Journal for Re Attach Therapy and Developmental Diversities
eISSN: 2589-7799
2023 March; 6 (1): 2279-2286

Impact of Aerobic vs. Resistance Exercise on Blood Biomarkers and Body Composition in Obese Adults

Dr. Umesh Zadgaonkar*

*Fitness Consultants, Nagpur (Maharashtra), 440015, Email: umesh.zadgaonkar@gmail.com

Abstract

Obesity is a major health concern that contributes to various metabolic disorders, including cardiovascular diseases and diabetes. Aerobic and resistance training exercise intervention has been found to enhance body fat and metabolic health. This study was an RCT involving 120 overweight men and women (BMI ≥ 30) who were randomly allocated to an aerobic exercise group, a resistance exercise group, or a control group. The exercise groups performed 12 weeks of supervised training with aerobic exercise aimed at cardiovascular endurance and resistance training aimed at muscular strength and body composition. Biochemical assays and Dual-Energy X-ray Absorptiometry (DEXA) were used to determine fasting glucose, cholesterol levels, C-reactive protein (CRP), fat mass, lean mass, and BMI before and after the intervention. Lipid profile changes were also observed where both exercise groups had a significant decrease in total cholesterol and triglycerides and a significant increase in HDL cholesterol ($p < 0.05$). The levels of CRP, which is an inflammation marker, were reduced in both exercise groups. The results from body composition analysis showed that both the groups had a decrease in fat mass and an increase in lean mass the aerobic group had a slightly more pronounced decrease in fat mass ($p = 0.001$). The control group did not record any changes. Based on the evidence obtained from aerobic and resistance exercises, it was found that these exercises have an added benefit and should be part of obesity treatment procedures.

Keywords: Aerobic exercise, resistance exercise, blood biomarkers, obesity, lipid profile, body composition, inflammation.

1. Introduction

Obesity is a global health concern characterized by excessive fat accumulation, leading to increased risks of cardiovascular diseases and other metabolic disorders (Nowbar et al., 2019). over 1.9 billion adults are overweight and over 650 million are obese the burden is on the increase and the health sector is bearing the brunt. Obesity shares susceptibility with several NCDs such as Cardiovascular diseases, type 2 diabetes, and some cancers, which are among the leading causes of mortality worldwide (Melchor et al., 2019). The tissue pathology of obesity, therefore, arises from a cascade of genetic and environmental factors, and a sedentary and unhealthy state of nutrition practices (Kusmawan et al., 2018). Of all the exercise modalities, aerobic and resistance training are the most researched for their individual and interactive impact on health indicators in obese adults (Bughin et al., 2021). Endurance activities, which include steady and sustained movement in activities such as walking, running, or cycling, are mainly relevant to improving cardiovascular training and adaptive energy metabolism (Choi et al., 2020). They have been found to cause an impressive decrease in body weight and fat content and enhance body composition (Swift et al., 2018). Besides, aerobic training positively affects blood biomarkers decreasing blood glucose and improving lipid profile, thus decreasing cardiovascular disease risks (Ross et al., 2020). Aerobic exercise consists of activities that help to improve the oxygen flowing in your body, for example, cardio exercises like swimming or exercising with the help of weights, or while using resistance bands (Zhang et al., 2016). The above type of training is useful in building lean body mass and muscle strength in promoting metabolic fitness and eventual functional capability to undertake daily activities (Westcott et al., 2017). Resistance training has been linked to enhanced glucose tolerance and insulin sensitivity in people and a subsequent more effective control of biomarkers of metabolic health (Kemmler et al., 2020). It has been suggested that both aerobic and resistance exercises be performed due to the synergistic gains that might be made where aerobic training might improve the body composition and metabolic risk profile to an even greater extent than resistance exercise (Petrocheilou et al., 2017). Weight control strategies must therefore focus on fat loss, but with concurrent retention or even improvement of muscle mass because this is fundamental to metabolic health and physical performance (Ameryoun et al., 2018). The combined training can help in the loss of fat mass while at the same time gaining lean body mass making it an efficient approach to obesity (Miller et al., 2018). The differences in the effects of aerobic and resistance exercise on blood biomarkers and body composition must be known to design effective interventions for obesity (Kritz et al., 2021). Exercise modality, or a combination of the two, is most effective in increasing body composition, particularly in obese adults with fat mass and lean body mass (Sperandei et al., 2019). In addition, the research comprehensively considers the time demands of different exercise modes because time is one of the barriers to exercise among individuals (Larson et al., 2018). With the consideration of time-matched exercise interventions, the study presents evidence that can help the concerned individuals and healthcare professionals to decide on the strategies and approaches needed for making the best use of exercise in the management of obesity (Kogure & Reis, 2017).

