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Original Article

Interventions based on practice of resistance exercises: a systematic review.

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Abstract:
Resistance exercises have been suggested as a good strategy for the treatment of metabolic syndrome (MS). However, given the heterogeneity of intervention protocols, there is still no consensus on the best exercise program prescribed for MS patients. Thus, the present review aimed to systematically assess, summarize and present the available evidence on the use of interventions based on the practice of resistance exercise indicated for MS treatment in young adults. The search for articles was carried out in the "PubMed" and "Cochrane" electronic databases up to September 2019 using the descriptor "metabolic syndrome" associated with "resistance training". The review followed the PRISMA guidelines and was filed in the PROSPERO registry base (CRD n ° 42020180252). Three hundred and eighteen studies were identified, 284 of which were excluded because they did not meet the inclusion criteria, and seven were analyzed in total. At 14 weeks, resistance exercise can improve inflammation and anthropometric parameters (body fat content), regardless of significant changes in body mass and SM classification factors. Resistance exercise also promoted increased exercise load during the 1RM test, indicating a functional adaptation to the stimulus generated in resistance exercise sessions. It has also been shown that resistance exercise can provide evidence of improvement in metabolic health and functional fitness in pre-menopausal women with moderate cardiovascular risk. For more extended periods of activity, 16 weeks, resistance exercise promoted muscle fiber hypertrophy and an increased proportion of type IIx fibers in the vastus lateralis muscle. With 24 weeks of resistance exercise, it was possible to demonstrate significant reductions in plasma levels of ALT, decreases in HOMA-IR and liver adiposity, and there was an improvement in glycolipid metabolism due to a decrease in ALT levels and the triglyceride content of the liver. The studies were unanimous in claiming that resistance exercise protocols effectively improve aspects of MS, such as benefiting the inflammatory profile and reducing body fat. Although the protocols were slightly different from each other, it is considered that resistance exercises can be a strategy for MS treatment.
Key Words: **Physical training; Chronic noncommunicable diseases; Health promotion; Metabolic Syndrome**

Introduction

In the last few decades, the prevalence of Metabolic Syndrome (MS) has increased significantly (Saklayen, 2018). The worsening of its components has been correlated with increased mortality from several diseases, especially cardiovascular ones (DeBoer et al., 2020; Sergi et al., 2020). Because of this, the direct and indirect onus derived from the consequences associated with MS overloads the health system, causing significant costs (Fong, 2019; Nilson et al., 2020; Yoo et al., 2020), representing, therefore, a severe global public health problem. With a complex etiology, MS seems to occur mainly in response to the combination of genetic/epigenetic factors (Ambrosini et al., 2020; do Nascimento et al., 2015) and lifestyles, such as an unbalanced diet (Fabiani, Naldini, and Chiavarini, 2019; Semnani-Azad et al., 2020) and sedentary behaviors (Amirfaiz and Shahril, 2019; Edwardson et al., 2012). Thus, approaches aimed at modifying lifestyle have stood out as essential strategies to be targeted both for prevention (Jo et al., 2020; Oliveira e Guedes, 2016; van Namen et al., 2019) and for the treatment of SM (Lin et al., 2014; Myers et al., 2019). Although evidence has suggested incorporating physical activity, associated or not with a restrictive diet and pharmacological treatment, within the scope of MS control strategies, there is still no consensus on the most effective approach (Albert Pérez et al., 2018; Pérez et al., 2019).

Current evidence states that resistance exercise in adults can effectively treat diseases associated with MS positively altering physiological variables derived from risk factors (Turri-Silva et al., 2018). Resistance exercise is beneficial for patients with MS when it comes to health improvement, as it is a common form of exercise and can promote an increase in muscle mass, reduces body fat and blood pressure, and improves lipidic profile (Turri-Silva et al., 2018). In addition, it causes a decrease in body weight and an improvement in insulin sensitivity, reducing the propensity for sarcopenia and osteoporosis (DeVallance et al., 2016). However, due to MS showing different standards based on different authors, a systematic review on SM and resistance exercise could help health professionals provide assertive interventions to promote non-pharmacologic health.

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For interventions based only on the practice of isolated physical activity, the results are promising, but the inconsistencies in the specificity of the improvement parameters, possibly in response to the diversity of physical exercise protocols used, age group and evaluated parameters (Lemes et al., 2016, 2018; Lin et al., 2015; Ostman et al., 2017) makes it challenging to define a more effective program. Thus, the present systematic review aimed to evaluate, synthesize and critically present the available evidence on physical activity prescription based on resistance exercise in young adults.

