a sense of belonging and commitment among participants, thereby increasing the likelihood of sustained lifestyle modifications.

The present study has several notable strengths. To the best of our knowledge, this is the first intervention in Saudi Arabia examining the effect of Zumba exercise training on body composition and IR in sedentary obese women. Moreover, its chief strength lies in the rigorously supervised exercise sessions at the gym for all subjects, which reduced problems with adherence and helped ensure a standardized program for all participants. It is noteworthy that we experienced excellent adherence to the intervention and low drop-out rates. However, certain limitations were unavoidable. Such factors as historical threats could have affected the changes between the baseline and follow-up measurements. In addition, physical activity is not the only factor responsible for IR risk; other factors were not included in this study due to such constraints as eating habits, stress, age, ethnicity, family history, and genetics, which can be considered useful context information in future studies. Furthermore, a control group is considered effective in ruling out single-group threats, but historical threats could still occur, and the researcher would never know what the participants in the intervention and control groups did in their private lives.

Conclusion

Zumba dancing is likely to facilitate commitment and retention, making it a feasible form of exercise that produces substantial improvements in such cardiometabolic risk markers as BMI, IR, lipid profiles, blood pressure, and visceral fat. In addition, it can assist in lowering the likelihood of chronic lifestyle diseases, such as T2D or CVD.

Availability of Data

Data cannot be shared openly to protect study participant privacy.

Authors' Contributions and Materials

The author confirms sole responsibility for the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.

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2024
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None

Conflict of Interest

The authors declare that there is no actual or potential conflict of interest.

Human Ethics and Consent to Participate Declarations

The participants signed the consent form, which provided all required information regarding the study's purpose, all measurements, and laboratory tests. Ethical approval was granted by the Research Ethics Committee of King Faisal University (KFU-REC-2023-SEP-ETHICS 1196) Saudi Arabia.

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2024
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