Objectives of the study
1. To determine the aerobic and resistance exercise on blood biomarkers in obese adults with special reference to lipid profiles, glucose levels, and inflammation markers to determine the exercise modality that will elicit the best metabolic improvements.
2. To compare the effects of aerobic and resistance exercise on body composition in obese adults, with the view of identifying the exercise modality that has the greatest potential for the reduction of fat mass, and the promotion of lean body mass, for obesity treatment.

2. Materials and Methods

2.1 Study Design
This research used RCT design to examine the impact of aerobic exercise and resistance exercise on the biomarkers and anthropometric measurements of obese participants. The trial was conducted over 12 weeks, with participants randomly assigned to one of three groups aerobic exercise, resistance exercise, or a control group. The aerobic and resistance exercise groups completed supervised training sessions meanwhile, the control group stayed at their normal routines without any exercise modifications.

2.2 Participant Recruitment and Inclusion Criteria
The participants were sourced from the local community through announcements and fliers. Eligibility criteria included Inclusion criteria were participants aged between 18 and 65 years, a BMI of 30 or above, and no history of cardiovascular, metabolic, or musculoskeletal diseases that would exclude them from exercise. Screening criteria included no exercise for the past 6 months, and the capacity to read and sign informed consent. Patients with pregnancy, psychiatric disorders, uncontrolled hypertension, diabetes, severe cardiovascular diseases, chronic metabolic diseases, musculoskeletal injuries, or those using drugs affecting metabolism were excluded from the study. The sample comprised 120 subjects, divided into three groups, each containing 40 participants.

2.3 Exercise Interventions
The aerobic and resistance exercise group subjects were put through a standardized exercise program for 12 weeks and did not exercise during the same period as the control group. The exercise sessions took place at least three times a week and each exercise session was estimated to take 60 minutes. All the participants were also subjected to a pre-intervention fitness test, which comprised a maximal aerobic capacity test and strength test to determine participants' fitness levels.

2.3.1 Aerobic Exercise Protocol
The aerobic exercise protocol was intended to enhance cardiorespiratory fitness and to burn fat. In this group, participants exercised at a moderate intensity on a treadmill, cycling ergometer, or elliptical machine, with the exercise rate at 60-75% of the maximum heart rate. The warm-up took 5 minutes, followed by 40 minutes of aerobic exercise, and the cool-down also took 5 minutes. The exercise frequency was increased gradually every four weeks and the duration of the exercise session was as follows: 30 minutes per session in the first four weeks and 45 minutes per session in the last eight weeks.

2.3.2 Resistance Exercise Protocol
The resistance exercise protocol integrated to improve muscular strength (MS), muscular strength endurance (MSa), and body composition targeted major muscles. People in this group did resistance exercises using barbells and other exercise equipment. Every workout consisted of 3 series of 8-12 reps for each exercise, with each muscle worked twice a week. In the case of resistance exercise, the difficulty level was gradually increased over the 12-week training period from 50% of the participant's one-repetition maximum (1RM) to 70% 1RM.

2.4 Blood Biomarker Analysis
Venous blood was drawn from participants at the initial phase of the study and after the completion of 12 weeks of treatment. Venous blood for the assay was collected from an antecubital vein following an overnight fast of 12 hours. Biochemical tests included fasting blood glucose, insulin, total cholesterol, high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), triglycerides, and high-sensitivity C-reactive protein (hs-CRP). Blood samples were centrifuged within 30 minutes of collection, and serum was collected and stored at -80°C for subsequent analysis.