Materials and methods

This systematic review is based on the PRISMA-E 2012 reporting guide (Preferred Reporting Items for Systematic Reviews and Meta-Analyzes) (Welch et al., 2016). The study was included in the international prospective record database of systematic reviews - PROSPERO (Nº CRD 42020180252).

Literature search and study selection Between August 14, 2019, and September 10, 2019, articles were searched for in the United States National Library of Medicine - PubMed and Cochrane Library electronic databases. The search terms used the indexing terms of the Medical Subject Headings (MeSH) database, whose descriptors were "metabolic syndrome" and associated with "resistance training" or "resistance exercise", or "Strength training" or "Strength exercise." Two independent researchers carried out the article selections and analysis whose disagreements were resolved with a third researcher's help.

Ineligibility criteria Studies over five years old, with animals, which did not include resistance exercise, psychological, nutritional, or medical interventions, evaluated children, adolescents, and the elderly, systematic reviews, review articles, editorials, and reports were deemed to be ineligible studies that did not use resistance exercises.

Bias risk assessment The Cochrane Collaboration's tool for assessing the risk of bias was used, according to the following categories: Generation of the random sequence; allocation secrecy; blinding of participants, evaluators, and professionals; incomplete outcomes; selective reports and other potential sources bias. The level of risk of bias was determined for each domain: (1) high risk, (2) uncertain risk, or (3) low risk.

Results

Study selection

As shown in Figure 1, the initial electronic search identified 318 studies. Of the 318 studies, 47 were removed because they were duplicated. Two studies were excluded because they were not available, two animal studies were also excluded, 45 were removed for not having resistance exercise in the study and 20 studies were removed for presenting resistance exercise associated with diet or psychotherapy. Furthermore, 121 studies involving other diseases such as cancer, HIV, polycystic ovaries, sarcopenia and menopause were excluded. Additionally, 23 studies with children, adolescents or the elderly were excluded, and a further 26 studies were removed for being systematic reviews and 25 studies for not using resistance exercise. Therefore, 7 articles were systematically analyzed in total.

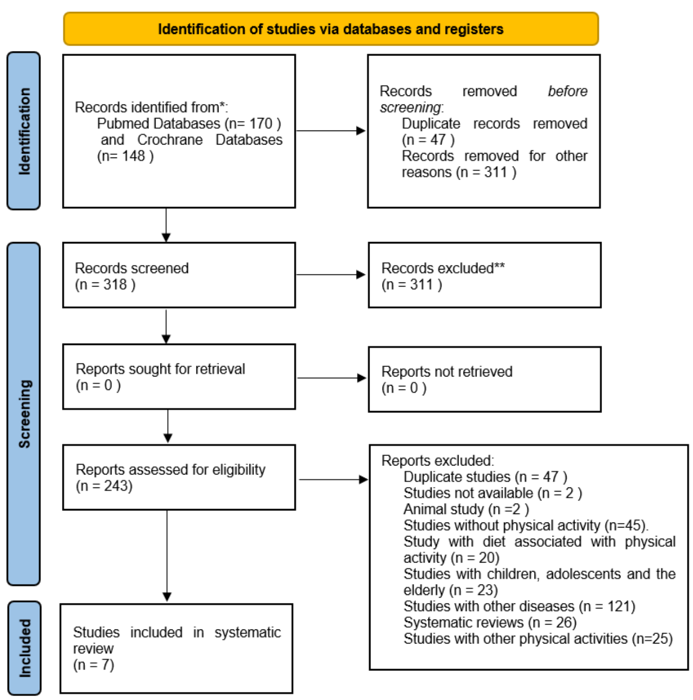

Figure 1. Flowchart of the present study.

Description of study interventions

The 7 studies included described the results of group interventions. Two studies had a quasi-experimental, and one a pre-experimental design, and four were clinical studies. There were seven studies with resistance exercise intervention (Table 1). The main findings were a reduction in body fat content and a reduction in inflammatory profile, contributing to a lower risk of cardiovascular disease. Increased muscle strength and increased skeletal muscle mass were also reported.

