REVIEW ARTICLE

Therapeutic resistance exercises for individuals with peripheral arterial obstructive disease: evidence for prescription

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ABSTRACT

A regular physical activity program is part of the initial clinical approach to patients with peripheral arterial obstructive disease. Therefore, use of exercises against resistance loads (resistance training) has been widely recommended for different populations, especially for elderly individuals with and without associated diseases. The few studies that have used this form of exercise in patients with peripheral arterial obstructive disease demonstrated its therapeutic efficiency. However, reported effects of resistance training in other populations have evidenced improvement in physical fitness and quality of life, with cardiovascular and musculoskeletal safety. These data indicate the possible benefits of resistance training in peripheral arterial obstructive disease therapy. Thus, this review aimed at presenting scientific information that can help prescription of resistance training for this population.

Keywords: Peripheral vascular disease, intermittent claudication, weight lifting, exercise therapy.

RESUMO

A prática regular de exercícios é parte do tratamento clínico inicial para pacientes com doença arterial obstrutiva periférica. Nesse sentido, a utilização de exercícios contra resistência (exercícios resistidos) tem sido amplamente recomendada para diferentes populações, especialmente para pessoas idosas com e sem doenças associadas. Os poucos trabalhos encontrados utilizando essa forma de exercícios em pacientes com doença arterial obstrutiva periférica documentam a sua eficiência terapêutica. No entanto, os efeitos documentados dos exercícios resistidos em outras populações têm evidenciado melhoria da aptidão física e da qualidade de vida, com segurança cardiovascular e músculo-esquelética. Essas informações fornecem indicativos sobre os possíveis benefícios dos exercícios resistidos na terapia de indivíduos com doença arterial obstrutiva periférica. Nesse sentido, esta revisão objetivou apresentar informações científicas que permitam auxiliar a prescrição dos exercícios resistidos para essa população.

Palavras-chave: Doenças vasculares periféricas, claudicação intermitente, levantamento de peso, terapia por exercício.

Introduction

Obstructive atherosclerotic lesions of vessels distal to the aortic bifurcation, which compromise or prevent arterial blood flow, resulting in reduced oxygen supply to peripheral tissues distal to the affected site, are called peripheral arterial obstructive disease (PAOD).[1]

The chronic ischemic process generated by PAOD seems to result in a cycle of progressive disability in patients with this disease. In this sense, individuals with PAOD have endothelial dysfunction, reperfusion ischemia, systemic inflammation and release of free radicals, atrophy and denervation of muscle fibers, change in muscle metabolism, reduced strength and muscle resistance and impairment of walking ability.[2] Such disorders, in their turn, result from reduction in autonomy and level of physical activity[3,4] and consequently reduction in physical fitness and quality of life of these patients.[5,6]

The first clinical manifestation reported by individuals with PAOD is intermittent claudication (IC).[7] IC consists of pain, cramp, tingling or burning in the lower limbs (more commonly in the calves, but also affecting thighs and gluteus in some cases), which occur during practice of physical activity and only stops with rest.[7,8]

According to the Transatlantic Inter-Society Consensus,[7] the first treatment to be adopted in the individual with IC is the practice of physical exercises. That recommendation is based on several studies that have demonstrated the effectiveness of this method to improve gait ability[9,10] and quality of life of these patients,[11-15] with lower cost than other treatment methods.[16]

Among modalities of physical exercise, resistance training (RT) has been widely used in the treatment and rehabilitation of elderly individuals and patients with chronic diseases.[17] This method consists of performing contractions of specific muscle groups against some form of external resistance (free weights, machines and elastic bands). The main advantages of this method are expressive improvements in physical fitness[18] and quality of life of different populations,[19,20] with proper control of movement variables (position and posture, performance speed, movement amplitude, volume and intensity).[21]

Although the benefits of RT in the elderly and in those with chronic diseases are well established in the literature, use of this method as therapeutic modality for patients with PAOD has been little

studied, [22,23] so that important information about applicability and structuring of RT programs for that population still requires more investigation.

Therefore, this study aimed at presenting the possible benefits of RT for individuals with PAOD and, based on the information available in the literature, suggesting a model to prescribe RT for these patients.