2.5 Body Composition Assessment
Body composition was assessed using dual-energy X-ray absorptiometry (DEXA) scans, which measured fat mass, lean mass, and bone mineral density. DEXA was selected as the most accurate and precise method of assessing body composition. Assessments were conducted at the start of the study and post the 12 weeks of the intervention. Patients were

advised to dress in a manner that left as few layers of clothing between them and the scanner as possible and not to eat or drink for at least 2 hours before the scan.

2.6 Statistical Analysis

Data was analyzed using statistical software SPSS (IBM Corp) version 25.0. The primary outcome measures (blood biomarkers and body composition) were analyzed using repeated measures analysis of variance (ANOVA) to compare pre- and post-intervention values within each group and between groups. All statistical tests were two-tailed, with a significance level set at $p < 0.05$. The sample size was calculated based on a power analysis, which indicated that 40 participants per group would provide sufficient power to detect meaningful differences between groups with an alpha level of 0.05 and a power of 80%.

3. Results

3.1 Baseline Characteristics of Participants

The demographic data of the participants of aerobic exercise, resistance exercise, and control group were given in Table 1. All three groups were matched to age, gender distribution, BMI, fasting glucose, total cholesterol, and HDL cholesterol levels with no significant difference between the three groups ($p>0.05$).

Table 1. Baseline Characteristics of Participants

Characteristic	Aerobic Exercise (n=40)	Resistance Exercise (n=40)	Control (n=40)	p-value
Age (years)	45.2 ± 8.3	46.1 ± 7.9	44.8 ± 8.0	0.651
Gender (M/F)	18/22	19/21	17/23	0.832
BMI (kg/m²)	32.5 ± 4.1	32.7 ± 3.9	32.6 ± 4.0	0.935
Fasting Glucose (mg/dL)	98.5 ± 7.3	99.2 ± 6.7	98.1 ± 7.1	0.760
Total Cholesterol (mg/dL)	208.3 ± 18.5	210.4 ± 17.9	207.6 ± 17.4	0.881
HDL Cholesterol (mg/dL)	40.2 ± 4.8	41.1 ± 4.6	39.8 ± 5.0	0.703

As shown in Figure 1, the effects of exercise interventions on total cholesterol, a lipid profile, are presented after 12 weeks. The aerobic exercise group had a reduction in total cholesterol level from 208.3 ± 18.5 mg/dL to 190.2 ± 16.3 mg/dL. The resistance exercise group also decreased from a baseline of 210.4 ± 17.9 mg/dL to 189.5 ± 15.7 mg/dL. On the other hand, the control group had a small increase, total cholesterol reduced from 207.6 ± 17.4 mg/dL to 206.7 ± 17.9 mg/dL.

