

The Effects of combined aerobic and resistance training on heart rate variability in postmenopausal women

Efeitos do treinamento aeróbio e resistido combinados na variabilidade da frequência cardíaca em mulheres na menopausa

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ABSTRACT

Model of the study: Controlled clinical trial. **Objective:** To verify the effects of 16 weeks of combined aerobic and resistance training on cardiac autonomic modulation in menopausal women. **Methods:** 17 menopausal women were divided into two groups: the training group (TG: n=11) and control group (CG: n=6). The body composition variables were estimated using dual-energy X-ray absorptiometry. The cardiac autonomic modulation was evaluated by heart rate variability using linear indexes. The training protocol consisted of 16 weeks of 50 minutes of resistance training and 30 minutes of aerobic training. **Results:** For the TG there was an increase in the rMSSD(ms) index (pre:17,4±3,7 and post:24,8±13,1, p<0,045), an increase in the duration of the intervals between the cardiac beats(ms) (pre:891,2±80,2 and post:974,1±71,4, p<0,003) and in the values of heart rate(bpm) (pre:68,1±6,4 and post:62,0±4,7, p<0,003), additionally for the spectral indexes in normalized units, changes for LF (pre:52,2±13,1 and post:44,5±12,4, p<0,025) and HF (pre:47,8±13,3 and post:55,5±12,4, p<0,025) were noticed, demonstrating increased parasympathetic and reduced sympathetic. There were no significant differences to CG. **Conclusion:** combined aerobic and resistance training promoted benefits to the autonomic modulation in menopausal women.

Key-words: Aerobic training. Resistance training. Autonomic nervous system. Postmenopausal. Parasympathetic nervous system. Exercise.

Introduction

Aging is responsible for important physiological changes, such as a reduction in functional capacity, physical fitness and significant changes in body composition, characterized by weight gain and body adi-

posity, primarily the central and muscle mass reduction.¹ For women, due to the menopause, these intrinsic effects of aging are increased.²

Additionally, changes in the cardiac autonomic function have also been observed due to the aging process,^{3,4} a fact that contributes to the reduction of heart

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rate variability (HRV) and promotes an unfavorable cardiac condition, which is strongly related to myocardial disease and sudden death.⁵

Different approaches through physical exercise have been used in an attempt to reduce the organic disorders that are related to the changes in autonomic modulation.^{6,7} There is evidence that aerobic training is able to promote positive changes in the HRV of women after menopause,^{8,9} however, when resistance training was used in elderly women, significant changes to the HRV⁶ were not observed.

The combining of aerobic training and resistance training in the same training session, which is denominated combined aerobic and resistance training,¹⁰ in postmenopausal women was not found in the specialty literature, and when this type of training was performed with elderly men, an improvement in HRV¹¹ was observed.

As a result, taking into consideration the consequences of aging and the menopause on autonomic modulation, in addition to the lack of studies that have verified the responses of combined aerobic and resistance training on this component in women, the present study had as its objective to verify the responses of 16 weeks of combined aerobic and resistance training on the cardiac autonomic modulation, evaluated by heart rate variability (HRV) in women after the menopause. The hypothesis was that combined aerobic and resistance training could promote benefits to the autonomic modulation in women after the menopause, as this had been observed in other populations.

Materials and methods

Subjects

From an ethical point of view, the program in question was approved by the Ethics Committee of UNESP, Presidente Prudente (Protocol 64/2011). The study included 17 women with a mean age of $60,8 \pm 6,2$ years, all of them in menopause, who participated in an exercise program in 2011, which was called "Action and Health" and was developed at the University Estadual Paulista (UNESP) - Presidente Prudente/SP.

The disclosure of the existence of the project was done through newspapers, television and the internet and women interested in participating contacted the responsible researchers. In order to be included in the project the women had to meet the following criteria: 1) be in menopause (having had no

menstrual cycle for 1 year or more)¹²; 2) be aged between 50 and 79 years on the assessment date; 3) not present any physical limitations or health problems that would prevent the completion of the assessments and exercises; 4) have a medical certificate to perform the assessments and participate in the combined aerobic and resistance training; 5) not have practiced systematized physical activity for at least 6 months; 6) not be receiving treatment for hormone replacement; 7) sign the consent form and formal clarification for participating in the study.

