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Effect of physical exercise on cardiac autonomic modulation in the elderly: systematic review

Efeito do exercício físico na modulação autonômica cardíaca em idosos: revisão sistemática

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Abstract

Objectives: The aim of this systematic review of randomized controlled studies was to assess the available scientific evidence on the effect of physical exercise on the muscular vasodilator response and cardiac autonomic modulation in the elderly. Methods: The articles selected for this review were indexed in PubMed/MEDLINE, SCIELO and LILACS. The descriptors used were "exercise" and "aged" and the keywords "vasodilator response muscular", "muscle blood flow", "heart rate variability" and "cardiac autonomic modulation". Results: Through this search strategy 1,686 articles were found. Of these, only five were considered eligible for data analysis. Conclusion: This review indicates that physical exercise can be effective in improving cardiac autonomic modulation in healthy elderly and for elderly after an acute cardiovascular event, with favorable prognosis, with heart failure and chronic atrial fibrillation. In elderly patients with heart failure physical exercise can also be effective in improving muscular vasodilator response.

Key words: Autonomic nervous system; Elderly; Exercise; Vasodilation.

Resumo

Objetivo: Avaliar as evidências científicas disponíveis a respeito do efeito do exercício físico sobre a resposta vasodilatadora muscular e a modulação autonômica cardíaca em idosos. Métodos: Os artigos selecionados estavam indexados nas bases PubMed/MEDLINE, SCIELO e LILACS. Foram utilizados os descritores "*exercise*" e "*aged*", e as palavras-chaves "*vasodilator response muscular*", "*muscle blood flow*", "*heart rate variability*" e "*cardiac autonomic modulation*". Resultados: Foram encontrados 1.686 textos, destes, apenas cinco foram considerados elegíveis. Todos avaliaram a modulação autonômica cardíaca e um deles avaliou a resposta vasodilatadora muscular concomitantemente. Conclusões: Esta revisão indica que o exercício físico pode ser eficaz na melhora da modulação autonômica cardíaca em idosos saudáveis e em idosos após evento cardiovascular agudo, com prognóstico favorável, com insuficiência cardíaca e com fibrilação atrial crônica. Aditivamente em idosos com insuficiência cardíaca, o exercício físico também foi eficaz na melhora da resposta vasodilatadora muscular.

Descritores: Sistema nervoso autônomo; Exercício físico; Idoso; Vasodilatação.

Introduction

The aging process is also linked to changes in the autonomic control of cardiovascular function[1], decreased vagal tone, increased sympathetic tone and attenuation of autonomic regulatory mechanisms[2].

Cardiac autonomic modulation refers to the sympathetic and parasympathetic influences exerted by the heart. Its assessment is intended to verify the integrity of sympathetic and parasympathetic efferents, which have important significance in various clinical conditions and/or functions of the individual. It can additionally be used as an independent prognostic factor for cardiovascular morbidity and mortality[3, 4, 5, 6].

The variability of heart rate is a reliable method for analyzing the modulatory effects of the autonomic nervous system, being a marker of cardiac autonomic control[7, 8], and is measured by means of analysis of the time domain and frequency domain[4, 5].

Egashira et al.[9] demonstrated that the reduction of endothelium dependent vasodilatation can also be related to age. With aging, studies have shown that vascular endothelium undergoes changes which can lead to a decrease in vasomotor tone and regional blood flow[10, 11].

Longitudinal and transverse studies suggest that physical exercise, when practiced with intensity, duration and appropriate frequency, causes changes in the cardiovascular system, the autonomic nervous system and neurocardiac function. Some of these changes would be possible increases in parasympathetic activity, heart rate variability and forearm blood flow[12, 13].

According Davini et al.[14], despite the large number of studies involving young people or adults, little attention has been given to elderly people with different patterns of physical exercise. Considering the growing participation of individuals of advanced age in physical activity programs, the goal of this study was to conduct a systematic review of randomized controlled studies to assess the available scientific evidence about the effect of physical exercise on the muscular vasodilator response and cardiac autonomic modulation in the elderly.

Methodology

The articles selected for this review are indexed in PubMed/MEDLINE, SCIELO and LILACS until March 2011. The descriptors used were "exercise" and "aged" and the keywords "vasodilator response muscular", "muscle blood flow", "heart rate variability" and "cardiac autonomic modulation".The descriptors were combined with each keyword in each database. There was no language restriction. Figure 1 shows the flow diagram of the researched literature.