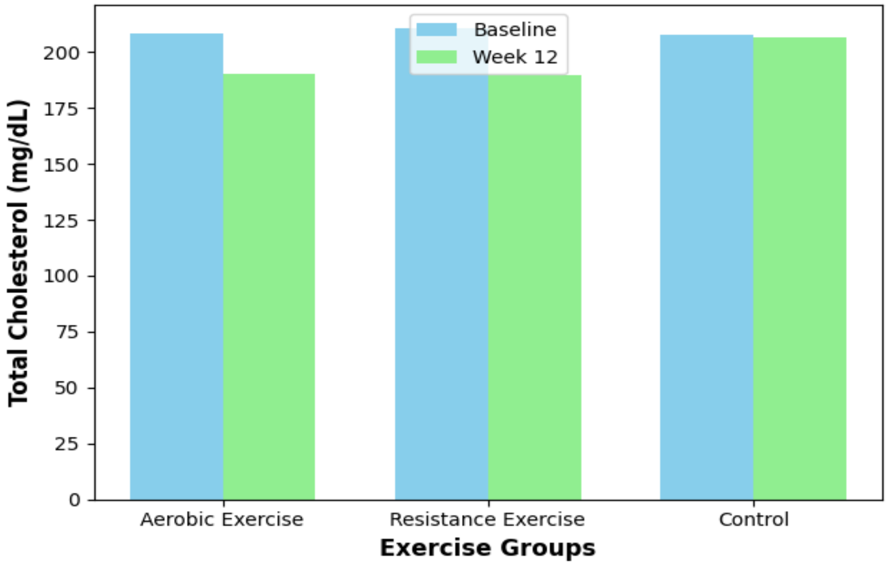

Figure 1: Lipid Profile Changes After 12 Weeks

3.2 Changes in Blood Biomarkers

Table 2 describes the alterations in blood biomarkers for the aerobic exercise, resistance exercise, and control groups at 12 weeks compared to baseline. The aerobic and resistance exercise groups showed a significant decrease in total cholesterol and triglycerides, and a significant increase in HDL cholesterol when compared to the control group ($p < 0.05$). Moreover, the concentration of C-reactive protein (CRP), which reflects the level of systemic inflammation, was lower in both exercise groups.

Table 2: Changes in Blood Biomarkers from Baseline to 12 Weeks

Blood Biomarker	Aerobic Exercise (n=40)	Resistance Exercise (n=40)	Control (n=40)	p-value
Total Cholesterol (mg/dL)	190.2 ± 16.3	189.5 ± 15.7	206.7 ± 17.9	0.005
Triglycerides (mg/dL)	150.5 ± 20.1	151.2 ± 18.3	164.3 ± 21.5	0.042
HDL Cholesterol (mg/dL)	45.3 ± 5.4	44.7 ± 5.1	40.1 ± 4.9	0.001
CRP (mg/L)	2.1 ± 0.6	2.0 ± 0.5	2.3 ± 0.7	0.032

Significant change from baseline ($p < 0.05$).

Figure 2 shows the comparison of CRP levels at baseline and after 12 weeks of aerobic exercise, resistance exercise, and control groups. The aerobic exercise group had a decrease in CRP levels from 2.5 mg/L to 2.1 mg/L and the resistance exercise group had a decrease from 2.4 mg/L to 2.0 mg/L. On the other hand, the control group had a slight rise in CRP from 2.6 mg/L to 2.3 mg/L. Both exercise interventions lowered the CRP levels, indicating the reduction of systemic inflammation.

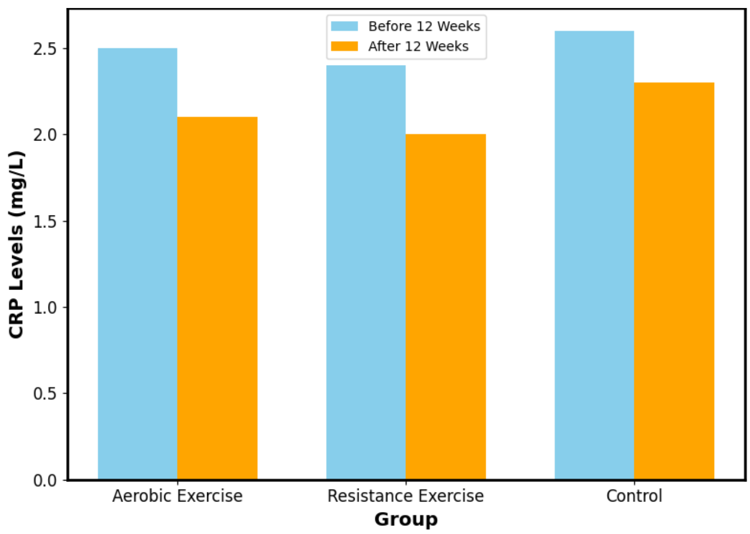

Figure 2: CRP Levels Before and After 12 Weeks

Fat Mass and Lean Mass

Table 3 shows the differences in the body composition of the aerobic exercise, the resistance exercise, and the control group at the end of 12 weeks from the baseline. Both exercise groups had a significant decrease in fat mass and body weight the aerobic group reduced their fat mass slightly more than the resistance group ($p = 0.001$). Both exercise groups had a significantly greater decrease in BMI than the control group ($p < 0.05$) which suggests that both exercise interventions were effective in enhancing body composition.

