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RESEARCH

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Effects of aerobic, resistance, and combined exercise training on body fat and glucolipid metabolism in inactive middle-aged adults with overweight or obesity: a randomized trial

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Abstract

Method Twenty inactive males (BMI 27.67 ± 0.88 kg/m^2, age 49.15 ± 2.58 years) participated in an eight-week were randomly assigned to one of three intervention groups (combined (CT), resistance (RT), and aerobic (AT)) exercise modalities to assess within-subject and between group changes in glycolipid profile. Data were analyzed using repeated measures ANCOVA.

Result Pre-post mean values of body fat percentage (%BF), area under the curve (AUC), low density lipoprotein (LDL), high density lipoprotein (HDL) and total cholesterol (TC) decreased in all three groups. The main effect of exercise modality on the AUC (F (2, 26) = 10.577, P = 0.001, η^2 = 0.569) was significant. Post-hoc analyses revealed that the RT group (-30.653 ± 6.766, p = 0.001) with 11.53% and the CT group (M = -0.896, SE = 3.347, P = 0.015) with 3.79% exhibited significantly greater reductions in AUC compared to the AT group. LDL levels showed significant different between groups (F (2, 26) = 6.33, p = 0.009, η^2 = 0.442), specially significantly 3.7% lowered in AT (MD = 4.783, SE = 1.563, P = 0.002) and 3.79% lower in CT (MD = 4.57, SE = 1.284, P = 0.008) groups compared to the RT group. AT significantly reduced TC by 17.716 ± 5.705 mg/dL (p = 0.02) compared to RT, representing a 7.97% decrease.

Conclusion Exercise type significantly influences lipid profiles and glycemic control. Notably, both aerobic and combined training demonstrated a superior ability to modulate the lipid profile**,** and resistance training and combined training were more effective in reducing the AUC.

Trial registration May, 31st 2024. Registration no: PACTR202405463745521 “Retrospectively registered”.

Keywords Glucose tolerance, Lipid profile, Resistance training, Aerobic training and combind training

Introduction

Obesity is the condition of having an abnormal or excessive accumulation of fat that poses a health risk. A body mass index (BMI) of over 30 is considered to be indicative of obesity [1]. The prevalence of obesity increased with age in this study, with the highest prevalence (44.3%) among middle-aged adults (40–59 years old) [2]. While women and older adults are generally more likely to experience obesity, these data suggest a trend across all age groups [3]. The incidence of obesity has been on the rise in recent decades and has been linked to a variety of health and socioeconomic issues [4]. It is important to prioritize strategies that can help reduce the healthcare costs associated with obesity.

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The combined estimates of the prevalence of obesity and overweight in Middle Eastern countries were 21.17% and 33.14%, respectively [5]. The combined crude prevalence rate of obesity in Nigeria was 14.3% [6]. Like in many other countries, overweight and obesity are becoming increasingly prevalent public health issues in Ethiopia [7].

Obesity is a significant risk factor for and contributor to increased morbidity and mortality, especially as individuals age, most importantly from cardiovascular disease (CVD) and diabetes but also from cancer and chronic diseases, including osteoarthritis, liver and kidney disease, sleep apnea, and depression [8, 9].

We can therefore strongly suggest that interventions improving both blood sugar control and cholesterol levels would be highly effective in preventing cardiovascular diseases [10]. Optimizing exercise for health goes beyond just choosing an activity. The global fitness business is moving in the direction of exercise for better health results [11].

A personalized approach that considers the type of exercise is required [12]. Exercise has been shown to enhance glycemic control and improve blood lipid profiles in individuals both with and without type 2 diabetes, as supported by different studies [13, 14]. Therefore, enhancing cardio-metabolic risk factors with sustained exercise modalities can lead to better health outcomes [15, 16]. Regular physical exercise enhances IR and glycolipid metabolism, which lowers the problems linked to obesity [17]. The current guidelines for managing adult obesity state that improving cardiometabolic health need regular multimodal exercise [18].

