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Resistance Training Contributes to Variability in Heart Rate and Quality of the Sleep in Elderly Women Without Comorbidities

Bruno B. Gambassi[1], Fabiano J.F. Almeida[1], Bismarck A. Sauaia[1], Tânia M.G. Novais[1], Ana E. A. Furtado[1], Luíz F.C. Chaves [1], Bruno Rodrigues[2] , Antônio R. M. Silva[3],Leandro P. Melo[3],Cristiano T. Mostarda[3]

[1]Ceuma University, Physical Education Department, São Luis, MA, Brazil, [2]University of Campinas, Faculty of Physical Education, Campinas, SP, Brazil, [3]Federal University of Maranhão, Physical Education Department, São Luis, MA, Brazil

ABSTRACT

Gambassi BB, Almeida FJF, Sauaia BA, Novais TMG, Furtado AEA, Chaves LFC, Rodrigues B, Silva, ARM, Melo LP, Mostarda CT. Resistance Training Contributes to Variability in Heart Rate and Quality of the Sleep in Elderly Women Without Comorbidities. **JEPonline** 2015;18(6):112-123. The purpose of this study was to evaluate the quality of sleep and heart rate variability in elderly women without comorbidities after engaging in a resistance training (RT) program. The study sample consisted of 16 elderly, divided into two groups: Sedentary Group (SG, n = 9) and Resistance Training Group (RTG, n = 7). The subjects underwent assessment of blood pressure (BP), Body Mass Index (BMI), heart rate variability (HRV), and sleep quality (PSQI questionnaire). The findings in this study indicate that elderly women without comorbidities who engage in resistance training have lower sympathovagal balance and better sleep quality compared to sedentary elderly women without comorbidities. However, interestingly, these variables do not appear to be associated.

Key Words: Resistance training, Elderly, Sleep quality

INTRODUCTION

Among the physiological changes during the aging process, it is important to acknowledge changes in the autonomic nervous system and the quality of sleep. The aging process results in a physiological decrease in the influence of vagal activity on the sinus node, which appears to be related to an increase in mortality rates (6). The normal cyclic variations of beat-to-beat (RR) intervals that reflects cardiac autonomic function (i.e., high heart rate variability, HRV) features healthy individual, while the diminished HRV is an indicator of autonomic nervous system distress (18).

Another problem faced by many adults over the age of 65 is the negative change in sleep quality. The 12 to 40% prevalence of insomnia in the elderly is a common complaint after individuals of 65 yrs of age (16). During the severe insomnia, aging increases the likelihood of mortality by 3 times in a period of 3½ yrs, and it contributes to the development of depression (11). In fact, it is reasonably clear that a few hours of sleep is associated with a higher risk of death due to acute myocardial infarction (1) while King et al. (12) conclude that a good night of sleep is inversely associated with a coronary artery calcification incident. Abnormal sleep situation may result from disturbance of endothelial function, cerebrovascular disorders, and autonomic dysfunction where, conversely, an increase in sympathetic activity is accompanied by an increase in heart rate and blood pressure (7,17,21).

Although there are numerous strategies to improve sleep quality, physical activity has been shown to be an excellent way to improve sleep. It is believed that regular exercise increases body temperature, stimulates the hypothalamus, and promotes heat dissipation; all help to induce sleep. Another consideration is the increased expenditure of energy during exercise, which has to be restored during sleep. Thus, a good night of sleep helps to replenish the energy that was used during exercise (2,3,13).

While it is important to point out that autonomic dysfunction and impaired quality of sleep in association with aging are often linked to the presence of chronic diseases, there are few studies that explore how these variables may be associated in elderly without comorbidities. Also, there are few studies that address the role of regular activity, specifically resistance training and how it may contribute to cardiac autonomic changes and sleep quality.

Our hypothesis was that the elderly subjects who engaged in resistance training would experience an improved sleep quality and autonomic function compared to sedentary subjects, and that the quality of sleep could be associated with increased autonomic modulation. Thus, the purpose of this study was to analyze the quality of sleep and heart rate variability in sedentary elderly subjects engaged in resistance training subjects without comorbidities.

METHODS

Subjects

This study was approved by the Research Ethics Committee of the University Ceuma, as recommended by the Resolution 466/12 of the National Health Council (with sound embodied 813,886 of 01/10/2014). All subjects signed the Informed Consent form. Each subject was properly informed, thus authorizing the research. The identity of the subjects was kept strictly confidential with only disclosure of the results with the same available to the completion of assessments and reassessments.