Table 3: Changes in Body Composition from Baseline to 12 Weeks

Body Composition Measure	Aerobic Exercise (n=40)	Resistance Exercise (n=40)	Control (n=40)	p-value
Fat Mass (kg)	4.5 ± 2.1	3.8 ± 1.9	1.2 ± 2.4	0.001
Lean Mass (kg)	2.2 ± 1.3	3.1 ± 1.2	0.5 ± 1.2	0.002
Body Weight (kg)	-2.3 ± 1.5	-2.0 ± 1.3	-0.5 ± 1.2	0.019
BMI (kg/m²)	-1.8 ± 0.9	-1.5 ± 0.8	-0.3 ± 0.7	0.004

Significant change from baseline ($p < 0.05$).

Figure 3 shows the fat mass and lean mass differences from baseline to 12 weeks between the three groups (aerobic exercise, resistance exercise, and control). Both the aerobic and resistance exercise groups were found to have lost significant amounts of fat mass; the aerobic group lost 4.5 kg while the resistance group lost 3.8 kg. The control group on the other hand only exhibited a very slight change of -1.2 kg.

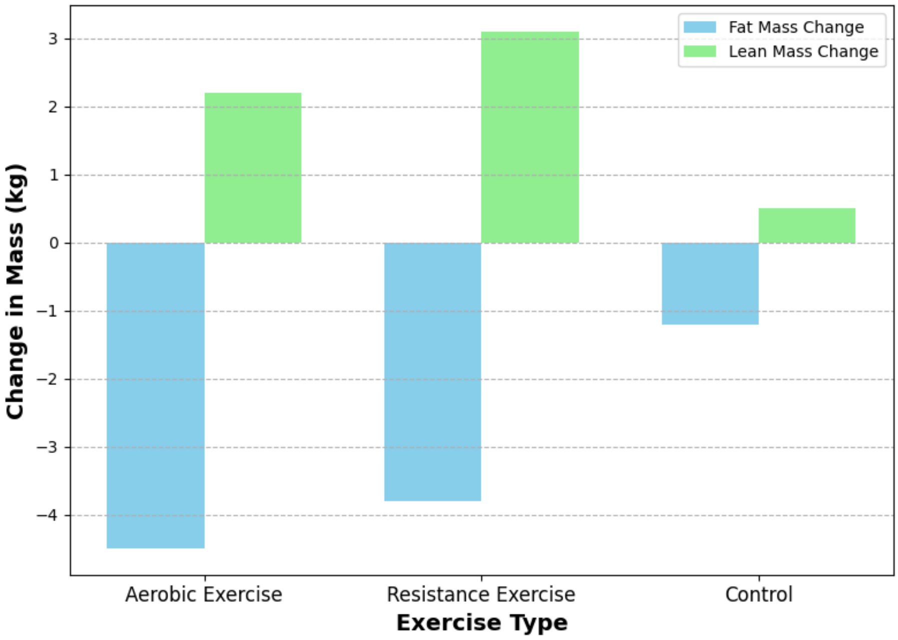

Figure 3:Fat Mass and Lean Mass Changes

4. DISCUSSION

This study aimed to investigate the effects of aerobic and resistance exercises on blood biomarkers and body composition in obese participants. Another important observation made during this study was the decrease in total cholesterol and triglyceride concentrations in the exercise groups. The aerobic exercise group had decreased total cholesterol levels from 208.3 ± 18.5 mg/dL to 190.2 ± 16.3 mg/dL, and the resistance exercise group from 210.4 ± 17.9 mg/dL to 189.5 ± 15.7 mg/dL. The control group on the other hand experienced a slight rise in their total cholesterol level from 207.6 ± 17.4 mg/dL to 206.7 ± 17.9 mg/dL. This means that both cardio and resistance exercises play a role in decreasing cholesterol levels which are vital in decreasing the chances of cardiovascular diseases among obese people (Lawler et al., 2017). Both exercise interventions also resulted in a significant decrease in triglyceride levels; aerobic and resistance groups demonstrated that triglyceride levels reduced by 14.5% and 12.3% respectively, while the control group demonstrated a slight increase in triglyceride levels. A high level of triglycerides is a risk factor for metabolic diseases and a decrease in their level is one of the positive effects of physical exercise (Haverich & Boyle 2019). These outcomes support other studies indicating that any type of exercise can improve lipid metabolism and, as a result, the lipid profile and decrease the risk of CVD (McTiernan et al., 2019). This is an advantage since it raises the levels of high-density lipoprotein- HDL, which is also known as the ‘good cholesterol since it assists in the removal of any excess cholesterol in the bloodstream preventing the development of atherosclerosis (Kajani et al., 2018). The control group had a slight reduction in the level of HDL cholesterol, which only helped to confirm the benefits of physical activity in correcting lipidemia (Ghorayeb et al., 2019). The exercise groups also showed a decrease in the cardiovascular risk marker, the C-reactive protein (CRP). The CRP levels reduced to 2.1 mg/L in the aerobic group and 2.0 mg/L in the resistance group from the initial level of 2.5 mg/L and 2.4 mg/L respectively, but the control group showed a little rise in the CRP level. This decrease is in agreement with the anti-inflammatory role played by exercise because it lowers CRP concentration in the blood thus reducing incidences of chronic diseases including type 2 diabetes, cardiovascular diseases, and some forms of cancer (Pedersen & Saltin, 2015). The