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Strength training as a potential tool in reducing modifiable cardiovascular risk factors and comparison to aerobic exercise: Review study

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ABSTRACT

Background: Cardiovascular diseases are a group of common ailments that are a leading cause of death worldwide. Various modifiable risk factors are identified, consisting of hypertension, diabetes, dyslipidemia, obesity, and tobacco smoking. This review aims to analyze the influence of strength training on these factors, compare it to the impact of more popular aerobic exercise, and evaluate its potential as an intervention in at-risk populations. *Method:* A systemic search was conducted in the publicly available databases Pubmed and Google Scholar for RCTs and review studies that included CVDs modifiable risk factors and strength or aerobic training intervention. After screening, ten studies were included in the analysis. *Results:* The review concludes that in the case of a few risk factors like hypertension and diabetes, strength training might be a valuable alternative to aerobic exercise. In the case of obesity, smoking cessation, and dyslipidemia, the influence of this intervention is less clear. *Conclusion:* Health practitioners worldwide should approach every patient individually, with careful consideration of the advantages and disadvantages of each intervention. Research indicates that strength training effectively reduces hypertension and increases glycemic control. It may have some value in patients struggling with obesity, dyslipidemia, and smoking cessation. However, personal preference, other benefits of exercises, availability of additional equipment, and other factors should be considered to ensure the best outcome.

Keywords: Strength training, resistance training, cardiovascular risk factors

1. INTRODUCTION

According to WHO, (2020), ischaemic heart disease was the leading cause of death in 2019. That is why an increasing need exists to combat this and other cardiovascular diseases (CVD). In order to more accurately address this problem, modifiable risk factors of cardiovascular diseases were identified, like hypertension, diabetes, obesity, dyslipidemia, and tobacco smoking. Apart from pharmacotherapy and typical medical interventions, an ever-growing body of evidence provides us with unshakable proof that regular and consistent physical activity is essential in preventing the development of risk factors for cardiovascular diseases.

Medical organizations and health professionals on both - global WHO, (2018) and national scales Lloyd-Jones et al., (2010), Jain et al., (2022) have been encouraging physical activity among the population. These programs usually emphasize aerobic exercise with little attention paid to resistance training, believed to be of lesser value. Contrary to those beliefs, there is a growing amount of research indicating that this kind of physical activity may also be an effective tool in combating modifiable cardiovascular risk factors. This review aims to summarise available knowledge about the benefits of strength training in reducing modifiable risk factors of cardiovascular diseases and to compare its effects with more often recommended aerobic activity.

2. METHOD

The search was conducted using publicly available database: Pubmed. Keywords used in the search consisted of: "Strength training, hypertension", "Strength exercise, hypertension", "Resistance exercise, hypertension", "Resistance training, hypertension", "Strength training, diabetes", "Strength exercise, diabetes", "Resistance exercise, diabetes", "Resistance training, diabetes", "Strength training, obesity", "Strength exercise, obesity", "Resistance training, obesity", "Resistance exercise, obesity", "Strength training, lipid levels", "Strength exercise, lipid levels", "Resistance exercise, lipid levels", "Resistance training, lipid levels", "Strength training, smoking cessation", "Strength exercise, smoking cessation", "Resistance training, smoking cessation", "Resistance exercise, smoking cessation".