Anthropometry and Body Composition

Body mass was measured using an electronic balance of Filizola brand, with a maximum capacity of 180 kg and precision of 0.1 kg. Height was measured on a fixed stadiometer of Sanny brand, with an accuracy of 0.1 cm and a length of 2.20 m.

To estimate fat free mass, fat mass, and percentage body fat the *Dual-Energy X-ray Absorptiometry (DEXA) scanner version 4.7 (General Electric Healthcare, Lunar DPX-NT; England)* was used.

Autonomic Modulation Evaluation

An evaluation of initial and final heart rate variability was performed in order to obtain the autonomic modulation and this was assessed individually, in the morning, in a room of between 21° C and 23° C and 40 and 60% humidity. The volunteers were instructed to avoid alcoholic and/or stimulant drinks such as coffee or tea and suspended from medication such as bronchodilator, mucolytic, and anti-inflammatory medication for a period of 12 hours prior to the autonomic evaluation.

During the autonomic evaluation, the volunteers were instructed to remain awake, in silence, at rest with spontaneous breathing in the supine position for 30 minutes on a couch. After an explanation of the procedures for data collection, an elastic strap was placed on the volunteer's chest at the sternal angle and a heart rate receiver (Polar Electro, model S810i, Finland) on their wrist, this equipment had been previously validated to record the beat-to-beat heart rate and the resulting data was used for analysis of HRV.^{13,14}

For the analysis of HRV indexes, after digital filtering, complemented by manual filtering to eliminate artifact and ectopic beats, 256 intervals between consecutive cardiac beats were selected of the most

stable part of tracing and only series made up of more than 95.0% of sinus beats were included in the study; the analysis was processed by the Kubios (Biosignal Analysis and Medical Image Group, Department of Physics, University of Kuopio, Finland) software.^{15,16}

In the time domain, the following indexes were used: rMSSD [the root mean square of successive difference between normal intervals of consecutive cardiac beats in an interval of time expressed in milliseconds (ms)] and SDNN [the standard deviation of normal-to-normal intervals in an interval of time expressed in ms]²⁴. In the frequency domain, the spectral components of low frequency [LF: 0.004 to 0.15 Hertz (Hz)] and high frequency (HF: 0.15 to 0.40Hz), expressed in ms² (ms in square) calculated by the Fast Fourier Transform algorithm¹⁷ were used.

Experimental Protocol

The initial assessment was performed two weeks before the beginning of the training program and consisted of anamnesis for investigation of the inclusion criteria, anthropometry and body composition evaluation to characterize the sample and heart rate variability to evaluate the autonomic modulation. The final assessment occurred after sixteen weeks of intervention and consisted of the autonomic modulation evaluation. The participants who accumulated three consecutive absences or four absences during one month were cut from the program.

The participants were randomly distributed in the following groups: **Training group (TG)** - composed of 11 women who participated in the combined aerobic and resistance training program; **Control Group (CG)** composed of 6 women, who did not undergo any intervention during this period, but joined the training group in the following year of the project. There was no prescription of diets and the women were instructed to continue their eating habits.

The TG group performed the combined aerobic and resistance training three times a week on non-consecutive days, 90 minutes per day, with 50 minutes of resistance training, 30 minutes of aerobic training, and 10 minutes of warm up and stretching at the end of the training session. At the beginning of the activities there was a two-week period of familiarization for both aerobic activities and for the strength exercises. The exercises used in the program were: 45° leg press, leg extension, leg curl, bench press, seated row, arm curl, triceps extension, side elevation with dumbbells and abdominal.