Methods

A literature review was performed in electronic databases LILACS, PUBMED and SciELO. To do so, the terms *resistance training*, *strength training*, *weight training*, *intermittent claudication* and *peripheral arterial obstructive disease were used*. After obtaining the references, the full articles were acquired from *on-line* journal databases (Sibinet and Portal da Pesquisa) and in libraries in São Paulo, Brazil.

Physical fitness in individuals with peripheral arterial obstructive disease

Individuals with PAOD have reduced tolerance to physical exercise, especially in walking ability.[7] Such physical inability seems to be related to the stage of disease evolution, so that the more advanced the disease, the higher the functional disability.[3,4] Studies performing outpatient measurements by subjective questionnaires to analyze levels of physical activity and gradual walking tests, observed that physical function and daily levels of physical activity in these individuals reduced as the disease became more severe.[3,24]

Besides reduction in walking ability, individuals with PAOD have impairments in other components of physical fitness, especially those related to muscle function. In a study carried out by McDermott et al.,[25] muscle strength and resistance of individuals with PAOD were reduced as the disease became more severe. Such information was confirmed by other authors, who verified lower values of muscle strength and resistance in individuals with PAOD when compared with control individuals.[26-29] According to Regensteiner et al.[29] and Gerdle et al.,[27] reduced strength in individuals with PAOD is directly associated with their gait ability.

Individuals with PAOD also have important morphological changes. In a study performed by McDermott et al.,[30] there was less muscle mass in lower limbs of individuals affected by that disease. These findings were confirmed by Askew et al.[31] and Regensteiner et al.,[29] who observed, through biopsy in lower limb muscles, smaller size in type I and type IIa muscle fibers in these patients, compared to controls.

Considering that prevalence of PAOD increases with age,[32,33] it is important to note that changes resulting from PAOD mostly occur concomitantly with dysfunctions secondary to the ageing process. Thus, it is possible to conclude that reduced general physical fitness and muscle function resulting from ageing occurs even more markedly in individuals with PAOD.

Because of that, adoption of interventions that allow reversion of impairments associated with the ageing process and improvement of functional limitation of individuals with PAOD has been recommended for the treatment of these patients.[7] In this sense, the practice of RT has been increasing along the past decades, since this modality of exercises seems to help preventing and treating diseases, as well as providing improvements in physical fitness and health in the elderly.[17,18,23,34,35]

Benefits of resistance training

According to the American College of Sports Medicine,[36] regular practice of RT can provide improvements in physical fitness and health in the elderly,[37] as well as help to prevent and treat chronic diseases, such as hypertension,[38] diabetes mellitus,[39] obesity[40] and osteoporosis.[41]

RT are movements performed against graded resistances, usually weights, and have been gaining increasingly more attention from the scientific community, currently being part of programs of physical conditioning, aiming at prevention and rehabilitation of elderly individuals and in patients with varied diseases.[17] The main advantage of this method is proper control of all movement variables (position and posture, performance speed, movement amplitude, volume and intensity)[21] with cardiovascular and musculoskeletal safety.[34,42,43] In addition, the equipment used to perform RT allows regulating overloads to be used according to the individual's level of fitness, opposed to classical gymnastic movements, in which overload is usually body weight.[44]

There are many advantages in using RT for the health of elderly individuals, which are summarized in Table 1.[45-48]

Table 1 - Effects of resistance training in physical fitness, hemodynamic measurements, glucose metabolism, serum lipids and inflammatory markers

Variable measured	Effect of resistance training
Physical fitness	
Strength	↑↑↑
Muscle resistance	↑↑↑
Flexibility[46]	↑
Aerobic power	↑
Body composition	
Body fat	↓
Muscle mass	↑↑
Bone mineral density	↑↑
Hemodynamic measurements	
Resting heart rate	↔
Systolic volume	↔
Resting systolic blood pressure	↔
Resting diastolic blood pressure	↓↔
Systolic blood pressure during effort	↓↓
Diastolic blood pressure during effort	↓↓
Systolic blood pressure after effort[47,48]	↓↓
Glucose metabolism	
Insulin response to glucose stimulation	↓↓
Level of basal insulin	↓
Sensitivity to insulin	↑↑
Number of transporters GLUT-4	↑
Serum lipids	
High-density lipoprotein (HDL)	↑↔
Low-density lipoprotein (LDL)	↓↔
Inflammatory markers	
Homocysteine	↓
Lipid peroxidation	↓↓
Activity of antioxidative enzymes	↑
Systemic inflammation (TNF-α, PCR, IL-6)	↓