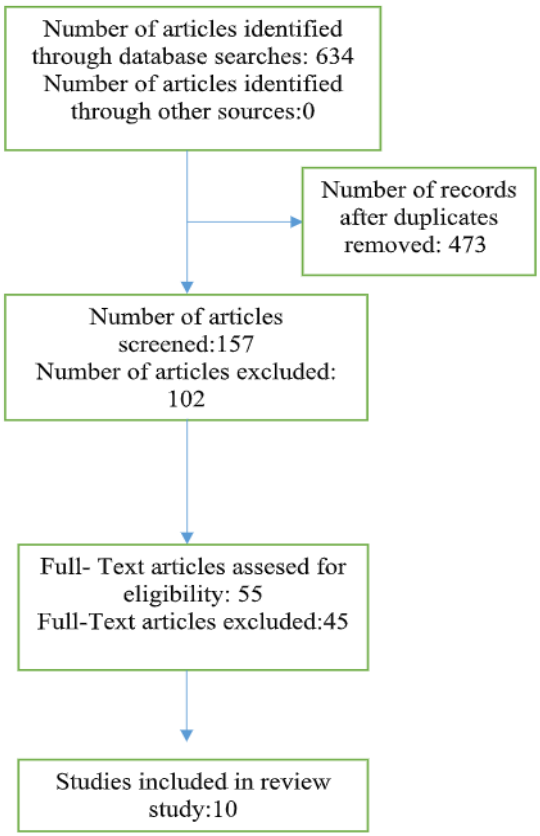

Figure 1 flow chart

The number of records identified through database searches was 634 (Figure 1). The inclusion criteria were Randomized trials and meta-analyses published in English after 2010. The exclusion criteria were non-randomized studies, cohort studies, cross-sectional studies, and case reports. After investigating the articles for these criteria, ten studies that matched the purpose of this review were selected.

3. RESULTS

Hypertension

Hypertension is usually defined as systolic blood pressure greater than 129 mm Hg or diastolic pressure greater than 79mm Hg based on the average of two or more careful readings obtained on two or more occasions (Whelton et al., 2018). Hypertension is a modifiable risk factor for cardiovascular diseases (Centers for Disease Control and Prevention, 2024). Besides pharmacotherapy and a healthy diet, exercise is often encouraged to lower blood pressure. However, most commonly, activities that are recommended to patients are, in some form, aerobic exercises (American Heart Association, 2024). Correia et al., (2023), in their meta-analysis of 14 randomized clinical trials, analyzed the outcomes of at least eight weeks-long strength training interventions in reducing systolic and diastolic blood pressure. They analyzed 253 participants, 75% of whom were hypertensive.

They concluded that strength training intervention of two or three training days per week, for at least eight weeks, had a significant effect on systolic blood pressure, decreasing it by on average by 9.52 mmHg comparing it to baseline, and diastolic pressure was decreased on average by 5.19 mmHg comparing it to a baseline. A study done by Pedralli et al., (2020), while focusing on endothelial function, also compares how different types of exercise influence blood pressure in individuals with prehypertension or hypertension. Forty participants were divided into three groups – resistance training group, aerobic exercise group, and combined exercise group. They each conducted 40-minute exercise sessions twice a week for eight weeks.

The study showed that the resistance and aerobic training groups decreased their mean systolic blood pressure by 4mmHg and 5.1mmHg, respectively, with no effect in the combined training group. This might suggest that aerobic and resistance training can be similarly promising interventions for hypertension (Table 1). Due to less time spent on aerobic training, less than usually recommended working sets (which was doing only two sets of each of the six exercises, compared to 4 sets done by the resistance group) Ralston et al., (2017), and less than usually recommended time to rest between working sets during resistance training part of the workout Schoenfeld et al., (2016), participants in the combined group might not have been able to get above threshold to possibly benefit from either form of exercise.

Table 1 Hypertension studies

Study	Type of study	Number of analyzed participants	Primary outcome
Correia et al., (2023)	Meta-analysis	253	A strength training intervention of two or three training days per week for at least eight weeks decreased systolic blood pressure in patients by, on average, 9.52 mmHg compared to baseline and reduced diastolic pressure on average 5.19 mmHg compared to baseline.
Pedralli et al., (2020)	Randomised Controlled Trial	40	Groups that performed 40-minute strength training sessions twice a week for eight weeks decreased their systolic blood pressure by 4mmHg. Groups that performed 40-minute aerobic training sessions twice a week for eight weeks decreased their systolic blood pressure by 5.1mmHg. Groups that performed 40-minute sessions of combined training twice a week for eight weeks did not see a statistically significant difference in their blood pressure.

Diabetes

One of the most critical factors for cardiovascular diseases is diabetes (Spencer et al., 2008). Across the globe, around one-third of all type 2 diabetes mellitus is affected by CVDs, with cardiovascular diseases contributing to around half of the deaths in T2DM patients (Einarson et al., 2018). That is why controlling sugar levels in diabetic patients is one of the most critical challenges in combating the risk factors of CVD. In their meta-analysis, Jansson et al., (2022) found no statistically significant difference in the influence of HbA1c levels in blood between strength training interventions and aerobic exercises. They included studies that contained two, two to three, or three training sessions per week; however, few studies contained more frequent training, even to the point of everyday exercise.