Table 1 - Characterization of the experimental design and main findings

Author (s)	Sample	Study design and consensus used	Instruments/ evaluation	Main findings
(Silveira Martins, Boufleur Farinha, et al., 2015)	15 sedentary men (57.53 ± 7.07 years old) with 2 or more MS components.	Quasi-experimental study / American Heart Association (AHA) and the National Heart, Lung, and Blood Institute (NHLBI)	Cardiorespiratory fitness via the Bruce test, with blood pressure measurement (SBP-; BPD, flexibility via the Wells bench, height, abdominal circumference, body composition via DXA. Biochemical measurements: TG, TC, HDL, and FG, IL-1β cytokines IL-6, IL-10, TNF-α, and IFN-γ and application of the three-day food record.	Despite body weight changes, total muscle content, and biochemical parameters, individuals reduced body fat content. Also, RT resulted in lower circulating TNF-α and IL-6, higher levels of IL-10, and stabilization of concentrations of IL-1β and IFN-γ. Body fat and inflammatory profile were reduced, as well as the risk of CD
Takahashi et al. 2015	59 patients with NAFLD were assigned to a resistance exercise group (n = 28) man = 8, woman = 20 years old 56.7 ± 12.0 or a control group (n = 31) men = 9, women = 22;52.9 ± 15.4 years old	Clinical trial / World Health Organization (WHO) and The Adult Treatment Panel III (ATP III) National Cholesterol Education Program (NCEP)	Body weight, BMI, AST, ALT, GGT, LDL-c, TG FG, and plasma insulin. Insulin resistance was calculated, and hepatic steatosis was assessed via USG.	A significant interaction of time per treatment between body weight and BMI. Also, a significant interaction of time per treatment was observed between ALT and HOMA-IR levels. The reduction of ALT (76.9 ± 63.4 vs. 59.3 ± 49.2), HOMA-IR (4.0 ± 2.9 vs. 3.1 ± 1.6), and degree of hepatic steatosis (2.00 ± 0.82 vs. 1.55 ± 0.71) were observed.
South et al. 2016	19 men and women between (18 and 55 years old). Nineteen subjects (9 men and 10 women) years old 18–55, split between 2 groups, consisting of 10 subjects at-risk for Type II diabetes mellitus	Quasi-experimental study / World Health Organization (WHO); European Group for the Study of Insulin Resistance (EGIR); The Adult Treatment Panel III (ATP III) National Cholesterol Education Program (NCEP); International Diabetes Foundation (IDF)	Body mass, height, and body composition were measured. Measurement of subcutaneous folds in 7 locations and waist circumference. Specific urinary severity (USG) was measured	The MS group (n=10) and the NMS group (n = 9) statistically showed differences in body composition variables. The first group showed high values for body mass, lean body mass, fat percentage, the sum of skinfolds, and waist circumference. The other group showed high values for IPF, RFD, and static jump peak power at 0 and 20 kg. This group had higher values for SBP and DBP and total cholesterol ratio for HDL and insulin. This condition may mean that we have multiple sclerosis, higher levels of body fat but less favorable body composition, lean mass and increased absolute strength, but were less fit for aerobic exercise. They have more risk factors.
DeVallance et al. 2016	57 individuals (28 healthy sedentary individuals; 29 SM). 28 healthy controls (46 ± 11 year old; and 29 MetS (51 ± 12year old	Clinical trial / World Health Organization (WHO); European Group for the Study of Insulin Resistance (EGIR); The Adult Treatment Panel III (ATP III) National Cholesterol Education Program (NCEP); International Diabetes Foundation (IDF)	Height and weight, together with waist and hip circumference, were measured, fat distribution was assessed, body composition was calculated, TC, HDL, TG, FG, HbA1c, and insulin were analyzed. SBP and DBP, pulse pressure, and carotid-femoral pulse wave velocity were measured.	There were differences between blood lipids, abdominal/general obesity and BP, baseline TG and hemoglobin A1c. After the exercise intervention, the RT with MetS group showed a non-significant 11% reduction in body fat. The MetS RT group had a 12% increase in VO_2peak, while no change was found with the Con RT or among the sedentary (non-exercise) groups.
Stuart et al. 2017	11 obese men and a close relative with type 2 diabetes. The average years old was 40, with a range of	Quasi-experimental study / National Cholesterol Education Program (NCEP)	An insulin infusion at 40 mU $\cdot m^2 \cdot min^{-1}$ was performed for 2 h and a steady-state glucose infusion rate (ssGIR) to quantify insulin sensitivity. Fasting glucose and insulin. Body fat mass and lean body mass were measured. Maximum leg and hip strength were evaluated	After 16 weeks of training, weight was not statistically different and there was no change in fasting glucose or insulin. Body composition did change with an increase in lean body mass and a decrease in fat mass. The proportion of type IIa fibers decreased, and type IIx fibers increased. Peak force significantly increased.