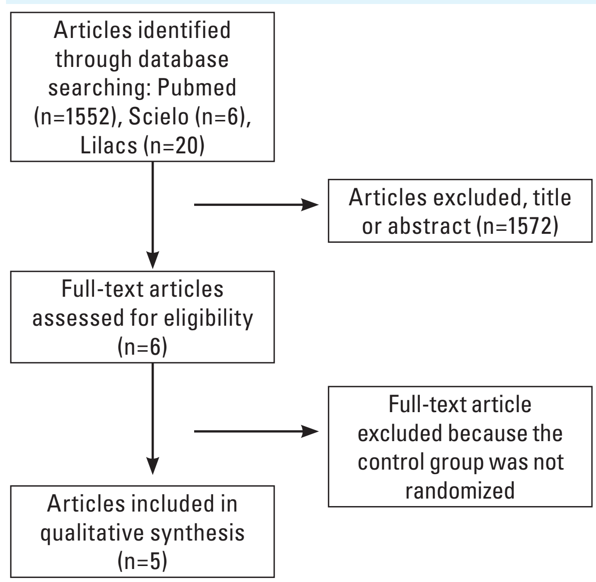

Figure 1: Flow chart of researched literature

The titles and abstracts, identified by the electronic search, were initially examined to select the articles. The inclusion criteria were randomized controlled studies assessing the effect of physical exercise on cardiac autonomic modulation and muscular vasodilator response in the elderly. Studies that conducted other types of assessment in the elderly, that conducted other interventions that were not physical exercise, or whose samples were not composed exclusively of elderly, were excluded.

To assess the methodological quality of studies, the modified Jadad scale[15] was used. The Jadad system consists of three topics focused on the internal validity of the research, containing seven dichotomous questions, related to randomization, blinding and loss of participants, directly related to the reduction of bias. Clinical studies with a score of 0-2 are considered low quality, 3-4 as moderate quality, and 5-6, high quality.

Results

Using this search strategy, 1,686 articles were found. Of these, five were included for data analysis: Stahle, and Nordlandert Bergeldt[16], Schuit et al.[12], Selig et al.[13], Hegbom et al.[17] and Madden, Levy and Stratton[18]. The other papers were excluded for not meeting the eligibility criteria, as shown in Figure 1.

Concerning the assessment of methodological quality, the selected articles reached a score of five or six points, according to the modified Jadad scale[15], indicating a high methodological quality for the studies.

In the Table 1 describes the characteristics of the selected studies for healthy elderly. Two studies totaled 44 women and 22 men undergoing physical exercise.

Table 2 describes the characteristics of the selected studies for elderly patients with heart disease, cardiac rhythm disorder and coronary events. The sample sizes of studies that underwent physical exercise ranged from 15 to 29 participants, totalling 37 women and 26 men.

Table 1: Characteristics of selected studies with healthy elderly

Study	Sample	BMI	Exercise	Intensity	Duration
Schuit et al. (1999)[12]	(36/EG) 14F/22M, 67 ± 5.1years	25,8±3,8	6 months of aerobic training (Sports in which the elderly have skill)	60-80% MHR	45 minutes / 3x weekly
Madden, Levy and Stratton (2006)[18]	45 (resistance 15-EG1, 69.8 ± 1.5 years; 15-EG2 aerobic 70.0 ± 2.6 years), healthy elderly	EG1: 26.8 ± 1.5 EG2: 28.5 ± 2.2	EG1: 6 months of resistance training (10 exercises for UL and LL) EG2: 6 months of aerobic exercise on a ergometer cycle	EG1: up to 85% MVC EG2: Moderate to vigorous (up to 80-85% MHR)	EG1: 3 sets of 8-12 repetitions per exercise 5x per week EG2: 5x per week

M = male; F = female; MHR = maximum heart rate; MVC = maximal voluntary contraction; UL: upper limbs; LL = lower limbs; EG = exercise group; CG = control group.

Table 2: Characteristics of selected studies with elderly patients with pathologies

Study	Sample	BMI	Exercise	Intensity	Duration
Stahle, and Nordlandert Bergeldt (1999)[16]	65 (29/EG) 22F/7M, post acute coronary event, 71 ± 4 years	26±5	3 months of ergometric cycling	Interval training with three peaks of 4 minutes (> 85% MHR)	50 minutes / 3x weekly
Selig et al. (2004)[13]	39 (19/EG) 15F/4M, HF functional class 2.3 ± 0.5, 65 ± 3 years	–	3 months of resistance training (UL and LL)	Moderate Intensity	3x per week
Hegbom et al. (2006)[17]	30 (15/EG), elderly males with chronic atrial fibrillation, 64 ± 7 years	–	2 months of aerobic and resistance exercise (LL, back and stomach)	Aerobic: 70-90% MHR	1.25 hours / 3x per week

M = Male; F = Female; VO_{2max} = maximum volume of oxygen; MHR = Maximum Heart Rate; COPD = Chronic Obstructive Pulmonary Disease; HF = Heart Failure; UL = Upper Limbs; LL = Lower Limbs; EG = Exercise Group; BMI = Body Mass Index.