↑ = small increase; ↑↑ = moderate increase; ↑↑↑ = large increase; ↓ = small reduction; ↓↓ = moderate reduction; ↔ = no alteration; TNF-α = tumor necrosis factor alpha; PCR = polimerase chain reaction; IL-6 = interleukin-6. Adapted from Vincent & Vincet,[45] Barbosa et al.,[46] Rezk et al.[47] and Melo et al.[48]

As to RT safety for elderly individuals and/or patients with disease, Graves & Franklin[17] claim that this method, as long as it is well oriented, is a safe strategy both for the cardiovascular system and for the musculoskeletal system.

Opposite to predominantly aerobic exercises that provide increase only in heart rate and systolic blood pressure, RT provides increase in heart rate, systolic blood pressure and diastolic blood pressure.[49] Increase in diastolic blood pressure, in its turn, has been considered a factor of cardiovascular protection, since it favors coronary flow, increasing oxygen supply to the myocardium and, consequently, reducing ischemic and arrhythmic events.[42] In fact, the protective factor of RT for reduction in ischemic cardiac and arrhythmic events has been widely demonstrated in the literature.[42,50-52] An example of that are the results by Bertagnoli et al.,[50] who, in a study of coronary patients, verified that increment of dumbbells in the hands of patients during aerobic exercises, at the moment of ischemia onset, resulted in normalization of coronary flow. In addition, lower venous reflux during RT seems to generate less distension of myocardial walls, facilitating subendocardial coronary circulation.[35] Finally, it is worth stressing that the three cases of brain hemorrhage reported in the literature in association with RT were attributed to rupture of congenital aneurysms,[53] and, in more than 26,000 maximum load tests performed in a university environment, there were no cases of cardiovascular incidents.[54]

With regard to safety for the musculoskeletal system, RT, because it allows control of the main training variables, provides mitigation of risk factors for lesions such as sudden accelerations and decelerations, torsions, impact, direct trauma and risk of falls.[34,42-44] Such control, in its turn, has made this modality extremely recommended for the treatment of different musculoskeletal disorders, such as joint instabilities, arthroses, idiopathic arthralgias, enthesopathies, tendinitis and tenosinovitis, capsulitis, reflex dystrophy, bursitis, fasciitis, fibrositis/fibromyalgia, panniculitis, discopathies, reported or irradiated pains in the vertebral column and posture disorders.[34,43,55,56]

Benefits of resistance training for patients with peripheral arterial obstructive disease

Due to several benefits provided by RT, the use of this method for the treatment of individuals with PAOD started being investigated over the past years.[28,57]

Although the information available in the literature about the effectiveness of RT in the treatment of individuals with PAOD is still scarce, the results of two published studies on this theme indicated a positive effect of this exercise modality on the treatment of patients with PAOD.[28,57]

Practice of RT in individuals with PAOD resulted in improvement in walking ability, providing significant increase in initial walking distance and in total walking distance,[28,57] in muscle strength, in exercises *leg press* and plantar flexion.[57] Furthermore, increase in capillarization of leg muscles, verified by muscle biopsy,[57] in walking speed, in ability of climbing stairs and in quality of life[58] was also verified after RT programs in individuals with PAOD.

An important advantage of RT in relation to other exercise modalities, especially walking, is absence of claudication during training programs. In the studies by McGuigan et al.[57] and Hiatt et al.,[28] there was no claudication during RT, a common complaint by individuals with PAOD, which has been pointed as one of the factors that could compromise treatment adherence.[59]

Prescription of resistance training for individuals with peripheral arterial obstructive disease

Prescription of RT comprehends manipulation of a series of variables that comprise the training

program. According to that manipulation, it is possible to enhance responses to RT program and increase safety of this practice.

Therefore, the first step to prescribe RT is definition of the objectives that should be achieved using this intervention. In individuals with PAOD, the main objective of an RT program is to improve general physical fitness,[7] resulting in increased autonomy and quality of life for these patients.

However, since it is a population that usually has different comorbid conditions, such as hypertension, diabetes mellitus, obesity, cardiovascular and cerebrovascular diseases, among others,[60] it is prudent to prescribe RT for individuals with PAOD taking into account such limitations.