The elderly subjects in this study were part of a project called UNICEUMA Without Borders. In this program, they were participating in a computer class to stimulate memory. A total of 126 elderly participated in this project, which included active, sedentary with and without skeletal muscle problems, and with and without chronic degenerative diseases.

For this research, the sample was defined by convenience. The study protocol consisted of adopting criterion for non-inclusion of individuals with chronic degenerative diseases (e.g., hypertension and/or diabetes). To check such conditions, each subject was required to present fasting blood glucose and, in addition, blood pressure was measured in order to verify possible cases of hypertension.

The subjects were grouped randomly into two groups: the Resistance Training Group (RTG = 8) that practiced resistance training at least 12 wks with an intensity of 80% of 1RM, 2 times·wk^{-1} with 3 sets of 8 repetitions maximum. The program consisted of running leg press 180°, seated row, leg curl, bench press, abductor chair, triceps pulley, chair pipeline and simultaneous threads, alternated by segment. The Sedentary Group (SG = 9) did not perform physical exercise for a 6-month period.

The study sample consisted of 16 elderly women with a mean age of 65 ± 3 yrs, mean blood glucose in the fasting of 96.43 ± 3.0 mg·dL^{-1}, and a mean systolic blood pressure of 127.1 ± 5.0 mmHg and a diastolic blood pressure of 84.2 ± 2 mmHg. The recording of the subjects' blood pressure, body mass index (BMI), heart rate variability, and sleep quality were placed in the database built in a progressive and didactic way for statistical evaluation.

Procedures

Body Mass Index (BMI)

The subjects' body weight was measured using a digital scale with a maximum capacity of 150 kg and 100 g division. Height was measured with a tape measure attached to a wall with no baseboard with a length of 2.00 m that was divided into centimeters and subdivided into millimeters. Body mass index (BMI) was calculated from the subjects' weight and height measurements according to the formula BMI = weight (kg) ÷ height (cm).

Sleep Quality

To evaluate the quality of sleep of the subjects, the Sleep Quality Index (PSQI) was used. It is a questionnaire that evaluates the sleep quality and sleep disorders. The PSQI used seven components: (a) Quality subjective sleep; (b) Sleep Latency; (c) Duration of sleep; (d) habitual sleep efficiency; (e) Sleep disorders; (f) Use of medication to sleep; and (g) daytime sleepiness and disorders during the day.

The score of each component was added to give an overall score ranging from 0 to 21 points. Each component was individually determined. The higher the value obtained, the worse the quality of sleep (global score is between 6 and 21). For good quality sleep, the sum of the scores is only 5.

Heart Rate Variability

Each subject remained lying at rest for at least 20 min. A 12-lead electrocardiogram (WinCardio 6.1.1) with a sampling frequency in the ECG signal of 600 Hz (Micromed Biotechnology Ltd.) was used to obtain R-R interval moment to moment. At the end of the ECG exam, the series of R-R intervals was extracted as text from the Wincardio analysis software for later analysis through the program Kubios HRV 2.0 (Biosignal Analysis and Medical Imaging Group, Kuopio, Finland) in electrocardiographic signal processing to obtain variables referring to Heart Rate Variability (HRV) in frequency domains.

The data analysis of heart rate variability in the frequency domain was conducted by Fast Fourier Transform (FFT) in 5-min snippets with 4 Hz interpolation with an overlap of 50%. The bands of interest can be: (a) Very Low Frequency (VLF) (0 to 0.04Hz); (b) Low Frequency (LF) (0.04 to 0.15Hz) that referred predominantly to sympathetic modulation; and (c) High Frequency (HF) (0.15 to 0.4Hz) referring to the parasympathetic modulation.

In addition, the ECGs were analyzed and presented in their normalized form (%), and the sympathovagal balance (LF/HF) was established, that is, LF (nu) equals the power of HF ÷ (total power ms^2-VLF) x 100.

HF normalized units (nu) = power of HF(ms^2) x 100 ÷ total power

LF normalized units (nu) = power of LF(ms^2) x 100 ÷ total power

LF/HF= relation $LFm^2 \div HFm^2$

Statistical Analyses

The data were analyzed using the Stata/SE 11.1 (Stata Corp, College Station, Dallas, USA). With regards to the normality of groups, the Shapiro-Wilk test was applied as well as the quantitative variables expressed as mean ± standard deviation (SD). Significant differences were found using the unpaired Student *t* test with the alpha level set at $P<0.05$. In addition, Pearson correlation was used to investigate a possible correlation between the autonomic parameters and body composition.