Extensive research has been conducted on the effects of aerobic training modalities of exercise on various health outcomes [13, 19, 20]. For clinically successful weight reduction that aims to enhance many cardiometabolic health indices, regular endurance training is essential [21, 22]. During aerobic exercise workouts, the body burns fat for most of its energy and becomes better at breaking down fat stores (lipolysis) [23, 24]. National guidelines on physical activity and recommendations for public health were released by the American College of Sports Medicine and the Centers for Disease Control and Prevention. All healthy individuals between the ages of 18 and 65 must engage in moderate-intensity aerobic (endurance) physical activity for at least 150 min per week or vigorous-intensity aerobic physical activity for at least 75 min per week in order to promote and maintain their health [25].

Resistance training has been demonstrated to increase the body's consumption of glucose by inducing a hypertrophy response and a type shift in the muscular fibers of exercised muscles [26]. It can help obese people manage their weight [27] and become more insulin-sensitive, manage lipid profile and glycemic control in obese adults [28, 29]. High-intensity resistance training burns mostly carbohydrates for immediate energy [24]. It also triggers the release of hormones such as growth hormone and testosterone [30]. By influencing the body's chemistry, hormones promote muscle growth and make it easier to access the body's ability to burn glucose derived from fat stores (lipolysis) [31]. Increased overall muscle mass, an increase in the number of insulin receptors in muscle cells, and an increase in the number of glucose transporter (GLUT) proteins are some probable underlying mechanisms for the beneficial effects of resistance (strength) training [26]. The combined exercise program had a positive impact on body mass and composition as well as enhanced glucose and lipid metabolism [21, 32], which includes both aerobic and resistance exercise within a single session. Research has confirmed the benefits of combined training in improving glycemic management and lipid parameter health in obese adults [21, 33, 34]. Current ADA guidelines advocate a combination of aerobic and resistance training, which may be the most beneficial exercise modality for regulating lipid profile and glucose levels [35].

Regardless of the type or intensity of exercise, hormonal changes affecting blood lipid levels are not significantly impacted when individuals burn the same amount of calories [36]. To accurately assess the impact of exercise programs on health, participants need to follow a strict dietary monitoring protocol [37]. This involved carefully tracking the participants' food intake, often through a food frequency questionnaire, to ensure that any observed changes were primarily due to the exercise intervention itself and not influenced by significant shifts in their dietary habits [38].

There is a lack of research evaluating the effects of resistance and aerobic exercise on the risk factors associated with glycolipids profile, and even fewer have studied the two types of training separately or in combination. Further studies are required to better understand how various exercise modalities affect these risk variables while controlling dietary practices, given the rising burden of chronic disease. Hence, the objective of this study was to assess and compare the efficacy of various exercise modes (AT, RT, and CT exercise) and changes over time in enhancing lipid profile changes and glucose tolerance among adults who are obese.

Methods and materials

This study is reported following the CONSORT guidelines.

Research setting and design

This research combined pretest posttest with a repeated measures design component to capture within-subject changes over time with a randomized parallel group experimental design to assess between-group differences.

The study involved physically inactive male persons between the ages of 45 and 60 years who had a BMI greater than 24.9 kg/m2. The participants were selected from a volunteer pool of inactive residents of Debre Markos town, Ethiopia and were informed through local radio and notice board postings.

The inclusion criteria were as follows: (a) had a BMI > 24.9 kg/m^2, (b) were aged between 45 and 60 years, (c) volunteered to participate, (d) were physically inactive (not achieving 30–60 min per day or 150 min per week of moderate intensity exercise or 20–60 min per day (75 min per week) of vigorous intensity [39] and cleared a medical history form the physical activity readiness questionnaire, and (d) were able to perform the necessary exercises. The exclusion criteria were as follows: (a) any cardiovascular, respiratory, or muscle-skeletal disorders precluding physical exercise; (b) uncontrolled hyperglycemia (≥ 126 mg/d) or hypertension (a resting blood pressure ≥ 140/100 mm Hg); and (c) active infection, (d) acute myocardial infarction, stroke, trauma, surgery or severe liver dysfunction.