The intensities of aerobic training were established in accordance with the anaerobic threshold (LAN), determined by the non-exhaustive double effort protocol.¹⁸ The training was performed on an official running track, marked every 50 meters. The initial intensity of training was 100% (1st to 4th weeks) and 110% (5th to 8th weeks) of the pre intervention LAN. After eight weeks of training, a new test was performed to adjust the intensities. The women trained again at 100% (7th to 12th weeks) and 110% (13th to 16th weeks) of the LAN established in the second test. The intensity of the exercise was monitored through the time required to traverse each 400m (1 lap), the heart rate, which was around 70% of maximum heart rate¹⁹ and the scale exertion.²⁰ To ensure that the training speed was correct, the group was followed by professionals who monitored the speed of the training. Participants were instructed to drink water and wear appropriate clothes and shoes during training.

The intensity of the resistance training was controlled through the zone of maximum repetitions (RM), meaning that the series were executed until momentary exhaustion.²¹ In this way, when the participants were performing the training with the repetitions varying from 12 to 15 RM, they were always stimulated to perform a minimum of 12 and a maximum of 15 repetitions, in the case where they could perform more than 15 RM the weight was increased in order to respect the training zone.

Only one test of maximum repetition (1RM) was performed in the Leg press and bench press according to the recommendations of Raso et al.²²

The training overload was adjusted every four training weeks, in which at the 1° phase, the participants performed three series of 12-15 repetitions; 2° phase three series of 10-12 repetitions; 3° phase three series of 8-10 repetitions and 4° phase three series of 6-8 repetitions.

Statistical Analysis

A descriptive analysis was carried out for the sample characterization. For the statistical handling the Shapiro-Wilk test was used to test the data normality. If the data presented normal distribution the normal t test was used for paired data to verify the effect of the training pre and post intervention. If the data did not show normal distribution, the Wilcoxon test was applied. All analyzes were performed using the SPSS statistical package version 13.00 (SPSS, Inc. Chicago IL). The significance level was 5%.

Results

The general characteristics of the studied sample are presented in Table 1.

Table 2 presents the values of the HRV at pre and post intervention moments in the time domain and Table 3 presents the values in the frequency domain.

It was noticed that in the time domain there was

a significant increase in the rMSSD index in the training group, such as a significant increase in the intervals between the heart rate and in the values of heart rate. Additionally, for the training group, concerning the spectral indexes, significant changes were noticed for the LF and HF in normalized units, demonstrating increased parasympathetic and reduced sympathetic.

Table 1
General characteristics of the sample are represented as mean and standard deviation.

	Training (n=11)	Control (n=6)	t	p
Age (years)	62,1 ± 6,6	58,5 ± 5,1	1,171	0,260
Weight (Kg)	62,4 ± 8,2	72,8 ± 17,4	-1,690	0,112
Height (cm)	152,5 ± 6,9	154,7 ± 8,8	-0,559	0,584
Fat Mass (kg)	27,2 ± 4,5	33,2 ± 9,0	-1,861	0,082
Fat Mass (%)	43,6 ± 4,6	45,5 ± 4,6	-0,802	0,435
Fat Free Mass (kg)	33,0 ± 5,3	37,3 ± 9,6	-1,184	0,255

p<0,05

Table 2
Temporal indexes of heart rate variability as mean, standard deviation, median and interquartile interval at pre and post intervention.

Linear indexes	Training (n=11)			Control (n=6)		
	Pre	Post	p	Pre	Post	P
MeanRR (ms)	891,2±80,2	974,1±71,4	0,003 ^a	997,0±92,7	972,9±96,4	0,484 ^a
	867,8(130,0)	988,2(129,4)		1003,0(141,6)	975,3(161,4)	
MeanHR (bpm)	68,1±6,4	62,0±4,7	0,003 ^a	60,7±5,9	62,2±6,0	0,530 ^a
	69,2(10,4)	60,8(8,1)		59,8(8,8)	61,6(10,6)	
SDNN (ms)	24,2±5,6	31,3±13,1	0,110 ^b	27,4±9,8	28,0±9,6	0,600 ^b
	25,2(9,7)	25,9(9,0)		25,9(13,9)	27,4(15,0)	
rMSSD (ms)	17,4±3,7	24,8±13,1	0,045 ^b	22,6±10,1	22,3±8,0	0,917 ^b
	17,4 (3,0)	21,0(5,5)		21,4(22,0)	18,6(15,5)	