RESULTS

There were no differences between the SG and RTG groups for both systolic blood pressure and diastolic blood pressure. With respect to the subjects' blood glucose, both groups were within the normal range. In addition, there was no difference in BMI between the two groups. (Table 1).

Table 1. Clinical and Epidemiological Characteristics of SG and RTG (M ± SD).

Characteristics	Sedentary Group	Resistance Training Group
Age (yrs)	64.3 ± 3.00	65.3 ± 4.00
SBP (mmHg)	125.71 ± 8.55	125 ± 7.55
DBP (mm/Hg)	83.71 ± 5.35	83.75 ± 5.17
Blood Glucose ($mg{\cdot}dl^{-1}$)	96.28 ± 2.42	96.43 ± 3.00
Weight (kg)	64.82 ± 3.6	64.53 ± 2.70
Height (m)	1.57 ± 3.6	1.53 ± 0.02
BMI ($kg{\cdot}m^{-2}$)	26.10 ± 0.6	27.43 ± 0.70

Mean (**M**); standard deviation (**SD**); **SBP** = Systolic Blood Pressure, **DBP** = Diastolic Blood Pressure, **BMI** = Body Mass Index, **SG** = Sedentary Group, **RTG** = Resistance Training Group

The higher score in the SG vs. the RTG indicates worse sleep quality in the sedentary elderly (Table 2). As for the individual indices, it was not found difference in rates: subjective sleep quality, sleep latency, sleep duration, daytime sleepiness, and disorders during day. However, a difference was found in the habitual sleep efficiency (RTG = 0.29 ± 0 28 vs. SG = 1.89 ± 0.35) and sleep disorders (RTG = 1.14 ± 0.14 vs. 1.67 ± SG = 0.17). No elderly of both groups made use of medication to sleep.

Table 2. Distribution of Sleep Quality Levels between SG and RTG.

Sleep Quality in Active and Sedentary Elderly			
	SQL in RTG	**SQL in SG**	
	GTR	**GS**	**P**
SQL	05	03	
	03	05	
Good (0 a 4)	06	09	
Bad (5 a 10)	02	07	0.01
Sleep Disorders	04	05	
(SD > 10)	03	11	
	05	08	
		12	
		06	

SQL = Sleep Quality Level; **SD** = Sleep Disorders; **SG** = Sedentary Group, **RTG** = Resistance Training Group
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Sympathetic and vagal modulation (LFms^2 and HFms^2, respectively) did not differ between the two groups (Table 3). The mean ± SD for LFms^2 in the RTG was 130.57 ± 151.40 vs. the SG of 121.44 ± 161.39. The mean ± SD for HFms^2 in the RTG was 205.43 ± 262.61 vs. the SG of 106.22 ± 152.31. However, when normalized to sympathetic modulation, LF% was lower in the RTG vs. the SG.

Table 3. Distribution of Heart Rate Variability Indexes in the Frequency Domain between RTG and SG In (ms²).

Heart Rate Variability in the Frequency Domain in (ms^2)								
Total RTG	Total SG	P	LFRTG	LFSG	P	HFRTG	HFSG	P
1489.96	585.64		296	168		355	100	
424.36	228.01		86	28		121	81	
745.29	219.04	0.21	42	27	0.91	62	18	0.40
268.96	1466.89		26	534		42	505	
2246.76	228.01		396	90		746	53	
466.56	320.41		46	69		64	82	
249.64	174.24		22	38		48	56	
-	302.76		-	103		-	49	
-	231.04		-	36		-	12	

Total RTG = Total Variability of Resistance Training Group, **Total SG** = Total Variability of Sedentary Group, **LFRTG** = Low Frequency in Resistance Training Group, **LFSG** = Low Frequency in Sedentary Group, **HFRTG** = High Frequency in Resistance Training Group, **HFSG** = High Frequency in Sedentary Group ($P < 0.05$)

The vagal modulation as standard (HF%) was shown to be increased in trained elderly (60.92 ± 4.74) versus the sedentary elderly subjects (45.38 ± 15.33) (refer to Table 4). Interestingly, then, when the subjects' sympathovagal balance (LF/HF) was calculated, the results indicate that the RTG group showed a decrease (0.65 ± 0.13) in the sympathovagal balance compared to the SG group (1.43 ± 0.81) (Table 4).