The ideal sample size for our investigation was determined by using the G*Power program. We determined a sample size of 21 people, as described by Sousa et al., taking into account zero correlation among each measure TGC, Total-c, LDL-c, and HDL-c in the AT [40], a significance level (α) of 0.05, and a power of 0.8. An overall sample size of 24 was needed, accounting for a 10% non-response rate. Our study's intended statistical power and significance level were achieved by successfully detecting the given effect size with this sample size.

The current investigation recruited and registered a total of 36 male overweight and obese individuals. After applying the inclusion criteria, 32 out of the 36 volunteers who we had initially registered as physically inactive remained. The researchers were created a final study group consisting of 24 participants via a simple random selection procedure. After that, these people were randomized at random to one of three exercise groups (each with eight participants): combined training, resistance training, or aerobic training. The study was conducted in Debere Markos, Ethiopia, using homogeneous samples and balanced randomization (1:1:1) (Fig. 1). The data collectors were blinded to one another during the study.

Before obtaining their informed consent, participants were completely told about all procedures, hazards and protocols to ensure ethical conduct. This satisfied the requirements set forth by the American College of Sports

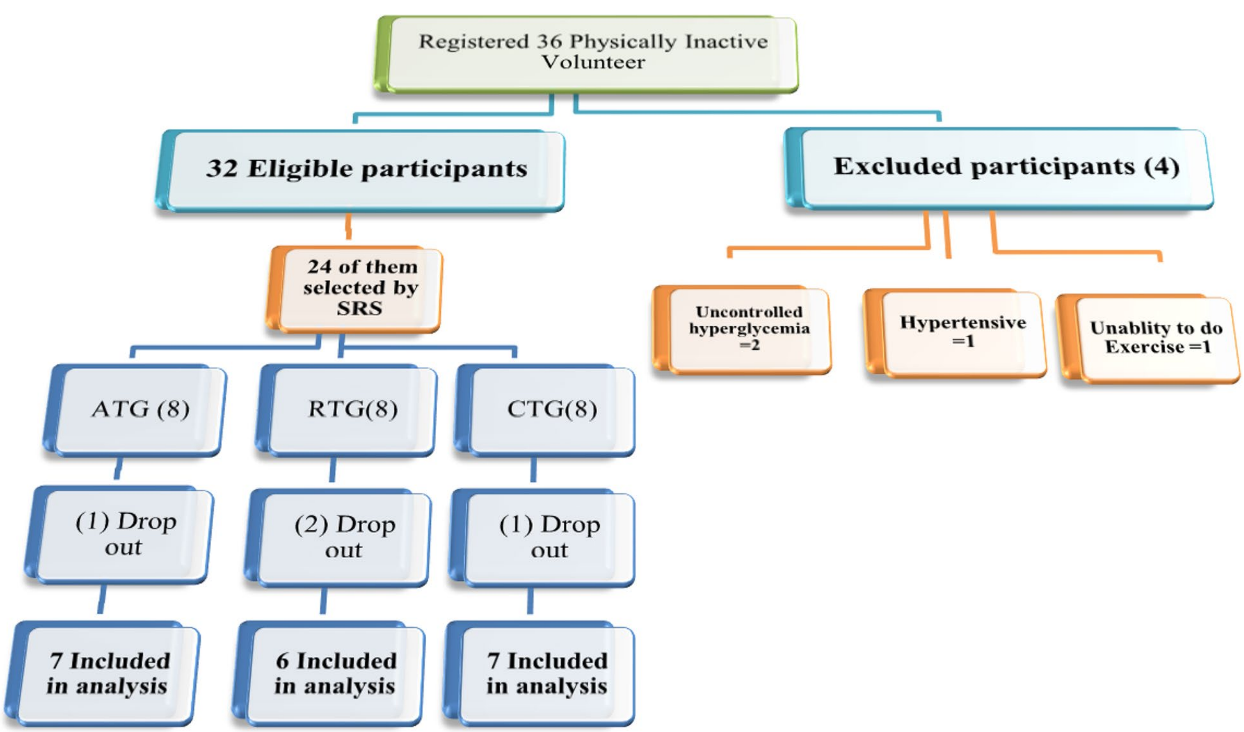

Fig. 1 Participant description chart

Medicine [39]. Additionally, the Sport Academy research ethics committee at Debre Markos University reviewed and provided input on all procedures involving human subjects. Lastly, the study was carried out in accordance with the ethical standards provided in the 2000 revision of the Declaration of Helsinki.