	30 to 54		isometrically. The maximum jump height was measured without load and with a load of 20 kg. $\dot{V}O_2max$ was measured using an ergometer cycle. Percutaneous biopsies with a vastus lateralis needle were performed after an overnight fast and 2h in the supine position using a muscle biopsy needle. The fiber composition was determined. Western blots were performed	Aerobic fitness quantified by $\dot{V}O_2max$ was increased. GLUT4 in muscle increased.
Flandez et al. 2017	62 sedentary pre-menopausal women diagnosed with MS (40−50 years old (46.47 ± 3.71 years old). Randomly divided into an experimental group and a control group	Clinical trial / World Health Organization (OMS); European Group for the Study of Insulin Resistance (EGIR); The Adult Treatment Panel III (ATP III) National Cholesterol Education Program (NCEP); International Diabetes Foundation (IDF)	Anthropometric tests, determination of the percentage of fat mass and body weight, height and waist circumference. Analysis of blood chemical parameters: lipid profile (total cholesterol, low-density lipoprotein cholesterol [LDL-c], and TGs. An immunoturbidimetry test was used to determine levels of C-reactive protein, BMs, HbA1c. Flexibility measured and balance.	The C-reactive protein level decreased significantly from baseline to after the intervention in both the ETG and FWG compared with the control group. HbA1c was significantly reduced in both EGs and augmented considerably in the CG. A similar trend was found for the CG for the other metabolic parameters (not statistically significant) at the end of the intervention period. For the ETG, there was also found a considerable reduction in LDL-c from baseline to postintervention and a trend toward reduction in all of the metabolic parameters (not statistically significant). There were no statistically significant within- or between-group differences in total cholesterol after the training program intervention. There were no significant differences between the two EGs in blood BMs. All the functional variables analyzed showed improved intragroup values in both the ETG and FWG. An increase in physical performance ability concerning the CG was also noted in each of the EGs, and there was no significant difference between the ETG and FWG. There was a significant increase in general coordination, maximal voluntary isometric strength of the upper and lower limbs, the local muscular endurance of the lateral and ventral trunk area, and aerobic capacity in the EGs relative to the CG. None of these functional skills significantly changed in the CG.
Turri-Silva et al. 2018	50 individuals with MS. Men and women, years old-matched between 40 and 60 years who had MetS	Clinical trial / World Health Organization (WHO); The Adult Treatment Panel III (ATP III); International Diabetes Foundation (IDF)	BP, heart rate, height, body mass, and muscle strength were evaluated. Beat-to-beat heart rate data for HRV analysis were performed. The subjects were instructed to avoid taking ANS. In order to obtain correct measurements, it was requested that participants do not use stimulants, such as alcoholic drinks, caffeine, and chocolate, 24 h before performing an assessment. The data were collected individually, and the subjects were instructed to remain at rest and avoid conversations for 30 minutes with spontaneous breathing and supine.	12 weeks of RT protocol can be a reliable intervention for autonomic dynamic balance, increasing the properties of chaos in individuals with MS. Resistance exercise can promote other beneficial cardiovascular adaptations, such as left ventricular hypertrophy and reduced vascular resistance, which together can reduce the effort of the heart.

Note: RT = resistance training; DXA = dual-energy X-ray absorptiometry; TG= triglycerides; HDL: high-density cholesterol; LDL: low-density cholesterol; SBP = systolic blood pressure; DBP = diastolic blood pressure; FG = fasting glucose; IFN-γ = interferon-gamma CD = cardiovascular disease; HOMA-IR = insulin resistance; IMC = Body mass index; AST = aspartate aminotransferase, ALT = alanine aminotransferase; GGT = γ-glutamyl transpeptidase; HbA1c =glycated hemoglobin; bSBP = Brachial systolic blood pressure; bDBP = Brachial diastolic blood pressure; IPF = isometric peak force; IPFa = isometric peak force; RFD = rate of force development; BP = Blood pressure; USG = ultrasound; MS = metabolic syndrome; MNS = non-metabolic syndrome; MetS = individuals with metabolic syndrome; Con = a non-exercised control; GLUT 4 = Glucose transporters; EG = experimental group; CG = control group; ETG = elastic tubes; STP = strength training program; FWG = bars and discs; BMS = biomarkers; CFP = Chaotic forward parameters; NAFLD = non-alcoholic fatty liver disease.

Description of the exercises

The description of the types of exercises, duration of the training and muscle groups worked are shown in Table 2.