What is important to point out is that the more significant effect intervention had on muscular strength, the more influential the reduction in HbA1c levels was. Higher blood pressure values are more prevalent in patients with type 1 diabetes Maahs et al., (2005), and prevention of hyperglycemia is one of the most critical factors in reducing the long-term risk of developing hypertension (De-Boer, 2008). Physical activity, in addition to pharmacotherapy, is often encouraged as one method to achieve this goal. In their study, Petschnig et al., (2020) showed resistance training to be an effective method of controlling glycemia in children with type 1 diabetes treated with insulin.

After 32 weeks of resistance training, mean HbA1c levels decreased from 8.75±1.37% to 7.97 ± 1.30%, which was a significant improvement in comparison to the control group, which had no physical activity interventions (from 7.84% ± 1.38% to 8.72% ± 1.33%). It is also important to note that the study showed that after exercise sessions, blood glucose levels measured by self-monitoring devices had decreased significantly, from mean 169.32 ± 18.39 mg·dL−1 to 123.78 ± 17.18 mg·dL−1P < 0.00 or 26.5% ± 4.4% after each session. However, a low number of participants (11 in the intervention group and 10 in the control group) means that data may be insufficient and indicates that further research is required (Table 2).

Table 2 Diabetes studies

Study	Type of study	Number of analyzed participants	Primary outcome
Jansson et al., (2022)	Meta-analysis	1489 (adults with T2DM)	Resistance training considerably reduced HbA1c compared with controls (weighted mean difference=−0.39). Training effect significantly ($p<0.05$) moderated the results, with more significant improvements in muscular strength leading to greater reductions in HbA1c.
Petschnig et al., (2020)	Meta-analysis	21 (children with T1DM)	Strength training performed twice a week for 32 weeks decreased mean HbA1c levels from 8.75±1.37% to 7.97 ± 1.30%, in comparison to the control group of no physical activity interventions (from 7.84% ± 1.38% to 8.72% ± 1.33%).

Obesity

Obesity is one of the most well-documented and known risk factors for cardiovascular incidents (Koliaki et al., 2019). Due to the increasing amount of obese people in the world, a significant number of NGOs, governments, and other health institutions have been promoting physical activity in the general population. However, most of the time, recommended activities are some form of aerobic training, not strength training. Even though it is believed that the health benefits of this kind of training are superior, a growing amount of evidence suggests that strength training may also be effective in combating obesity. In their meta-analysis, Lopez et al., (2022) analyzed 114 trials containing weight training interventions in combating obesity. A total of 4184 participants, including 874 children and adolescents, were involved.

They concluded that resistance exercise was an effective intervention in losing both weight and body fat in nearly every scenario. However, it is essential to note that every scenario included caloric restriction. The most effective interventions were resistance training

+ caloric restriction and resistance training + aerobic exercise + caloric restriction, resulting in mean 5.3kg and 5.6kg body mass loss, respectively. This shows that weight exercises can be used to combat obesity, though they may not be as powerful as aerobic exercise. Willis et al., (2012) conducted a study that directly compared the effects of aerobic and resistance training on body weight and fat mass.

They concluded that even though strength training did not decrease the body mass of individuals during an 8-month exercise protocol, it increased lean body mass. It also showed no statistically significant fat mass loss. Aerobic training, on the other hand, led to a statistically significant loss of fat mass. These two studies prove that aerobic exercise may be a better tool for weight loss without additional interventions. However, combined with caloric restriction, both kinds of physical activity may lead to similar results and should be encouraged by health professionals (Table 3).

Table 3 Obesity studies

Study	Type of study	Number of analyzed participants	Primary outcome
Lopez et al., (2022)	Meta-analysis	4184 including 874 children	Resistance training + caloric restriction and combined resistance and aerobic exercise + caloric restriction were the most effective for reducing body weight with changes of −5.3 kg and −5.6 kg, respectively.
Willis et al., (2012)	Randomised Controlled Trial	119 sedentary, overweight or obese adults	The aerobic training and aerobic training /resistance training saw a reduction of total body mass and fat mass more than RT ($P < 0.05$), but they did not differ from each other. RT and AT/RT increased lean body mass more than AT ($P < 0.05$).

Lipid levels

High serum total cholesterol, LDL concentrations, and triglycerides levels are known risk factors for CVD, also increasing their mortality (Jung et al., 2022). High-density lipoprotein – HDL – is strongly negatively associated with the risk of cardiovascular disease (Gordon et al., 1977). Using this knowledge, various health organizations have created recommendations, usually focused on reducing serum levels of total cholesterol, LDL, and triglycerides while increasing HDL levels (Mach, 2020). Usually, these guidelines include recommending physical activities to individuals with dyslipidemia. However, they are typically not specified, and if they are, they tend to mention more often aerobic exercises like walking, biking, and water sports (Jellinger, 2018). There seems to be a lack of understanding of the influence that strength training has on lipid levels.