Table 4. Distribution of Heart Rate Variability Indexes in the Frequency Domain between Active and Sedentary Institutionalized Elderly Groups, São Luís, MA, 2014 (in Percentage, %).

Heart Rate Variability in the Frequency Domain in (%)								
LFRTG	**LFSG**	**P**	**HFRTG**	**HFSG**	**P**	**LF/HFRTG**	**LF/HFSG**	**P**
45.47	62.69		54.53	37.31		0.83	1.68	
41.55	25.69		58.45	74.31		0.71	0.35	
40.38	60.00		59.62	40.00		0.68	1.50	
38.24	51.40	0.02	61.76	48.60	0.02	0.62	1.06	0.02
34.68	62.94		65.32	37.06		0.53	1.70	
41.82	45.70		58.18	54.30		0.72	0.84	
31.43	40.43		68.57	59.57		0.46	0.68	
-	67.76		-	32.24		-	2.10	
-	75.00		-	25.00		-	3.00	

LFRTG = Low Frequency in Resistance Training Group; **LFSG** = Low Frequency in Sedentary Group; **HFRTG** = High Frequency in Resistance Training Group; **HFSG** = High Frequency in Sedentary Group; **LF/HFRTG** = Low Frequency / High Frequency in Resistance Training Group; **LF/HFSG** = Low Frequency / High Frequency in Sedentary Group

When the Pearson correlation coefficient data were analyzed to determine the association between the level of quality of sleep and LF%, HF%, and LF/HF, respectively, the RTG obtained an r = - 0.0545, P = 0.9077 for LF%. These findings indicate a weak negative correlation. The association between the level of quality of sleep and HF% produced an r = 0.0545 and a P = 0.9077, which indicate a weak positive correlation. The association between the level of quality of sleep and LF/HF produced an r = - 0.0189 and a P = 0.9679 that indicates a weak negative correlation.

The results in Table 5 indicate that the findings do not maintain a significant association between the variables. That is, as one variable increases or decreases the other does not change either positively or negatively and, therefore, regardless of the situation the variable is independent from each other.

Table 5. Distribution of Sleep Quality Frequency and its Relationship with Heart Rate Variability in the RTG.

Sleep Quality in Elderly and its Relationship with Heart Rate						
	SQL	LF(%)	HF(%)	LF/HF	r	P
	05	45.47	54.53	0.83		
	03	41.55	58.45	0.71	- 0.0545	0.9077
Good (0 to 4)	06	40.38	59.62	0.68	0.0545	0.9077
Bad (5 to 10)	02	38.24	61.76	0.62	-0.0189	0.9679
Sleep Disorders	04	34.68	65.32	0.53		
(SD >10)	03	41.82	58.18	0.72		
	05	31.43	68.57	0.46		

SQL = Sleep Quality Level; **LF** = Low Frequency; **HF** = High Frequency; **LF/HF** = Relationship low frequency/high frequency; **SD** = Sleep Disorders.

Additionally, when we analyze the data based on the Pearson correlation coefficients to assess the association between the level of quality of sleep and LF%, HF%, LF/HF, respectively in SG, was obtained r = 0.0417; P = 0.9151 indicator and weak positive correlation r = - 0.0417; P = 0.9151 weak negative correlation indicator, and r = - 0.0304; P = 0.9382 too weak negative correlation indicator (Table 6).

Table 6. Distribution of Sleep Quality Frequency and its Relationship with Heart Rate Variability in the SG.

Sleep Quality in Elderly and its Relationship with Heart Rate						
	SQL	LF(%)	HF(%)	LF/HF	r	P
	03	62.69	37.31	1.68		
	05	25.69	74.31	0.35		
	09	60.00	40.00	1.50	0.0417	0.9151
Good (0 a 4)	07	51.40	48.60	1.06	- 0.0417	0.9151
Bad (5 a 10)	05	62.94	37.06	1.70	- 0.0304	0.9382
Sleep Disorders	11	45.70	54.30	0.84		
(SD > 10)	08	40.43	59.57	0.68		
	12	67.76	32.24	2.10		
	06	75.00	25.00	3.00		

SQL = Sleep Quality Level; **LF** = Low Frequency; **HF** = High Frequency; **LF/HF** = Relationship low frequency/high frequency; **SD** = Sleep Disorders.