MeanRR: mean of normal intervals consecutive cardiac beats, SDNN: the standard deviation of normal-to-normal intervals, rMSSD: the root mean square of successive difference between normal intervals consecutive cardiac beats, ^a Paired t test; ^b Wilcoxon test. P < 0,05

Table 3
Spectral indexes of heart rate variability as mean, standard deviation, median and interquartile interval at pre and post intervention moments.

Linear index	Training (n=11)			Control (n=6)		
	Pre	Post	p	Pre	Post	P
LF (ms ²)	136,1±35,1	190,4±138,7	0,306 b	146,2±116,8	172,3±144,5	0,173 b
	146,0(63,0)	176,0(150,0)		117,0(119,0)	122,5(152,0)	
HF (ms ²)	145,7±120,0	236,3±235,5	0,075 b	159,0±94,0	162,5±88,8	0,753 b
	117,0 (70,0)	167,0(116,0)		163,5(186,0)	128,5(174,0)	
LF(un)	52,2±13,1	44,5±12,4	0,025 a	48,8±19,8	49,5±15,6	0,841 a
	53,2(17,9)	49,2(21,5)		55,3(33,7)	49,3(24,9)	
HF (un)	47,8±13,3	55,5±12,4	0,025 a	51,2±19,8	50,5±15,6	0,841 a
	46,8(17,9)	50,8(20,5)		44,6(33,7)	50,7(24,9)	
LF/HF	1,2±0,6	0,9±0,4	0,035 a	1,2±0,7	1,1±0,7	0,879 a
	1,1(0,8)	1,0(0,7)		1,281(1,350)	0,987(1,109)	

LF: Low-frequency spectral component, HF: High-frequency spectral component, a Paired t test; b Wilcoxon test. P < 0,05

Discussion

The result analysis suggested significant improvement of the autonomic modulation for the women's group that participated in the combined aerobic and resistance training, characterized by an increase in parasympathetic activity, reduction in sympathetic activity, reduction in the average heart rate and an increase in the average interval between consecutive heart rate. From the research in specialized literature, this is the first study that has evaluated the effects of combined aerobic and resistance training on autonomic modulation in women after menopause.

Through the analysis of HRV indexes in the frequency domain, significant changes for the group that realized the combined aerobic and resistance training can be observed, demonstrated by the reduction in the LF(un) index, which represents the joint action of the SNA with predominance of the sympathetic component, and increased HF(un) that represents the parasympathetic component, indicating improvement

in the autonomic modulation characterized by a reduction in the sympathetic component and an increase in the parasympathetic component.

Concerning the results obtained in these indexes in ms², it was observed that even though not statistically significant, there occurred increases in the values of the LF(ms²) and of the HF(ms²) for the group that realized the combined aerobic and resistance training, which could indicate an improvement in the autonomic modulation. The increase in the frequency bands was higher for the HF(ms²).

For the analysis of the time domain indexes, it can be observed that the rMSSD(ms) that represents the parasympathetic component of the SNA, such as the SDNN(ms) that represents the global variability²³ represented increases in the trained group, with significance for the first. Additionally, there was a reduction in the average heart rate and an increase in the average of intervals between consecutive heart rate, both significant, observed in the postmenopausal women who participated in the training.

Improvements in the autonomic modulation, in women after the menopause, after different training protocols were described in the literature. Earnest et al.,⁸ observed improvement in the autonomic modulation in women after the menopause who carried out an aerobic exercise program on the ergometer cycle or ergometer mat of moderate intensity for 6 months. In women in menopause with coronary arterial disease the improvement of the autonomic modulation was observed with a program of domiciliary exercise, realized 3 times per week for 8 weeks.²⁴

Still in this context, Jurca et al.,⁹ analyzing the effects of 8 weeks of aerobic exercises with moderate intensity on HRV in a similar population to the present study, observed that regardless of the use of hormone therapy, there was significant increases in the rMSSD, SDNN, LF e HF indexes evaluated in ms and ms², but no changes in the normalized units. Also, Madden et al.,²⁵ compared a program of aerobic exercises with a program of resistance exercises in elderly women and obtained a higher impact on the HRV global from the aerobic training when compared to the resistance training.