The first data were collected prior to the intervention, while the second data were collected at the end of the 8-week intervention. The data were collected at the Debre Markos referral hospital. We measured lipid profiles (TC, HDL and LDL) and glucose tolerance as primary outcomes and body fat percentage as a secondary outcome. The periods of follow-up (intervention) were from April 20/ 2022 to June 2022.

Measurement of study variables

Oral Glucose Tolerance Test (OGTT)

The oral glucose tolerance test (OGTT) measures how well the body can breakdown and use sugar (glucose) as well as clear it from the blood stream [41]. The glucose AUC (area under the curve) is a measure used in glucose tolerance tests to quantify the body's response to glucose over a specified period. It represents the total exposure to glucose following an intervention, like consuming a glucose load. AUC is calculated by plotting blood glucose levels over time and measuring the area under this curve [42]. After an overnight fast, blood samples for determination of glucose concentrations were taken at 0, 30, 60, and 120 min after a standard 75 g of oral glucose dissolved in 300 ml of water was given orally, and the blood samples were allowed to drink within 5 min [43]. Blood samples were taken 48 h after the previous training session and after a 12-h fast. After being drawn, blood samples were centrifuged and kept at -80 °C for 30 min. Glucose was analyzed by the hexokinase method (COBAS, Roche), and its intracoefficient of variation ranged between 1.58% ($\mu = 64.7$ mg/dl) and 1.38% ($\mu = 369$ mg/dl). The area under the curve of glucose was calculated using the trapezoidal rule and compared. Plasma glucose (PG-AUCs) were calculated by trapezoidal approximation of PG levels [44]. PG levels at x min were defined as PG(x), and the PG-AUC was calculated as follows:

$$\mathbf{AUC}(\text{mgh/dl}) = \frac{\boldsymbol{PG}(0) + PG(30) * 2 + PG(60) * 3 + PG(120) * 2}{4}$$

Lipid profile

After a 12-h fasting period, 5 ml of blood was collected from the left median cubital vein of a seated individual at 8:00 AM. Following immediate centrifugation and refrigeration, the samples were analyzed within 24 h. An enzymatic method utilizing an Alpha X autoanalyzer with E2HL-100 kits and a sensitivity of 0.1 mmol/dL (Hitachi, Tokyo, Japan) was employed for lipid measurement.

Body fat percentage

Abdominal, thigh, suprailiac and triceps skinfolds were measured on the right side of the body to the nearest 0.5 mm with a Lange caliper (Cambridge Scientific Instruments, Cambridge, MD, USA). All skinfolds were measured by the same technician. A reliability criterion of 2 mm was established for triplicate measurements, and the mean of these measurements was used for analytical purposes. To determine body fat percentage from skinfold measurements, we initially computed body density values using an equation specifically designed for older adults [45].

Body density = (0.29288 × sum of all the skinfolds) – (0.0005 × sum of all of the skinfolds squared) + (0.15845 × age) – 5.76377.

The body density equations were converted into fat percentage by using the Siri equation: %BF = ((4.95/D) – 4.50) × 100 for the purpose of the analysis [46].

Average daily energy intake

We utilized a 24-h interactive questionnaire with several passes that was developed and validated for use in developing countries. Instruments for measuring food frequency were adapted from Regassa IF, et al.,(2021) [47] The three 24-h sessions were held on Monday, Wednesday and Saturday to capture variation in intakes throughout different days of the week. We applied the Ethiopian food composition table to estimate nutrient and energy levels from dietary data. The names of foods and drinks, their descriptions, cooking methods, and amounts from both 24-h periods were coded and submitted to the NutriSurvey200 [48]. After determining the frequency of consumption per day, we used the product sum approach to determine daily food intake. Daily food intake = ∑ (food item's stated consumption frequency, translated to times per day) * (portion size ingested of that food). The daily average energy intake was also determined as follows: ADEi = ∑daily food intake/number of data collected days.