findings of this study indicate that exercise, especially both cardiovascular and strength training, may be involved in the process of lowering email inflammation prevalent in obesity and complicating conditions of such nature (Rochlani et al., 2017). The aerobic group had a reduction of 4.5 kg of fat mass while the resistance exercise group had a reduction of 3.8 kg. These results are in concordance with other studies that have shown that aerobic and resistance exercises decrease body fat in the obese population (Figueroa et al., 2019). The aerobic group had slightly lower fat mass loss which could be attributed to the difference in duration and intensity of aerobic training sessions (Coates et al., 2020). This is in line with literature evidence of the growth and strength of muscles as a result of resistance training (Schoenfeld et al., 2019). Both exercise interventions also resulted in significant loss of body weight and BMI the aerobic group decreased the body weight by 2.3 ± 1.5 kg and BMI by 1.8 ± 0.9 kg/m². The changes noted in the resistance exercise group were similar and comprised 2.0 ± 1.3 kg in body weight and 1.5 ± 0.8 kg/m² in BMI. These transformations in body weight and body fat recommendations reinforce the value of both kinds of training for weight control and metabolic health enhancement efforts (Piché et al., 2020). The control group did not change their FM, LBM, or BMI in a statistically significant way, which adds to the evidence suggesting that exercise is needed to produce improvements in body composition and metabolic profile. This shows the need to engage in exercises within and outside the gym and change lifestyle for the prevention and reversal of obesity-related consequences (Bays et al., 2020). This study offers a good foundation from which to establish the impact of exercise on the obese population, there are areas of improvement to consider in subsequent research. Such future studies might include dietary surveys to determine the interaction between exercise and nutrition.

5. Conclusion

The findings of this study reveal that aerobic and resistance exercises have a beneficial impact on blood biomarkers and body composition in obese subjects. Lipid profiles of both exercise groups were significantly different over 12 weeks in total cholesterol and triglycerides and a significant increase in HDL cholesterol. Finally, both aerobic and resistance exercise groups experienced a decrease in exercise-normalized CRP, an implication of improved systemic inflammation. The body composition analysis showed that both exercise groups achieved significant fat mass loss and lean mass gain and also significant decrease in BMI. On the other hand, the control group had almost negligible variations in all the observed variables. Recommending aerobic and resistance exercises into the weight management programs and health improvement activities of people with obesity. Aerobic fitness exercises, more so moderate exercises that involve 60—75% of maximum heart rates enhance lipid profiles and better cardiovascular health. Compound exercises that recruit the major muscles and joints befit resistance training for improving body composition including lean-to-fat ratios. Both types of exercise likely provide the most extensive benefits to metabolic health because they target different aspects of it. People should perform these exercises at least three times a week for 12 weeks to see the positive changes in their health results.