To do so, it is necessary, before starting an RT program, to submit individuals with PAOD to clinical assessment to diagnose all comorbidities and certify physical condition to practice physical exercises. According to Vincent & Vincent,[45] contraindications to RT, which are also applied to all other forms of exercises in special populations, are systolic blood pressure > 200 mmHg or diastolic blood pressure > 110 mmHg, at rest; drop in orthostatic arterial pressure > 20 mmHg, with symptoms; hypotension during effort > 15 mmHg; unstable angina; uncontrolled arrhythmias; critical or symptomatic aortic stenosis; acute disease or fever; resting heart rate > 120 bpm; decompensated heart failure; third degree atrioventricular block without pacemaker; ongoing pericarditis or myocarditis; recent infarction or pulmonary embolism; depression of ST segment > 2 mV at rest; severe orthopedic problems that prevent RT; hypertrophic cardiomyopathy; *coronary bypass* up to 4 weeks; left ventricular ejection fraction smaller than 30%; advanced or complicated pregnancy.

The main variables that are part of an RT program are weekly volume, exercises, number of series, type of contraction, number of repetitions, intensity, interval and amplitude. Next, we discuss factors that interfere with such variables and that should be considered for prescription of RT in individuals with PAOD.

Weekly volume

Weekly volume of training is usually represented by the number of training sessions per week. In the elderly, at least two weekly sessions of RT can provide improvements in strength,[61] aerobic power,[61] body composition[62] and flexibility.[46] Although studies on RT in individuals with PAOD have used three weekly sessions,[28,57] it is possible that only two weekly sessions are enough to provide positive adaptations, since these patients have low levels of physical fitness. This makes the amount of stimulus needed to provide significant adaptations relatively small.

Thus, an RT program for individuals with PAOD should be comprised of at least two weekly sessions, performed in alternate days.

Exercises

The exercises that are part of the training program comprehend two main aspects: the number of exercises and which muscle groups are emphasized.

There is still no consensus in the literature as to the ideal number of exercises to be used in RT. However, RT programs for beginners include approximately six to 10 exercises.[36] Evidence in the literature suggests that this amount of exercises is enough to cause positive adaptations in different components of physical fitness, being well supported by sedentary elderly individuals and by those with PAOD.[28,36,37,57]

Choice of exercises is directly related to muscle groups that will be exercised. In this sense, for beginners and in those with low levels of physical fitness, it is recommended to initially perform

exercises that reach large muscle groups and that, as the training evolves, specific muscle groups are exercised.[36,37] This recommendation seems to have a major impact on individuals with PAOD, since, in a study in which large muscle groups were emphasized,[57] there were more marked adaptations compared with the study that only prescribed exercises for the lower limbs.[28]

Therefore, RT program for individuals with PAOD should contain between six and 10 exercises, reaching the main large muscle groups.

Number of series

Since it is an effort with predominance of anaerobic metabolism, RT are usually prescribed in series. The authors who compared the adaptations caused by different numbers of series in beginners in RT have presented controversial results, especially when comparing one series with two or three.[63,64] It is known that, in the elderly and in individuals with PAOD, performance of two or more series is well tolerated.[28,37,57] Thus, so far, choice of number of series seems to depend mainly on available time individuals have for each training session.

An RT program for individuals with PAOD should use one to three series, according to the student's time availability.

Type of contraction

In the RT performed with free weights or weight lifting equipment, two types of contraction can be used: isometric and dynamic contractions. Isometric contractions are characterized by absence of articular movement, i.e., the exercise is performed statically. Dynamic contractions can be subdivided into concentric and eccentric. Concentric contractions are those in which there is reduction in articular angle, i.e., there is "shortening of the skeletal muscle." Concentric contractions are those in which there is increase in articular angle, i.e., there is "widening of the skeletal muscle."

RT programs prescribed to improve physical fitness of the elderly are mainly comprised of dynamic contractions, both concentric and eccentric. Although use of three types of contraction results in positive adaptations for the elderly,[65] use of predominantly dynamic contractions is justified by abnormal responses of the cardiovascular system to isometric contractions,[66,67] which have this type of contraction contraindicated for individuals with cardiac diseases.[67]

Therefore, an RT program for individuals with PAOD should predominantly use dynamic contractions, both concentric and eccentric.