Exercise intervention protocol

The individuals in the training groups were assigned to aerobic training (AT), resistance training (RT), or combined training (CT). The exercise regimens involved three weekly sessions over a period of eight weeks, with each session lasting 60 min. During each exercise session, participants engaged in a 5 to 10 min warm-up, followed by 30 to 40 min of main training. Finally, they concluded with 5 to 10 min of cool-down. The resistance training (RT) program consisted of six exercises per session, specifically targeting the major muscle groups of the body. The exercises were performed standing plantar flexion, squatting, machine leg press, neutral reowing, bicep curl, triceps pulley, dumbbell curl, and vertical bench press. The exercise routine involved three sets per day, with 8 to 12 repetitions at an intensity of 50% to 75% of their one-repetition maximum (1RM). The remaining intervals between each set and between training sessions were approximately 1 to 1.5 min and 48 to 72 h, respectively [49]. The aerobic exercise involved using a treadmill at an intensity level ranging from 50 to 75% of the maximum heart rate (HR max). The goal was to burn approximately 500 cal per session [50]. The combined exercise group (CT) followed a training program that included the same amount of exercises as the aerobic group (AT) and the resistance group (RT), which performed three exercises per session.

In each session, participants performed endurance exercises before moving on to strength exercises. Details of the general training intervention approach are outlined in Table 1. This specific exercise order was selected to explore the impact of aerobic training preceding strength training [51]. To minimize potential confounding factors, participants were explicitly advised not to engage in any additional resistance-type or aerobic training throughout the duration of the study.

Statistical analysis

The data were analyzed using SPSS version 26 (SPSS Inc., Chicago, IL). A paired t test was used to examine the differences in the baseline and follow-up variables within the group because within-subject information in the RM-ANCOVA output was inaccurate [52]. The researchers ensured reliable results by applying a Bonferroni correction for multiple comparisons in their RM-ANCOVA, with average daily energy intake as the covariate, which was performed for HDL, LDL, TC, AUC and %BF. Changes over time were compared among participants, while exercise types were compared among groups. Interactions between these factors were also investigated. All the statistical tests were two-tailed, and a p value of 0.05 or less was considered to indicate statistical significance.

Results

Table 2 summarizes the descriptive data characteristics at baseline and the adjusted absolute changes in %BF, AUC, HDL, LDL and TC levels during the study period. Four participants were dropped from the experiment due to exercise-induced injuries, parting a total of 20 participants who finished the study and were included in the analysis, 7 in the AT, 6 in the RT and 7 in the CT.

The average ages of the participants in the respective groups were AT = 49.00 ± 2.08, RT = 49.83 ± 3.06 and CT = 48.71 ± 2.87. The average body mass index of participant in AT, RT and CT group were 27.84 ± 1.10, 27.45 ± 0.74 and 27.70 ± 0.85 respectively. The results revealed no significant differences in any of the variables among the three groups in the pretest, suggesting successful randomization of the study participants.

However, there were significant differences in the %BF, AUC, HDL, LDL and TC between the pretest and posttest after 8 weeks of intervention in all three groups. The results indicated that after they received the aerobic training, body fat percentage in the aerobic training group was t (6) = 9.306, $p < 0.01$; in the RT group, t (5) = 11.158, $p < 0.01$; and in the CT group, t (6) = 8.294, $p < 0.01$. The area under the curve for the older adults' means for the pretest and posttest results differed significantly between the aerobic training groups: t (6) = 7.054, $p < 0.001$; RT: t (5) = 11.904, $p < 0.001$; and CT: t (6) = 9.56, $p < 0.001$. We also found that high-density lipoprotein levels significantly improved between the pretest and posttest scores in the aerobic training group. This improvement was observed for AT ($P < 0.012$), RT ($P < 0.013$) and CT ($P < 0.001$). The study additionally demonstrated a statistically significant improvement in AT (t (6) = 33.806, $p < 0.001$), RT (t (6) = 12.504, $p < 0.001$) and CT (t (6) = 10.405, $p < 0.001$) in low-density lipoprotein (LDL) cholesterol levels between the pretest and posttest within the aerobic training group. In