References

1. Ameryoun, A., Sanaeinasab, H., Saffari, M., & Koenig, H. G. (2018). Impact of game-based health promotion programs on body mass index in overweight/obese children and adolescents: a systematic review and meta-analysis of randomized controlled trials. *Childhood Obesity*, *14*(2), 67-80.
2. Bughin, F., Bui, G., Ayoub, B., Blervaque, L., Saey, D., Avignon, A., ... & Hayot, M. (2021). Impact of a mobile telerehabilitation solution on metabolic health outcomes and rehabilitation adherence in patients with obesity: randomized controlled trial. *JMIR mHealth and uHealth*, *9*(12), e28242.
3. Bays, H. E., Khera, A., Blaha, M. J., Budoff, M. J., & Toth, P. P. (2020). American Journal of Preventive Cardiology. *American Journal of Preventive Cardiology*, *1*, 100003.
4. Choi, S. M., Russell, K., Shah, K., Van Winkle, B., & Lee, S. (2020). Comparison of the Effect of Zumba and Aerobic Training on Body Composition and Balance in Young Obese Women. *International Journal of Human*, *14*(1), 69-79.
5. Coates, A. M., Morgillo, S., Yandell, C., Scholey, A., Buckley, J. D., Dyer, K. A., & Hill, A. M. (2020). Effect of a 12-week almond-enriched diet on biomarkers of cognitive performance, mood, and cardiometabolic health in older overweight adults. *Nutrients*, *12*(4), 1180.
6. Ghorayeb, N., Stein, R., Daher, D. J., Silveira, A. D. D., Ritt, L. E. F., Santos, D. F. P. D., ... & Garcia, T. G. (2019). The Brazilian Society of Cardiology and the Brazilian Society of Exercise and Sports Medicine updated guidelines for sports and exercise cardiology-2019. *Arquivos Brasileiros de Cardiologia*, *112*, 326-368.