Number of repetitions

The number of repetitions performed in each series seems to be related to the adaptations generated by the training. In this sense, it has been suggested that repetitions from one to five result in greater adaptations in power and maximum muscle strength, whereas a higher number of repetitions (15 to 25) enhances gains of local muscle resistance.[21,36,68] However, the current relationship between number of repetitions and adaptations to training has been questioned over the past years.[69]

On the other hand, it is well established in the literature that, the higher the number of repetitions performed in RT, the higher the increase in heart rate and systolic arterial pressure.[54,70] Thus, performing a large number of repetitions in individuals with PAOD, who usually have associated cardiac diseases, may put the patient's health at risk. In studies on RT for individuals with PAOD, the study that used eight to 15 repetitions[57] had more adaptations when compared with the study

that used only six repetitions.[28] Therefore, it is suggested that number of repetitions in an RT program for individuals with PAOD should have between eight and 15 repetitions.

Exercise intensity

Exercise intensity is usually determined by overload imposed by the equipment or free weight. Positive adaptations in the elderly have been observed after performing RT with moderate to high intensity.[71,72] However, performing high intensity RT is normally followed by effort apnea (Valsalva's maneuver) and increase in isometric component of the movement (movements are performed with slower speed).[73] Those two aspects, in their turn, result in marked increase of systolic arterial pressure during exercise and are considered indicative of an inadequate level of effort for hypertensive patients and for those with cardiac diseases.[35,45,49,73]

Thus, RT intensity for individuals with PAOD should be that in which the individual performs the exercise without apnea or reduction in movement speed, which corresponds to the level "slightly tiring" or "tiring" according to the subjective effort scale proposed by Borg.[74]

Interval

Intervals correspond to the recovery time between series and between exercises. The recovery interval is directly related to training intensity, and shorter intervals represent greater effort intensity. Recovery intervals adopted in RT programs in the elderly generally range between 1 and 2 minutes.[36] However, in a recent study,[75] it was demonstrated that short intervals (less than 90 seconds) are not enough to make systolic arterial pressure return to basal levels before starting the next series. Therefore, the individual starts the series with higher systolic arterial pressure and, consequently, during the effort, reaches higher pressure levels. On the other hand, it has been suggested that recovery intervals that are excessively long (more than 3 minutes) could acutely reduce the amount of circulating anabolic hormones.[76,77] Nevertheless, such information is controversial in the literature[78] and has not been confirmed in the elderly yet.

That is why recovery intervals between series of at least 90 seconds are recommended in RT for individuals with PAOD.

Amplitude

Movement amplitude can be understood as *the dimension of displacement of the body or its segments between given points, most of the times expressed in degrees*. Although there is not much evidence on the influence of this variable in RT responses, it is commonly accepted that, the higher the exercise amplitude, the higher the benefit. However, in individuals with musculoskeletal diseases or lesions, movement amplitude should be limited by painful feelings, which in some cases can be very limited, with only a few degrees of articular movement.[34,43] Therefore, RT amplitude in individuals with PAOD and musculoskeletal lesions should be that in which the individual can perform the exercise without having pain.

Conclusions

Few studies have assessed the effects of RT in patients with PAOD. Considering that patients affected by this disease can be benefited by the therapeutic effects of RT, it is recommended to include this modality in the treatment of PAOD. However, due to the presence of multiple diseases and risk factors in those patients, special cares must be adopted when prescribing RT for this population.

Table 2 - Summary of recommendations proposed for prescription of resistance training for individuals with peripheral occlusive arterial disease

Variable	Recommendation
Weekly volume	At least two weekly sessions
Exercises	6 to 10 for large muscle groups
Number of series	1 to 3
Type of contraction	Dynamic (concentric and eccentric)
Number of repetitions	8 to 15
Intensity	"Slightly tiring" to "tiring" according to Borg's scale[74] (without apnea or increase in isometric component)
Interval	At least 90 seconds
Amplitude	Limited by painful feelings

Therefore, this study aimed at discussing aspects related to prescription of RT for individuals with PAOD and proposing a prescription model based on scientific evidence, presented in Table 2.

It is worth stressing the need of performing new studies on the benefits of RT for individuals with PAOD, especially the effects of manipulating different training variables in this population.

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