DISCUSSION

The main finding of this study is the significant changes in cardiac autonomic modulation and sleep quality found in the RTG compared to the SG. These results are shown by the decrease in LF%, the increase in HF%, and the lower LF/HF in the frequency domain of the RTG versus the SG. Thus, it is appropriate to conclude that resistance training improves sleep quality compared to the sedentary elderly.

The data presented in this study partially confirm the hypothesis that the RTG would have better HRV and quality of sleep when compared to the SG. However, a correlation was not observed between the improvement in the modulation of autonomic nervous system and good sleep quality In the RTG.

Increasingly, regular exercise is used as a non-pharmacological intervention against the reduction of HRV and the decrease in quality of sleep during aging. It has been shown that aerobic exercise improves heart rate variability, baroreflex sensitivity, decreases sympathetic tone, and increases vagal tone; all contribute to the reduction in heart disease (14,17,19). In the present study, a higher HRV was observed in the subjects of the RTG compared to the subjects in the SG. This indicates that physical exercise may have improved HRV, thus reducing the risk of mortality in the study population.

These data corroborate the findings of Davy and colleagues (5). They reported that physically active postmenopausal women have higher heart rate variability and baroreflex sensitivity when compared to less active postmenopausal women. Similarly, the evidence supports better baroreflex sensitivity in middle-aged and physically active elderly compared to sedentary (4).

Resistance training also seems to have a positive influence on the autonomic nervous system in regards to hypertension. Taylor et al. (20) examined the effects of isometric handgrip training on resting arterial blood pressure, heart rate variability, and blood pressure variability in older adults with hypertension. Nine subjects performed four 2-min isometric handgrip contractions at 30% of the maximum voluntary contraction force, 3 $d \cdot wk^{-1}$ for 10 wk, and eight subjects served as controls. After training, there was a significant reduction in resting systolic pressure and mean arterial pressure. In addition, power spectral analysis of heart rate variability demonstrated that the low frequency: high frequency area ratio tended to decrease. They concluded that isometric training at a moderate intensity elicits a hypotensive response and a simultaneous increase in vagal modulation in older adults with hypertension.

In the present study, a higher quality sleep was observed in the RTG compared to the SG. Therefore it can be said that physical exercise improved the quality of the RTG sleep. Corroborating the findings of this research, Guimarães et al. (9) observed improvement in total sleep time and sleep quality in older women after aerobic exercise program that was carried out 2 $d \cdot wk^{-1}$ for 4 months. Similarly, Habte-Garb et al. (10) reported an improvement in their elderly subjects' sleep quality after engaging in aerobic exercises. Additionally Morgan (15) showed that the high level of physical activity appears to help with insomnia during the aging process. Fuzhong et al. (8) through the practice of Tai- Chi also showed improved sleep quality in the elderly.

Hence, it is apparent that regular exercise is a viable non-pharmacological strategy for the improvement of sleep quality in elderly individuals. The increase in the subjects' quality of sleep observed in the RTG in the present study is likely to be related to two factors: (a) being active; and/or (b) having a high HRV compared to the subjects in the SG. The latter is supported by the fact that Dettoni et al. (7) demonstrated dysfunction in the autonomic modulation after sleep deprivation for 5 d. There was an increase of the sympathetic nervous system and decreased parasympathetic activity.

The present study also investigated the correlation between the subjects' quality of sleep and their heart rate variability (i.e., time and frequency) in the RTG. The findings also indicate that a very weak correlation exists between high levels of sleep quality and the LF HRV index, LF/HF and HF in the frequency domain of the RTG. These data contradict our hypothesis possibly in part by the small number of subjects in the RTG. In addition, there was a great difficulty in the recruitment of elderly subjects without comorbidities.

CONCLUSIONS

The findings in this study indicate that elderly women without comorbidities who engage in resistance training have lower sympathovagal balance and better sleep quality compared to sedentary elderly women without comorbidities. However, interestingly, these variables do not appear to be associated.

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Address for correspondence: Professor Bruno Bavaresco Gambassi, Departamento de Educação Física, Universidade Ceuma, Rua Josué Montello, S/N, São Luis – MA, Brazil, 65080-805, Brazil, Phone: (55) (98) 991112624, Email: professorbrunobavaresco@gmail.com

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