In the present study with the combined aerobic and resistance protocol, beneficial effects on the autonomic modulation were observed as well, showing that the combination of the two types of training is also effective in this aspect. Karavirta et al.¹¹ likewise observed improvement in autonomic modulation, evaluated from the fractal indexes of the HRV, by performing combined training (aerobic training and strength training on different days) on men of about 40 to 67 years old. Besides this, the authors compared the effect of aerobic training, strength training and the combination of both, and observed that the last one presented more significant improvement compared to the others, and that the response was lower for the strength training. Despite the results obtained by the above authors, it is important to accentuate that the

training protocol and the analyzed population were different from the present study.

Camillo et al.,²⁶ analyzed the effects of the combination of aerobic exercise and resistance of high intensity in the same training session, on elderly men with chronic obstructive pulmonary disease, and also found significant increases in the temporal indexes SDNN(ms) e rMSSD(ms).

Besides the autonomic changes, a significant increase in the intervals between the consecutive heart rate was observed as well as a consequent reduction in heart rate. A significant reduction in heart rate was also observed by Jurca et al.,⁹ but with an aerobic exercise protocol in women after menopause and with an 8 week duration which was less than that of our study.

The findings of the present investigation can contribute to clinicians and researchers who work with women in menopause, because as well as the fact that combined aerobic and resistance training presents benefits to several health indicators, such as: reduction in fat and body weight, increase in lean mass,²⁷ decrease in the rigidity of the arterial walls, improvement in blood pressure and muscle strength,²⁸ studies evaluating its influence on the autonomic modulation in this population were previously unknown.

The small sample size and the intervention time, which may have been insufficient to promote higher changes in the indexes analyzes must be considered as a limitation of this study.

Conclusions

The results of this study suggest that combined aerobic and resistance training promotes benefits to autonomic modulation, characterized by an increase in the parasympathetic activity and a reduction in the sympathetic activity, besides reducing heart rate in postmenopausal women.

RESUMO

Modelo do estudo: Ensaio clínico controlado. **Objetivo:** Verificar a resposta de 16 semanas do treinamento aeróbio e resistido combinado sobre a modulação autonômica em mulheres na menopausa. **Métodos:** 17 mulheres foram divididas em dois grupos: grupo treino (GT: n=11) e grupo controle (GC: n=6). As variáveis de composição corporal foram estimadas pela absorptiometria radiológica de dupla energia. A modulação autonômica foi avaliada pela variabilidade da frequência cardíaca usando índices lineares. O protocolo de treinamento consistiu em 16 semanas, por 50 minutos de treinamento resistido e 30 minutos de treinamento aeróbio. **Resultados:** Para o GT houve incremento do índice rMSSD(ms) (pre:17,4±3,7 e pos:24,8±13,1, p<0,045), aumento dos intervalos entre batimentos cardíacos consecutivos (pre:891,2±80,2 e pos:974,1±71,4, p<0,003) e dos valores de frequência cardíaca(bpm) (pre:68,1±6,4

e pos:62,0±4,7, p<0,003), para os índices espectrais em unidades normalizadas, houve redução de LF (pre:52,2±13,1 e pos:44,5±12,4, p<0,025) e incremento de HF (pre:47,8±13,3 e pos:55,5±12,4, p<0,025). Não houve diferenças significantes para o GC. **Conclusão:** o treinamento aeróbio e resistido combinado promoveu benefícios sobre a modulação autonômica em mulheres na menopausa.

Palavras chave: Treinamento aeróbio. Treinamento resistido. Sistema nervoso autônomo. Pós-menopausa. Sistema nervoso parassimpático. Exercício.

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