Table 1 Training details

Weeks	Intensity				Duration			
	AT(HR_{max})	RT (1RM)	CT		AT (minutes)	RT (3 sets)	CT	
			AT	RT			AT	RT
Week 1 &2	65% -70%	50%-55%	65% -70%	50%-55%	25	10–12	13	10–12
Week 3&4	70%-75%	55%-60%	70%-75%	55%-60%	30	10–12	15	10–12
Week 5&6	75%-80%	60%-65%	75%-80%	60%-65%	35	10–12	17	10–12
Week 7&8	80%-85%	70%-75%	80%-85%	70%-75%	40	10–12	20	10–12

Table 2 Baseline and follow-up characteristics

Variable	AT		RT		CT	
	Baseline	Follow-up	Baseline	Follow-up	Baseline	Follow-up
Age	49.00 ± 2.08		49.83 ± 3.06		48.71 ± 2.87	
ADEi	2885.00 ± 109.180		= 2636.00 ± 98.82		2753.70 ± 178.12	
BMI	27.84 ± 1.10		27.45 ± 0.74		27.70 ± 0.85	
%BF	21.07 ± 1.472	14.73 ± 0.39	22.36 ± 0.99	16.06 ± 0.552	21.91 ± 1.52	15.39 ± 0.294
AUC	294.03 ± 4.425	291.11 ± 2.7	294.33 ± 8.05	249.77 ± 3.76	294.35 ± 11.6	273.76 ± 2.004
HDL	39.94 ± 2.51	44.35 ± 1.019	39.09 ± 1.525	44.71 ± 1.417	40.69 ± 2.475	43.26 ± 0.753
LDL	128.50 ± 1.09	119.84 ± 1.32	127.19 ± 1.61	116.34 ± 1.84	128.98 ± 2.503	120.05 ± 0.979
TC	237.72 ± 8.20	170.46 ± 3.41	235.44 ± 3.19	209.91 ± 4.744	232.35 ± 4.94	187.38 ± 2.523

BMI pre-test body mass index, *%BF* Body fat percentage, *AUC* Area under curve, *HDL* High-density lipoprotein cholesterol, *LDL* Low-density lipoprotein, *TC* Total cholesterol. The values are presented as the means ± standard deviations. Covariates appearing in the model were evaluated at average daily energy intake (ADEi) = 2671.5620.$_a$

all three groups, the participants' total cholesterol levels decreased significantly after the training compared to before they started, as shown in Table 3.

Table 4 shows that the main effect of exercise modality on the AUC was significant, F (2, 16) = 10.577, P = 0.001, η^2 = 0.569. Post hoc analyses using the Bonferroni post hoc criterion for significance indicated that the area under the curve from the OGTT was significantly lower for RT (-30.653 ± 6.766, p = 0.001) with 11.53% and CT (M = -0.896, SE = 3.347, P = 0.015) with 3.79% exhibited greater significant reduction compared to AT.

Low-density lipoprotein F (2, 26) = 6.33, p = 0.009, η^2 = 0.442 parameters were significantly lower in the AT by 3.7% and CT by 3.79% groups (MD = 4.783, SE = 1.563, P = 0.002 and M = 4.57, SE = 1.284, P = 0.008) respectively than in the RT group. There was a significant difference in total cholesterol between the training modalities, F (2, 16) = 4.849, P = 0.023, η^2 = 0.377. Interns with independent variables AT showed a significant reduction in RT (MD = -17.716, SE = 5.705, P = 0.02) representing 7.97% reduction. Despite observing a significant difference between the pretest and posttest results for high-density lipoprotein (HDL) and percentage of body fat (%BF), there was no significant difference attributable to the independent variables affecting these variables.

There was a significant group × time interaction for the area under the curve from the OGTT test results (F (2, 16) = 9.002, p = 0.002), η^2 = 0.530, high-density lipoprotein: F (2, 16) = 4.064, P = 0.037, η^2 = 0.337, TC: F (2, 16) = 15.075, P < 0.001, η^2 = 0.653), and no significant interaction for body fat percentage and high-density lipoprotein was detected. The results suggest that time had a different effect on the AUC, LDL and TC depending on the group, while the effect of time on %BF and HDL was the same across all groups.