Table 2 - Characterization of resistance exercise protocols

Author (s)	Intervention time	Weekly sessions and duration of sessions	Series and repetitions	Exercises or muscle groups
Silveira Martins et al. 2015	14 weeks	Three days a week for 14 weeks, with a minimum of 48-72 h of recovery between sessions. Average 1-hour session	In weeks 3 to 10, the subjects performed three sets of 15 repetitions, with the number of exercises increasing to 12. During the last four weeks, the subjects performed three sets of 12 repetitions.	Lat pull down, bench press, rower machine, triceps pulley extension, biceps curvature, trunk extension, abdominal curvature, leg-press, knee flexion, plantar ankle flexion, hip abduction, and adduction1.
(Takahashi et al., 2015)	24 weeks	Not related	20-30 minute series were comprising push-ups and squats. 3 sets of 10 push-ups and 3 sets of 10 repetitions.	The exercises include push-ups and squats. 3 sets of 10 push-ups and 3 sets of 10 squats with a 1-minute break between them lasting 20-30 minutes. There was dietary restriction and encouragement of physical activities following the guidelines of the American Gastroenterological Association for NAFLD and the Physical Activity of Health Promotion, recommended by the Ministry of Health, Labor, and Welfare of Japan.
South et al. 2016	8 weeks	The individuals exercised six days a week, with 3 to 4 of these days being dedicated to resistance exercises and 1 to 2 days dedicated to working on the middle section (abdominal) or stretching.	Rest between sets was only 3 minutes during the first block and just under 3 minutes during the 2 blocks.	First phase: weeks 1–4 light loads, high reps, and emphasizing strength endurance and basic fitness; Second phase: Weeks 5 to 8 heavier loads and fewer repetitions and emphasizing maximum power and strength training. Charges were increasing 5–10% each week. Weeks 5 to 8 consisted of increasing load and increasing training intensity. During weeks 5 to 7, load increase by 5–10% and decreased during week 8 to allow fatigue dissipation. The post-test was carried out during the 9th week, 2-3 days after the last training session. The exercises emphasized large muscle groups and multi-joint movements.
DeVallance et al. 2016	8 weeks	Three days a week	3 sets of 8-12 repetitions until fatigue, but not a failure. The load and repetition range is in line with those for hypertrophic training defined by the American College of Sports Medicine (ACSM) and the National Strength and Conditioning Association and is also in line with ACSM's stance RT for health in an adult population.	3 days/week six exercises (leg press, chest, side flexion, leg flexion, shoulder press, and leg extension) on weight machines. For familiarization, three sets of minimum resistance warm-ups, followed by sets of five and three reps with increasing resistance. Progressive increase in intensity over 2 weeks: weeks 1–2, 60% of maximum; weeks 3-4, 70% of maximum; weeks 5–6, 80% of maximum; and weeks 7–8, 85% of the maximum. Three sets of 8-12 reps until fatigue but not failure. The load and repetition range is in line with those for hypertrophic training defined by the (ACSM) and the National Strength and Conditioning Association and is also in line with the ACSM stance on RT for health in a population adult.
Stuart et al. 2017	16 weeks	4 blocks, 4 weeks each. Five days a week	During weeks 1–4, the set of goals and repetition scheme was 3 × 10; during weeks 5–8, the goal was 4 × 5; during weeks 9-12, the goal was 4 × 10; and during weeks 13-16, the target was 4 × 5. Thus, the training volume was maintained at relatively high levels during the 16 weeks.	During weeks 1–4, the target set and repetition scheme was 3 × 10; during weeks 5–8, the target was 4 × 5; during weeks 9–12, the target was 4 × 10; and during weeks 13–16, the target was 4 × 5. Thus, training volume was maintained at relatively high levels throughout the 16 wk. The training was carried out by strength power athletes and consisted primarily of large muscle mass multi-joint exercises such as squats and pulling movements (e.g., clean pulls). Training occurred 5 days a week, with light days devoted to midsection work on Tuesdays and Thursdays during weeks 1–4 and 9–12 and on Wednesdays during weeks 5–8 and 9–13. Squats Bent-legged sit-ups; Shoulder shrugs; Stretch; Bench press; Supine windshield wipers; Mid-thigh pulls; Seated dumbbell press; Stiff-legged Deadlifts; Front Raises; Bent-over rows; Bicep curls; Basket Hangs; Squat press; Squat press; Dumbbell incline press; Stiff-legged deadlifts.

Flandez et al. 2017	12 weeks	Three -Four sessions a week, with 3-4 sets of 10-15 repetitions per exercise	The sessions were organized in a circuit of 10 specific exercises for upper limbs, lower limbs, and lumbopelvic stability. 30 s of active between exercises (running in place and joint mobility of soft tissue for upper limbs) and recovery of 60 s between sets (completion of the entire circuit)	The ETG used a multifunction training station (111.8 cm long, 61 cm wide, and 5.1 cm high) with different elastic tubes anchored in several positions (TheraBand Exercise Station, Hygienic Corporation, Akron, OH). This training station also had anchor points for affixing elastic tubes with up to three different levels of viscoelastic hardness (30.5 cm of length) that could be attached to either individual handles or a bar. We developed the prescribed exercises by modifying the types of anchors and material and by adding a fitball. The FWG used bars, discs, and standard dumbbells, and as with the ETG STP, we used a fitball for assistance in specific exercises. The intensity was modified while the participant did the exercise by changing the equipment.
Turri-Silva et al. 2018	12 weeks	Three times a week, totaling 30 training sessions	Recovery intervals were 40 to 90 s, depending on loads	Leg press exercises, leg curl machine, and leg extension machine for both groups; for upper limbs, different exercises were performed. The cross-over machine uses the dorsal position for the back and chest exercises and the ventral position for the triceps and biceps exercises. For shoulder exercises, the Bozu equipment was used, classic executions were done on specific machines (biceps, triceps, pectorals, and back)