A study by Ihalainen et al., (2019) measured how different intensities of strength training influenced metabolic health markers, including HDL and LDL. They divided over one hundred Nordic elders aged 65-75 into four groups. They examined the effect of six months of weight training intervention with different frequency levels during the week. Four groups were not training at all, training once a week, twice a week, and three times a week. Results demonstrated that all three training groups had statistically significantly increased their HDL concentrations, and the group that trained three times a week also showed a statistically significant decrease in LDL concentration.

A study by Ho et al., (2012) compared the influence that weight training, aerobic training, and combined training have on different CVD risk factors in the obese population, including lipid profiles. Candidates were asked to perform exercises five times a week for a duration of 30 minutes for a period of 12 weeks. They were divided into four groups - control, weight training, aerobic, and combined training (consisting of 15 minutes of aerobic and 15 minutes of weight training). Resistance training group did not show any reduction in total cholesterol, LDL, and triglyceride mean levels, but showed a small increase in mean HDL levels from 1.34 ± 0.08 mmol/L to 1.44 ± 0.08 mmol/L.

In comparison, aerobic and combined groups showed no decrease in mean triglyceride levels, total cholesterol decreased in the aerobic group but slightly increased in the combined group, HDL decreased in the aerobic group and combined group, and finally, LDL decreased in the aerobic and the combined group. These results may indicate that 12 weeks of exercise may not be enough to see significant changes in lipid levels or that physical activity may not be an optimal intervention for improving lipid profiles. It seems

more research must be done in this area. An important fact to point out is that in both of these studies, HDL concentrations were consistently higher in strength training groups, indicating that this lipid group may be more sensitive to weight exercise interventions than others (Table 4).

Table 4 Lipid levels studies

Study	Type of study	Number of analyzed participants	Primary outcome
Ihalainen et al., (2019)	Randomised Controlled Trial	106 (age range 65–75 year)	All training groups obtained pre-to post-study growths in high-density lipoprotein concentration. These groups were divided to: Training once, twice and three times a week. Pre-to post-study reductions in LDL concentration were observed only in group training three times a week.
Ho et al., (2012)	Randomised Controlled Trial	Ninety-seven overweight or obese men and women	A 12-week resistance training program at a moderate intensity for 30-min, five days/week resulted in a small increase in mean HDL levels from 1.34 ± 0.08 mmol/L to 1.44 ± 0.08 mmol/L, LDL decreased in aerobic and combined group

Smoking

Smoking is not only one of the cardiovascular disease risk factors but also a risk factor for several other ailments. That's why it is imperative for every healthcare practitioner to actively encourage patients to quit smoking and educate them about the harmfulness of it. Most of the time, these interventions are based on psychological programs aimed at reducing smoking over time, nicotine substitutions using patches, gums, or other products, and, in some cases, drugs like bupropion. In general practice, physical activity is not mentioned in standard smoking cessation treatments. Although the data about the influence of resistance training and aerobic activity on the treatments is scarce, the research that we do have is promising.

In their study, Ciccolo et al., (2011) explored the influence of moderate resistance training intervention, consisting of only two sixty-minute sessions weekly, on standard smoking cessation treatment effectiveness. All participants were treated with nicotine patches, and all received a 15- to 20-min smoking cessation counseling session. Two milestones were identified:

Prevalence abstinence is defined as reported no smoking in the past seven days, obtaining a CO reading <10 ppm, and having no self-reports of smoking or CO ratings >9 ppm at any of the assessments in the previous seven days.

Prolonged abstinence is defined as reported no smoking since the beginning of Week 3 (allowing a two-week grace period after quitting) and obtaining a CO rating <10 ppm at each session.

They reported that in the intervention, group prevalence abstinence at three months and six months was 46% and 38%, respectively, while prolonged abstinence at three months and six months was 16% and 15%, respectively. Comparing it to a control group, which was reported to have a 17% prevalence abstinence at both three months and six months and prolonged abstinence of 8% at both three months and six months, it shows that resistance training can be an aid in reducing smoking in patients. However, it is essential to note that this study had a limited size of only 25 participants, so further research is needed.