Discussion

Over an intervention time of eight weeks, exercise emerged as a potent metabolic health intervention for obese older adult men. This program resulted in a remarkable decrease in body fat percentage and the levels of both "bad" cholesterol (LDL and TC). Simultaneously, it enhances the body's capacity to regulate blood sugar (glucose tolerance). Intriguingly, throughout the program, "good" cholesterol (HDL) levels improved while average daily energy intake was controlled. These

Table 3 Test within-subject effect changes in outcomes by time points of intervention

Variables	Between-Subjects Effects			Pairwise Comparison						
	F	Sig.[b]	η^2	Mean Difference	Std. Error	F	Sig.[b]	95% CID		η^2
								Lower Bound	Upper Bound	
%BF	6.633	.020	.293	6.368	0.372	6.633	0.001	5.578	7.157	0.293
AUC	7.923	.012	.331	22.096	0.217	7.923	0.001	19.516	24.677	0.331
HDL	2.192	.047	.162	-4.268	0.448	0.192	NS	-5.218	-3.319	0.012
LDL	8.470	.010	.346	9.340	0.690	8.470	0.000	7.878	10.802	0.346
TC	5.304	.035	.249	45.867	1.744	5.304	0.027	42.170	49.565	0.249

%BF Body fat percentage, *AUC* Area under curve, *HDL* High-density lipoprotein cholesterol, *LDL* Low-density lipoprotein, *TC* Total cholesterol

Table 4 Test between subject effect changes in outcomes within treatment groups

Variables	Between-Subjects Effects			Pairwise comparison					
	F	Sig.[b]	η^2	Treatment groups	Mean Difference	Std. Error	Sig.[b]	95% CID	
								Lower Bound	Upper Bound
%BF	1.179	NS	0.128	AT-RT	-0.983	0.889	NS	-3.385	1.419
				AT-CT	-0.671	0.44	NS	-1.859	.517
				RT-CT	0.312	0.739	NS	-1.662	2.286
AUC	10.577	0.001	0.569	AT-RT	30.653	6.766	0.001	12.567	48.739
				AT-CT	10.896	3.347	0.015	1.950	19.841
				RT-CT	-19.758	5.561	0.08	-34.622	-4.893
HDL	0.224	NS	0.027	AT-RT	1.436	2.149	NS	-4.310	7.181
				AT-CT	0.450	1.063	NS	-2.392	3.292
				RT-CT	-0.983	1.767	NS	-5.707	3.737
LDL	6.33	0.009	0.442	AT-RT	4.783	1.563	0.002	.606	8.960
				AT-CT	0.213	0.773	NS	-1.853	2.279
				RT-CT	-4.570	1.284	0.008	-8.003	-1.137
TC	4.849	0.023	0.377	AT-RT	-17.716	5.705	0.02	-32.965	-2.468
				AT-CT	-5.570	2.822	NS	-13.112	1.972
				RT-CT	12.146	4.689	0.050	-.387	24.678

%BF Body fat percentage, *AUC* Area under the curve, *HDL* High-density lipoprotein cholesterol, *LDL* Low-density lipoprotein, *TC* Total cholesterol, *NS* Not significant. Covariates appearing in the model are evaluated at the following values: average daily energy intake = 2671.5620

findings align with studies involving longer exercise durations, such as the 32-week program described [40].

These findings have established a physiological foundation supporting the hypothesis that resistance training may elicit favorable alterations in glucose tolerance. Similarly, other investigators have reported that strength training also reduces basal and glucose-stimulated insulin levels [53, 54]. In contrast, both the aerobic training (AT) and resistance training (RT) groups demonstrated improvements in glucose tolerance (Smutok et al., 1994).