Note: RT = resistance training; NAFLD = non-alcoholic fatty liver disease; ACSM = American College of Sports Medicine; ETG = elastic tubes; STP = strength training program; FWG = bars and discs

Discussion

Resistance exercise has been shown to have beneficial effects on muscle mass, muscle strength and aerobic capacity, and has been recommended as an alternative therapy to MS. Given the heterogeneity of the results obtained from the application of resistance exercise in the improvement of MS symptoms, the present study systematically characterized the results of the studies designed to identify the best resistance exercise protocol to be used in young patients diagnosed with MS. In general, the data presented here suggest that the heterogeneity of the experimental protocols used in the studies makes it difficult to determine a consensus on the best resistance exercise protocol to be used in patients with MS, which points to the need for more homogeneous studies to find the best design of an effective protocol.

The study-sample characteristics about age and gender were not homogeneous, varying between 18 and 75 years and having both male and female study populations. One study collected information about 15 sedentary men with MS (Silveira Martins et al., 2015); another study assessed a sample of men and women with non-alcoholic fatty liver disease (NAFLD) (Takahashi et al., 2015); three studies evaluated men and women with MS (DeVallance et al., 2016; South et al.,2016a; Turri-Silva et al., 2018); one study assessed obese men (Stuart et al., 2017) and another study evaluated pre-menopausal women (Flandez et al., 2017).

Concerning the study design, three studies presented a quasi-experimental design (Silveira Martins et al., 2015; South et al., 2016; Stuart et al., 2017) and four studies presented an experimental design (DeVallance et al., 2016; Flandez et al., 2017; Takahashi et al., 2015; Turri-Silva et al., 2018).

With regard to the measurements used in the studies, three studies assessed cardiorespiratory fitness (Silveira Martins et al., 2015; Stuart et al., 2017; Turri-Silva et al., 2018); three measured blood pressure (DeVallance et al., 2016; Silveira Martins et al., 2015; Turri-Silva et al., 2018); six used body assessment and anthropometric testing as an instrument (DeVallance et al., 2016; Flandez et al., 2017; Silveira Martins et al., 2015; Stuart et al., 2017; Takahashi et al., 2015; Turri-Silva et al., 2018); three evaluated abdominal circumference (DeVallance et al., 2016; Silveira Martins et al., 2015; South et al., 2016); one study assessed flexibility (Silveira Martins et al., 2015); three measured insulin resistance (DeVallance et al., 2016; Stuart et al., 2017; Takahashi et al., 2015); only one study evaluated pulse pressure and carotid-femoral pulse wave velocity (DeVallance et al., 2016); three evaluated biochemical measures (DeVallance et al., 2016; Flandez et al., 2017; Silveira Martins et al., 2015); two used USG, one evaluating hepatic steatosis and the other evaluating an estimate of hydration status (South et al., 2016a; Takahashi et al., 2015) and one study assessed maximum strength of the leg and hip and maximum jump height without a load and with a load of 20 kg (South et al., 2016).

The main findings of the seven studies analyzed were not homogeneous, although they showed some results in common. South et al. (2016) reported that endurance exercise promoted greater endurance strength, improving health indicators. However, increasing training time is essential. In turn, DeVallance et al. (2016) pointed out that intervention with the same duration (8 weeks) had as its central finding that progressive resistance exercises did not alter arterial stiffness. However, a significant improvement was achieved in muscle strength, and aerobic capacity also increased. Flandez et al. (2017) demonstrated improved pre-menopausal women's metabolic health and functional fitness with moderate cardiovascular risk using elastic tubes in the training protocol. It is important to note that these non-traditional devices are efficient, low-cost, accessible, effective and motivating. The study provides scientific evidence supporting the use of practical tools that healthcare professionals can use to help prevent and treat cardiovascular and metabolic diseases in sedentary pre-menopausal women. Regarding the functioning of the heart's capacity, resistance training was more recently, Turri-Silva et al. (2018), found to be effective, increasing the chaos and dynamics of the autonomic nervous system (ANS). These findings showed significant changes in heart rate variability (HRV) analysis means by non-linear parameters. Resistance exercise protocol can be a reliable intervention for dynamic autonomic balance. It was increasing the properties of ANS chaos in individuals with MS. In addition, there are other benefits for the cardiovascular system; for example, left ventricular hypertrophy and reduced vascular resistance together can reduce cardiac strain.