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Table 3 presents the results, limitations and conclusions of each selected article for healthy elderly. The articles evaluated only the cardiac autonomic modulation.

Table 4 presents the results, limitations and conclusions of each article selected for elderly suffering from heart disease, cardiac rhythm disorder and coronary events. The articles assessed the cardiac autonomic modulation and one of them also assessed blood flow in the forearm.

Discussion

This review indicates that physical exercise can be effective and important for the improvement of cardiac autonomic modulation in healthy elderly and elderly patients after acute cardiovascular event, with a favorable prognosis and with chronic atrial fibrillation. In elderly patients with heart failure, physical exercise, in addition to improving cardiac autonomic dysfunction, may also be effective in increasing muscular vasodilator response.

Table 3: Variables, findings, limitations and conclusions of the selected studies with healthy elderly

Study	Variables time/ monitored	Results	Conclusion	Limitations
Schuit et al. (1999)[12]	HRV	↑ HRV time domain SDNN (+6% - p <0.05) ↑ FL (+15% - p <0.05) ↑ VFL (+10% - p <0.05)	The regular practice of physical activity increases HRV in elderly	–
Madden, Levy and Stratton (2006)[18]	HRV	EG1: No significant change in HRV EG2: ↑ SD (+16%, p = 0.02) ↑ SDANN (+21%, p = 0.02) ↑ FL (+81%, p = 0.004) ↑ FH (+48%, p = 0.046)	Aerobic training had significant impact on HRV, in contrast to resistance training.	–

↓ = significant decrease; ↑ = significant increase; HRV = Heart Rate Variability; FL = low frequency component; VFL = very low frequency component; FH = High frequency component; SDNN = Standard deviation RR interval; SD = Mean of all the 5-minute standard deviations of RR intervals; SDANN = standard mean deviation of all RR intervals for all 5-min periods of time analyzed; – = data not supplied.

Table 4: Variables, results, limitations and conclusions of studies of elderly suffering from pathologies

Study	Variables / time monitored	Results	Conclusion	Limitations
Stahle, Nordlandert and Bergeldt (1999)[16]	HRV	↑ HRV time domain SDNN (p <0.01) and SDANN (p <0.05)	A program of regular aerobic training can significantly modify HRV in elderly patients with favorable prognosis after an acute cardiovascular event	–
Selig et al. (2004)[13]	HRV and forearm blood flow	↓ FL / FH 44 ± 53% (P <0.01) ↑ blood flow at rest (20 ± 32% - P <0.01) at sub maximal exercise (24 ± 32% - P <0.01) and limb ischemia (26 ± 45% - P <0.01)	A program of resistance training in patients with HF produced favorable changes in HRV and forearm blood flow at rest and the muscular vasodilator response to sub maximal exercise and limb ischemia	–
Hegbom et al. (2006)[17]	HRV	↓ HRV at rest and after 10 minutes of exercise (p<0.05) ↑ FH (p<0.05)	HRV increases after two months of aerobic and strength training in the group of patients with chronic atrial fibrillation	–

FBF = forearm blood flow; ↓ = significant decrease; ↑ = significant increase; NS = Not Significant; HRV = Heart Rate Variability; FL= low frequency component; FH = high frequency component; HF = Heart Failure; SDNN = Standard deviation RR interval; SDANN = standard mean deviation of RR intervals in 5 minutes; – = data not supplied.

Only five articles were included, two involving healthy elderly and three involving elderly suffering from heart disease, cardiac rhythm disorder and coronary events. All studies assessed the cardiac autonomic modulation and one of them also assessed the muscular vasodilator response. It is worth noting that all the studies examined showed consensus on the effectiveness of physical exercise in the improvement of these cardiovascular parameters.

All the studies that assessed the cardiac autonomic modulation used the heart rate variability (HRV) through the analysis of the domain of time and frequency, whilst the study evaluating the muscular vasodilator response used venous occlusion plethysmography. The methods used are reliable for evaluation of these cardiovascular variables[7, 8, 19].

The three studies with elderly patients with pathologies involved heart failure, chronic atrial fibrillation and elderly patients after acute cardiovascular events that impair the performance of the autonomic nervous system. The impairments after acute cardiovascular events and heart failure involve activation of neurohumoral systems, especially sympathetic nervous system hyperactivity, in which, during early myocardial injury, acute activation of the sympathetic system occurs due to the adaptive response, with the aim of restoration or maintenance of blood pressure and cardiac output. In atrial fibrillation, the operation of the sympathetic nervous system can happen through its action on the substrate and by the stimulation of triggers, which are ectopic in focus[4, 20].