Our analysis indicated that compared with RE, AE and concurrent training are the most effective exercise modalities for reducing LDL and TC in older adults. The present study implemented an 8-month aerobic exercise intervention involving 111 randomly selected participants. The results indicated that the exercise group experienced a significant reduction in total cholesterol (TC) and low-density lipoprotein cholesterol (LDL-C) levels among centrally obese older adults [55]. A similar study involving sedentary older adults who participated in a 16-week exercise intervention was performed. Similarly, studies on the effects of different exercise modalities on lipid metabolism in individuals with concurrent type 2 diabetes and obesity According to a narrative review, regular exercise helps to raise HDL-C levels [56] while lowering TG, TC, VLDL, and LDL-C at the same time [57]. The findings of the other comprehensive review revealed that there were no noteworthy variations in low-density lipoprotein cholesterol levels between the AEDT and ST groups [58]. A separate investigation revealed that exercise modality had no effect on blood lipids. Over time, the lipid levels were decreased in all groups. There was a considerable decrease in triglycerides, low- and high-density lipoprotein, and total cholesterol. The decline in all groups could [59]. This discrepancy could be attributed to inadequate energy expenditure during resistance exercise compared to aerobic exercise with low to moderate intensity [60].

The results of this study highlight that there were no significant differences in the effect on high-density lipoprotein (HDL) or percentage of body fat (%BF) levels among AT, RT and CT. These results align with the work of Moraleda et al., who similarly demonstrated that HDL cholesterol remained significantly unchanged across groups [61] and % BF [62]. In contrast, in a previous study, resistance exercise exhibited a more robust association with HDL levels than did aerobic exercise ($\beta = 2.56210$, $p < 0.0001$ vs. 1.33748, $p < 0.0001$) [63]. In contrast to our results, fat mass was reduced more in the AT and CT groups than in the RT group [62].

One limitation of this study is the absence of a non-intervention control group, which restricts the ability to fully attribute observed changes solely to the intervention. While the study was designed with random assignment and control of key confounding factors, the lack of a traditional control group limits the ability to isolate the effects of the intervention from other potential influences. Future research should consider incorporating a non-exercising control group to strengthen the validity of causal inferences and provide a more comprehensive understanding of the intervention's impact. However, the observed differences in the effectiveness of each modality suggest that individualized exercise prescriptions could optimize outcomes, especially for older adults. Future studies should explore the long-term effects of these interventions and evaluate whether combining different modalities yields synergistic benefits. Additionally, more diverse participant groups and the inclusion of non-exercising control groups will be essential in validating these results and refining clinical guidelines.

Conclusion

Aerobic training (AT) and combined training (CT) were more effective at reducing low-density lipoprotein (LDL) and total cholesterol (TC) levels. Moreover, resistance training (RT) and combined training (CT) demonstrated greater efficacy than aerobic training (AT) in reducing glucose intolerance among previously inactive obese older adults. Interestingly, there was a significant change in the pretest and posttest levels of high-density lipoprotein (HDL) and percentage of body fat (%BF). However, when comparing aerobic training (AT), resistance training (RT), or a combination of both programs, there was no significant difference. Interestingly, the effect of time on AUC, LDL, and TC varied depending on the group, while the effect of time on %BF and HDL remained consistent across all groups.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13102-024-00982-7.

Supplementary Material 1.

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Adverse effect report

No adverse effects were recorded in participants during and after the intervention.

Authors' contributions

All authors contributed significantly to this work. Friew Amare conceived and designed the study methodology. Yehualaw Alemu, solomon Adamu and mollalign Enchalew involved in intervention performed the investigation. Friew and Yalemsew conducted the formal analysis. Friew and Yehualaw drafted the original manuscript. All authors participated in reviewing and editing the manuscript. All authors oversaw the project and managed project administration. All authors meet the criteria for authorship by substantially contributing to the research, manuscript preparation, and approval for publication.

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Data availability

The data that support the findings of this study are not openly available due to reasons of sensitivity and are available from the corresponding author upon reasonable request.

Availability of data and materials

The datasets generated and/or analyzed during the current study are not publicly available due to data security before publication but are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The trial was approved by the Ethics Review Board of Debre Markos University of Sport Sciences Academy (Reference number: SPSC 05/22). All the participants were informed about the intervention and possible adverse events before the commencement of the trial and signed an informed consent form.

Consent for publication

Not Applicable.

Competing interests

The authors declare no competing interests.

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