The main findings of Silveira Martins et al. (2015) in a 14-week intervention were that resistance exercises cause improvements in inflammation and anthropometric parameters (body fat content) regardless of significant changes in body mass and SM classification factors. Furthermore, resistance exercises promoted increased exercise load during the 1RM test, indicating a functional adaptation to the stimulus generated in resistance exercise sessions. For Stuart et al. (2017), resistance exercises resulted in increased strength, increased lean body mass, muscle fiber hypertrophy and an increased proportion of type IIx fibers in the vastus lateralis muscle. Aerobic fitness also increased and effectively reduced body fat, increased muscle size, and changed skeletal muscle fiber to type IIx fast-twitch fibers, but insulin responsiveness to the whole body did not change in the absence of weight loss.

The studies analyzed here, which lasted at most 24 weeks, showed that simple resistance exercises achieved significant reductions in alanine aminotransferase (ALT) plasma levels, accompanied by decreases in insulin resistance (HOMA-IR) and liver adiposity. There was also an improvement in glycolipid metabolism caused by decreased ALT levels and the liver's triglyceride content induced by resistance exercises. There was no significant change in body weight (Takahashi et al., 2015).

Regarding the time allocated to interventions, the studies were not homogeneous in the duration of the programs and the frequency of meetings. Two studies (published in the same year) had a shorter period, 8 weeks, one of them with 6 meetings a week (South et al., 2016) and one with 3 meetings a week (DeVallance et al., 2016). Two studies lasted 12 weeks, both with meetings 3 times a week (Flandez et al., 2017; Turri-Silva et al., 2018). One study lasted 14 weeks with 3 meetings a week (Silveira Martins et al. 2015). Another study lasted 16 weeks with 5 meetings a week (Stuart et al., 2017) and another study lasted 24 weeks, not describing the meetings' duration in detail (Takahashi et al., 2015).

Types of exercises, series and repetitions in the studies were also not homogeneous. One study performed supervised resistance exercise three days a week for 14 weeks, with a minimum of 48-72h of recovery between sessions. The first two weeks of RT consisted of 15 repetitions and then two series of 17 repetitions in five exercises for all muscle groups, respectively, at 40% of a maximum repetition (1RM). From weeks 3 to 10, the subjects performed three sets of 15 repetitions at 60% 1RM, with the number of exercises increasing up to 12. During the last four weeks, the subjects performed three sets of 12 repetitions at 70% 1RM in the following exercises: pull-down, bench press, rower, triceps pulley extension, biceps curl, trunk extension, abdominal curl, leg press, knee flexion, plantar ankle flexion, abduction and hip adduction, on average for 1h. At the beginning of the sessions, the warm-up was carried out using a low-intensity walk in a closed place for 10 min. In the end, stretching was performed individually. Stretching exercises varied with the sessions and were directed to stretch the upper and lower back, shoulders, arms, chest, abdomen, thighs (back, front, internal and external) and calves (Silveira Martins et al., 2015).

In another study, patients performed push-ups and squats. There were 3 sets of 10 push-ups and 3 sets of 10 squats, with intervals between sets of 1 minute for 20 to 30 minutes. The control group made dietary restrictions, encouraging regular physical activity following the American Gastroenterological Association for NAFLD and the Health Physical Activity Promotion guidelines recommended by the Japanese Ministry of Health, Labor and Welfare of Japan (Takahashi et al., 2015).

On the other hand, South et al. (2016) carried out training that consisted of two phases: the first phase lasted 4 weeks, using light loads with high repetitions, reinforcing endurance and conditioning. Lasting for 8 weeks, the second phase was used with heavy loads and fewer repetitions, highlighting maximum strength and power. Each week the load and intensity were increased, with load being increased by 5-10% weekly, reducing in the last week to reduce fatigue. Post-tests were carried out during the 9^{th} week. The exercises emphasized large muscle groups and multi-joint movements. Higher body strength training with higher speed was emphasized during mid-thigh pulls, squats and vertical jumps. Also, higher speed and greater power were emphasized during light days. The individuals exercised 6 days a week, with resistance exercises alternating with abdominal exercises or stretching.