The ageing process, even without associated pathologies, already promotes decreased vagal tone, increased sympathetic tone and attenuation of autonomic regulatory mechanisms, with consequent decrease in HRV[21, 22]. With ageing, studies also show decreased vasomotor tone and regional blood flow, explained by increased peripheral vascular resistance[10, 11, 23].

There was a predominance of women in both elderly groups. Rennie et al.[24], Sanchez et al.[25] and Zhang[21] stated that women, until the age range 45-55 years of age, have different in cardiac autonomic control in relation to men with parasympathetic predominance and higher HRV. With aging however, especially after menopause, these differences tend to decrease[25, 26]. According to some authors, gender can influence the neural and hemodynamic responses in various situations[24, 27, 28].

The protective effect attributed to estrogens would be related to the metabolism of plasma lipoproteins, with the reduction of LDL cholesterol and increase of HDL cholesterol. However, these changes in lipid profile would contribute only about 25% of the protective effect of estrogens. Other potential mechanisms of estrogen action include protection against LDL oxidation, decreased lipoprotein, enhancement of fibrinolysis and increased insulin sensitivity. In arteries, estrogens improve vasodilator function, reduce calcification and secretion of cell adhesion molecules and the formation of atherosclerotic lesions and may improve endothelial function and reduce the risk of atherosclerosis in premenopausal women. With aging however, especially after menopause, these differences tend to decrease[25, 26, 29].

With respect to body mass index there was similarity in the samples, since the three studies that reported this data gave values corresponding to the overweight range. According Ichinose et al.[30] there is greater sympathetic action on the internal organs and skeletal muscle in obese subjects.

In the studies with healthy elderly, aerobic and resistance exercise took place over six months[12, 18]. However, only the elderly undergoing aerobic training had a significant increase in HRV. In the study by Madden, Levy and Stratton[18] the chosen aerobic exercise was the ergometer cycle, with sessions occurring five times per week at intensity 80-85% MHR. The study by Schuit et al.[12] used aerobic training in sport, in which the elderly had ability, with sessions of 45 minutes three times per week, at 60-80% MHR.

The study by Madden, Levy and Stratton[18] was the only one of the five studies in which the results found were not significantly favorable. One of the groups was subjected to resistance training with three sets of 8-12 repetitions per exercise, five times a week from 10 exercises for upper and lower limbs, at up to 85% MVC. These elderly showed improvement in cardiac autonomic modulation, although of a form that was not statistically significant. The authors explained that the increase in arterial compliance is associated with increased HRV through increasing the sensitivity of arterial baroreceptors and resistance training involves abrupt and sustained elevations in blood pressure that results in the stiffening of large vessels and might reduce arterial baroreflex sensitivity, not improving the HRV, however.

In studies with elderly patients with pathologies, aerobic and resistance exercise took place over 2-3 months[13, 16, 17]. All the studies showed significant increases in HRV. Selig et al.[13] also evaluated the forearm blood flow and found a significant improvement.

In the study of Stahle, Nordlandert and Bergeldt[16], with elderly people after acute coronary event, the aerobic exercise chosen was the ergometer cycle, with sessions of 50 minutes, three times a week, and interval training with three peaks of four minutes of more than 85% MHR, for three months. The work by Selig et al.[13], with elderly patients with heart failure, used three months of moderate resistance training for upper and lower limbs, with three weekly sessions. In the study of Hegbom et al.[17], with elderly patients with chronic atrial fibrillation, there was a combination of strength exercises for the lower limbs, back and stomach, and aerobic exercise of intensity 70-90% MHR, with sessions from 1.25 hours, three times a week, for two months.

The article of Hegbom et al.[17] was the only one that reported study limitations, stating that the sample size was small and that the sample was heterogeneous, being predominantly male and few with heart failure.

Conclusion

This review indicates that six months of aerobic exercise can be effective in promoting positive changes in cardiac autonomic modulation in healthy elderly. However, no study has evaluated muscular vasodilation in this elderly group.

In elderly patients after an acute cardiovascular event, with a favorable prognosis, three months aerobic exercise can improve cardiac autonomic dysfunction. Additionally, in elderly patients with heart failure three months of physical strength exercise may promote favorable changes in the reduction of cardiac autonomic dysfunction and improve muscular vasodilation. Whilst, on the other hand, two months of aerobic and resistance exercise can reduce cardiac autonomic dysfunction in elderly patients with chronic atrial fibrillation.

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