Ussher et al., (2019) reviewed 22 studies concerned with smoking cessation for smokers who wished to quit. Cardiovascular exercises were conducted in 17 trials, resistance training was conducted in one trial, combined training was done in one trial, and two trials didn't specify the form of the exercise. They concluded that there is no evidence that adding exercise to smoking cessation treatment improves abstinence compared with support alone. However, the great majority of studies focused on cardiovascular exercise; the only one focused on resistance by Ciccolo et al., (2011), which yielded positive results. This might suggest that strength training could have a higher success rate than cardiovascular exercise, but there is a great need for a more extensive body of evidence to support that (Table 5).

Table 5 Smoking studies

Study	Type of study	Number of analyzed participants	Primary outcome
Ciccolo et al., (2011)	Randomised Controlled Trial	25 smokers	Prevalence and prolonged abstinence were higher at both three months and six months in the intervention group than in the control group
Ussher et al., (2019)	Meta-analysis	7279 adults	Aerobic exercise does not have an impact on success rate of smoking cessation. Only found study with weight training intervention was previously discussed Ciccolo et al., (2011), which had promising results.

4. DISCUSSION

There are a vast number of details that we are still in the process of researching. The optimal exercise selection for decreasing CVD risk factors, details about rest periods between sets, number of sets, how intense each training should be, or how many training days weekly should be considered are still not properly explored. Even though evidence for strength training interventions in at-risk patients is less than ideal, resistance exercise, due to its low-risk nature and great adaptability to the point that severely handicapped people can perform some sort of strength training, should be considered if the patient prefers it. A meta-analysis done by Correia et al., (2023) shows that in the case of hypertension, it might be of equal or similar value to regular aerobic exercise.

A meta-analysis done by Jansson et al., (2022) also shows us that both kinds of interventions, strength, and aerobic ones, are similarly potent tools to control blood sugar, which means that for pre-diabetic and diabetic patients, recommendations for physical activity should be person specific, after taking into consideration other factors like personal goals for a patient, different health predispositions, availability and other details that might influence the final decision. Research on obesity clearly shows that neither aerobic activity nor strength training are good interventions alone, and their role in losing fat mass is supplementary. Studies done on lipid levels seem to indicate that the only lipid fraction positively influenced by strength training is high-density lipoprotein, which may indicate that resistance training may be useful in patients with a concentration of this specific fraction that is too low.

In comparison, aerobic exercise seems to influence positively low density, which could mean it is a better choice for people with problems associated with this specific fraction. There is little to no evidence about smoking cessation and resistance training intervention, and studies done with aerobic exercise show no influence of training on success rate. The only study with strength training found, showed promising results. However, its low number of participants may not be enough to derive conclusions. It looks promising, but we need greater research. While this study focuses on risk factors of cardiovascular diseases, other documented benefits of strength training, like increasing bone density, muscle mass and decreasing the risk of falling in the elderly, should be considered while consulting a patient. Every healthcare provider must address every patient individually, and recommendations should be tailored individually to best match them.

5. CONCLUSIONS

Aerobic exercise has traditionally been the cornerstone of physical activity recommendations. However, there is a growing body of evidence that weight training might be a valuable alternative approach for patients in need of combating the risk factors of cardiovascular diseases. Its contribution to the reduction of blood pressure, improvement in glycaemic control, supplementary role in weight management, and slight lipid profile enhancement seems relevant enough for health practitioners to advocate for its inclusion in recommendations not only in patients at risk of CVD but also in a wide array of other populations. While its role in successful smoking cessation needs more research, it could be recommended due to its limited side effects. Continued research and larger-scale studies are needed to refine our knowledge in this subject and optimize exercise prescriptions.

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Authors' Contribution

Michał Bielecki: Conceptualization, writing- rough preparation, editing
Agata Zapałowska: Writing- rough preparation, methodology
Adam Jaskulski: Writing- review and editing,
Dominika Kabała: Methodology, supervision, investigation
Tymon Zatorski: Formal analysis, investigation
Marcin Głód: Conceptualization, supervision
Milena Szczepańska: Visualization, supervision
Project administration: Michał Bielecki
All authors read and approved the final manuscript.

Informed consent

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Ethical approval

Not applicable.

Conflict of interest

The authors declare that there is no conflict of interests.

Data and materials availability

All data sets collected during this study are available upon reasonable request from the corresponding author.

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