In another study, individuals with MS and healthy subjects were randomly selected to participate in a weight machine resistance exercise program doing six exercises (leg press, bench press, pull-down, leg curl, shoulder press and leg extension) 3 days a week. Before starting the series of exercises, the participants performed warm-ups using the machines for familiarization. Then they did a series of five and three repetitions, ending with one repetition and increased resistance. In fourteen days, the resistance exercise was increased to fatigue, as long as failure did not happen (DeVallance et al., 2016).

In another study, the training consisted of specific supervised exercises 5 days a week. Saturdays were considered a very light training day, and participants were instructed to perform specific stretching exercises independently. Each day the exercises were performed in the indicated sequence. During weeks 1–4, the set of goals and repetition scheme was 3 × 10; during weeks 5–8, the goal was 4 × 5; during weeks 9-12, the goal was 4 × 10; and during weeks 13-16, the target was 4 × 5. Thus, the training volume was kept at relatively high levels during the 16 weeks. The training was performed by strength and power athletes and consisted mainly of multiarticular exercises of large muscle mass, such as squats and pull movements (for example, clean pulls). The training took place 5 days a week, with light days dedicated to mid-section work on Tuesdays and Thursdays during weeks 1–4 and 9–12 and on Wednesdays during weeks 5–8 and 9–13 (Stuart et al., 2017).

In the study by Flandez et al. (2017), a standard strength training program (STP) was designed and applied equally to elastic tubes (ETG) and bars and discs (FWG) over the 12-week intervention (which involved 3-4 sessions per week, with 3-4 sets of 10-15 repetitions per exercise). The first 2 months of the program focused on developing local muscle endurance resistance, and the last month focused on developing muscle hypertrophy. The sessions were organized in a circuit of 10 specific exercises for upper limbs, lower limbs, and lumbar-pelvic stability. Three familiarization sessions were conducted before starting the program to ensure an adequate and safe execution with an ideal adaptation to each workout's intensity.

The warm-up was also planned (with a maximum duration of 10 min), including a light trot, joint-mobility exercises and stretching. The intensity of the elastic tube exercises was controlled from the beginning to the end of the program using the rating of perceived exertion scale between 7-9 arbitrary unit. Thirty seconds of activity were allowed between exercises (running on-site and joint mobility of the soft tissue for upper limbs) and 60s of recovery between sets (completion of the entire circuit). Nurses and technicians with extensive experience in physical activity always supervised the exercises.

Turri-Silva et al. (2018) demonstrated that the loads were increased from the first to the last day of training, using an interval of 40-90, depending on the loads. Exercises using the leg press, leg curl machine and leg extension machine were the same for both groups; for the upper limbs, the exercises differed. The dorsal or ventral position was adopted on a 45 ° inclination bench for the use of the cross-over machine, with the dorsal position for the back and chest exercises and the ventral position for the biceps and triceps exercises. These postures were chosen to stimulate the contractions which caused the contraction of muscle groups. For shoulder exercises, Bozu equipment was used to promote instability throughout FRT exercise execution. For TRC, classic exercises were performed to work the biceps, triceps, chest and back.

Conclusion

Interventions based on structured exercise sessions of at least 8 weeks in duration demonstrated improvement in physiological variables related to health (for example, blood lipids), muscle AST, a significant improvement in muscle strength and increased aerobic capacity. Resistance exercise protocols for 12 weeks can be a reliable intervention for autonomic dynamic balance, increasing the properties of ANS chaos in individuals with MS. Resistance exercise can promote other good cardiovascular adaptations, such as left ventricular hypertrophy and reduced vascular resistance and heart strain. At 14 weeks, resistance training can improve inflammation and anthropometric parameters (body fat content), regardless of significant changes in body mass and SM classification factors.

Also, resistance exercises promoted increased exercise load during the 1RM test, indicating a functional adaptation to the stimulus generated in resistance exercise sessions. It has also been shown that resistance exercise can provide evidence of improvement in metabolic health and functional fitness in pre-menopausal women with moderate cardiovascular risk. For more extended periods of activity, 16 weeks, resistance exercise promoted muscle fiber hypertrophy and an increased proportion of type IIx fibers in the vastus lateralis muscle; with 24 weeks of resistance exercise, it was possible to demonstrate significant reductions in plasma levels of ALT, decreases in HOMA-IR and liver adiposity and there was an improvement in glycolipid metabolism due to a decrease in ALT levels and the triglyceride content of the liver.

Thus, resistance exercise could be recommended as a beneficial therapy to improve the cardiovascular health of populations with MS; however, the heterogeneity of the experimental designs used in the studies limits the ability to achieve a consensus on the best resistance exercise protocol to be used in young patients with MS.

Conflicts of interest - None.

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