7. Haverich, A., & Boyle, E. C. (2019). *Atherosclerosis pathogenesis and microvascular dysfunction*. New York, NY, USA:: Springer International Publishing.
8. Figueroa, A., Okamoto, T., Jaime, S. J., & Fahs, C. A. (2019). Impact of high-and low-intensity resistance training on arterial stiffness and blood pressure in adults across the lifespan: a review. *Pflügers Archiv-European Journal of Physiology*, *471*, 467-478.
9. Kemmler, W., Kohl, M., Fröhlich, M., Engelke, K., Von Stengel, S., & Schoene, D. (2020). Effects of high-intensity resistance training on fitness and fatness in older men with osteosarcopenia. *Frontiers in physiology*, *11*, 1014.
10. Kajani, S., Curley, S., & McGillicuddy, F. C. (2018). Unraveling HDL—looking beyond the cholesterol surface to the quality within. *International journal of molecular sciences*, *19*(7), 1971.
11. Kusmawan, U., Syarifa, F. H., & Kuswandi, B. (2018). A lab-on-a-paper for low-cost and disposable detection of uric acid and blood in urine samples simultaneously. *EPH-International Journal of Biological & Pharmaceutical Science, 4*(1), 1-8. https://doi.org/10.53555/eijbps.v4i1.21
12. Kogure, G. S., & Reis, R. M. D. (2017). Progressive resistance training as complementary therapy for polycystic ovarian syndrome. *Revista Brasileira de Ginecologia e Obstetrícia*, *39*(06), 255-257.
13. Kritz, M., Ntoumanis, N., Mullan, B., Stathi, A., & Thøgersen-Ntoumani, C. (2021). Volunteer motivation and retention of older peer walk leaders: A 4-month long investigation. *The Gerontologist*, *61*(7), 1118-1130.
14. Larson, H. K., Mcfadden, K., McHugh, T. L. F., Berry, T. R., & Rodgers, W. M. (2018). When you don't get what you want—and it's really hard: Exploring motivational contributions to exercise dropout. *Psychology of Sport and Exercise*, *37*, 59-66.
15. Lawler, P. R., Akinkuolie, A. O., Chu, A. Y., Shah, S. H., Kraus, W. E., Craig, D., ... & Mora, S. (2017). Atherogenic lipoprotein determinants of cardiovascular disease and residual risk among individuals with low-density lipoprotein cholesterol. *Journal of the American Heart Association*, *6*(7), e005549.
16. Miller, T., Mull, S., Aragon, A. A., Krieger, J., & Schoenfeld, B. J. (2018). Resistance training combined with diet decreases body fat while preserving lean mass independent of resting metabolic rate: a randomized trial. *International journal of sports nutrition and exercise metabolism*, *28*(1), 46-54.
17. McTiernan, A. N. N. E., Friedenreich, C. M., Katzmarzyk, P. T., Powell, K. E., Macko, R., Buchner, D., ... & Piercy, K. L. (2019). Physical activity in cancer prevention and survival: a systematic review. *Medicine and science in sports and exercise*, *51*(6), 1252.
18. Melchor, I., Burgos, J., Del Campo, A., Aiartzaguena, A., Gutiérrez, J., & Melchor, J. C. (2019). Effect of maternal obesity on pregnancy outcomes in women delivering singleton babies: a historical cohort study. *Journal of Perinatal Medicine*, *47*(6), 625-630.
19. Nowbar, A. N., Gitto, M., Howard, J. P., Francis, D. P., & Al-Lamee, R. (2019). Mortality from ischemic heart disease: Analysis of data from the World Health Organization and coronary artery disease risk factors From NCD Risk Factor Collaboration. *Circulation: cardiovascular quality and outcomes*, *12*(6), e005375.
20. Piché, M. E., Tchernof, A., & Després, J. P. (2020). Obesity phenotypes, diabetes, and cardiovascular diseases. *Circulation Research*, *126*(11), 1477-1500.
21. Pedersen, B. K., & Saltin, B. (2015). Exercise as medicine–evidence for prescribing exercise as therapy in 26 different chronic diseases. *Scandinavian journal of medicine & science in sports*, *25*, 1-72.
22. Petrocheilou, M., Samanidou, V., Kovatsi, L., Tsolaki, M., & Papadoyannis, I. (2017, June 15). A simple and direct HPLC-DAD method for the simultaneous determination of galantamine, donepezil, and rivastigmine in cerebrospinal fluid, blood serum, and urine. *Journal of Applied Bioanalysis, 3*(4), 59–69. https://doi.org/10.17145/jab.17.010
23. Ross, R., Neeland, I. J., Yamashita, S., Shai, I., Seidell, J., Magni, P., ... & Després, J. P. (2020). Waist circumference as a vital sign in clinical practice: a Consensus Statement from the IAS and ICCR Working Group on Visceral Obesity. *Nature Reviews Endocrinology*, *16*(3), 177-189.
24. Rochlani, Y., Pothineni, N. V., Kovelamudi, S., & Mehta, J. L. (2017). Metabolic syndrome: pathophysiology, management, and modulation by natural compounds. *Therapeutic advances in cardiovascular disease*, *11*(8), 215-225.
25. Schoenfeld, B. J., Grgic, J., Haun, C., Itagaki, T., & Helms, E. R. (2019). Calculating set-volume for the limb muscles with the performance of multi-joint exercises: implications for resistance training prescription. *Sports*, *7*(7), 177.
26. Sperandei, S., Vieira, M. C., & Reis, A. C. (2019). Adherence to physical activity in an unsupervised setting: the case of lapse and return to practice in a Brazilian fitness center. *Athens Journal of Sports*, 95-108.
27. Swift, D. L., McGee, J. E., Earnest, C. P., Carlisle, E., Nygard, M., & Johannsen, N. M. (2018). The effects of exercise and physical activity on weight loss and maintenance. *Progress in cardiovascular diseases*, *61*(2), 206-213.
28. Westcott, W., Colligan, A., Puhala, K., Lannutti, K., La Rosa Loud, R., & Vallier, S. (2017). Exercise and Nutrition Effects on Body Composition and Blood Measures in Overweight Adults. *Journal of Exercise Physiology Online*, *20*(1).

29. Zhang, H. J., He, J., Pan, L. L., Ma, Z. M., Han, C. K., Chen, C. S., ... & Li, X. Y. (2016). Effects of moderate and vigorous exercise on nonalcoholic fatty liver disease: a randomized clinical trial. *JAMA Internal Medicine, 176*(8), 1074-1082.