The Practice of Sport Climbing Contributes to the Improvement of Autonomic Modulation in Young Individuals
The Practice of Sport Climbing Contributes to the Improvement of Autonomic Modulation in Young Individuals

Catalina G Gomez1, Diego AS Rodríguez1, Wellington RG Carvalho3,4, Cristiano T Mostarda3, Bruno B Gambassi5, Bruno Rodrigues5, Fabiano F Silva2, Wonder P Higino2, Renato A Souza2

1Universidad de Ciencias Aplicadas y Ambientalis, Bogotá, Colombia, 2Group of Studies and Research in Health Sciences, Federal Institute of Education, Science and Technology of the South of Minas Gerais, Muzambinho-MG, Brazil, 3Department of Physical Education, Federal University of Maranhão, São Luís-MA, Brazil, 4Federal University of Uberlândia, Faculty of Physical Education, Uberlândia-MG, Brazil, 5Faculty of Physical Education, University of Campinas, Campinas-SP, Brazil

ABSTRACT

Gomez CG, Rodríguez DAS, Carvalho WRG, Mostarda CT, Gambassi BB, Rodrigues B, Silva FF, Higino WP, Souza RA. The Practice of Sport Climbing Contributes to the Improvement of Autonomic Modulation in Young Individuals. JEPonline 2017; 20(2): 84-91. The aim of this study was to evaluate the chronic effects of 3 yrs of sport practice climbing on autonomic modulation by analyzing the HRV using a time/frequency-domain method. Sixteen male subjects were allocated to two groups: (a) sedentary group (SG, n = 9), participants with no or irregular physical activity; and (b) indoor rock climbing group (IRCG, n = 7), participants have practiced indoor rock climbing for 3 yrs with regular practice at 2 times-wk−1 and with similar technical skill. There were statistically significant differences in HRV time and frequency domains (RR interval, SD1, RMSSD, LF, and HF) between the SG group and the IRCG group. However, IRCG showed higher values in all differences. The findings indicate that the long-term practice of sport climbing produces higher HRV in the indoor rock climbers compared to sedentary individuals, thus indicating some cardiovascular benefit.

Key Words: Autonomic Nervous System, Cardiovascular, Deconditioning, Heart Rate Variability, Sport Climbing
INTRODUCTION

A sedentary lifestyle is considered one of the major modifiable risk factors for the development of metabolic disturbances (8). Individuals who avoid regular exercise have lower heart rate variability (HRV) when compared with trained individuals (1). A reduced HRV is considered a factor for increased cardiovascular morbidity and mortality in patients with a large number of diseases and even in non-diseased subjects (15,17). The HRV indicates the heart's ability to respond to multiple physiological stimuli, such as exercise, breathing, and metabolic disorders. Therefore, HRV is considered as a non-invasive measure to evaluate the autonomic nervous system (11).

Although there are numerous studies (2,4,6,9,14,20) that speak to the benefits of the practice of resistance exercise and aerobic exercise on HRV in the elderly, adults in general, in hypertensive subjects, and in judo athletes, there are still questions regarding the effects of sport climbing practice on the HRV. Sport climbing emerged in the beginning of the 1980 decade as a tool of physical and technical training for rock climbers. Nevertheless, as the years passed by, it gained its own followers, especially due to its greater accessibility when compared to rock climbing (3). Sport climbing is the branch of climbing in which the element of danger is reduced by placing protection points in the rock or indoor wall. In the practice of this sport, falls are common but relatively safe (19).

In a recent review, it was observed that climbing is unique from a physiological point of view because it requires sustained and intermittent isometric forearm muscle contractions for upward propulsion. During climbing, there is an increase in oxygen consumption and heart rate, which suggest sport climbing requires the utilization of a significant portion of whole body aerobic capacity. With an increase in climbing difficulty, there is an increase in the climber's reliance on anaerobic energetic pathways. This is evidenced by the increase in blood lactate and a disproportionate rise in heart rate in relation to oxygen consumption. However, the determinants of climbing performance are still not clear (19).

Thus, the aim of this study was to evaluate the chronic effects of 3 yrs of sport practice climbing on autonomic modulation by analyzing the HRV using a time/frequency-domain method.

METHODS

Subjects
A total of 16 male subjects were allocated to two groups: (a) sedentary group (SG, n = 9), participants with no or irregular physical activity; and (b) indoor rock climbing group (IRCG, n = 7), participants have practiced indoor rock climbing for 3 yrs with regular practice 2 times·wk\(^{-1}\) and with similar technical skill. Written informed consent was obtained from the subjects. All subjects were carefully informed about the experiment procedures and the possible risk and benefits associated with participation in the study. Each subject signed an informed consent document pursuant to law before any of the tests were performed.

Anthropometric Measurements
Anthropometric measurements were obtained using standardized techniques by well-trained interviewers (13). Anthropometric measurements were performed in all subjects wearing light clothes without shoes. Body weight was measured in kilograms (kg) using a digital scale (Seca®803, Hamburg, Germany) with a precision of 100 grams (g). Height was measured in meters (m) and recorded with an accuracy of 0.1 cm with a portable stadiometer (Seca®213, Hamburg, Germany).
Each subject’s body mass index (BMI) was calculated using the formula: \( \text{BMI} = \frac{\text{body weight (kg)}}{\text{body height (m)} \times \text{body height (m}^2\}). \)

**Heart Rate Variability**

The RR interval (iRR) acquisition was collected at 1000 kHz sample rate for a 10 min period in the supine position with the head elevated at 30°. To assess the subject’s HRV (the temporal series of RR intervals) was registered by the Polar RS 800 CX (Kempele, Finland).

Temporal series from the tachogram were related to each selected segment, and were quantitatively evaluated considering the values for the HR, total, and normalized (nu) powers. The sympathovagal index (LF/HF) was calculated based on the LF ad HF normalized. Normalized units (nu) were obtained by dividing the power of given component by the total power (from which VLF was subtracted) and multiplied by 100 (16).

The tests were analyzed using the program Kubios HRV 2.0 (Biosignal Analysis and Medical Imaging Group, Kuopio, Finland) in which the ECG signal was processed to obtain the variables related to HRV in the time and frequency domains. In the time domain, the following variables chosen were VarRR (Variance of RR intervals), SDNN (standard deviation of RR intervals), RMSSD (square root of the mean squared differences between adjacent normal RR intervals, expressed in milliseconds, ms), and pNN50 (the proportion of NN50 divided by total number of NNs). In the Poincare plot, the variables were SD1 (short variation of RR interval) and SD2 (represents HRV in long-term records). The analysis of HRV in the frequency domain was performed using Fast Fourier Transform (FFT) in portions of 5 min with 4 Hz interpolation overlap by 50%. The bands of interest were low frequency or LF (0.04 to 0.15 Hz and this component refers predominantly to sympathetic modulation) and high frequency or HF (0.15 to 0.4 Hz that refers parasympathetic modulation).

Normalized LF and HF components of R–R variability were considered, respectively, as markers of cardiac sympathetic and parasympathetic modulation, and the ratio between them (LF/HF) was considered as an index of the autonomic modulation of the heart. The results were expressed in absolute values (HF and LF ms\(^2\)) and percentage (HFnu and LFnu).

**Statistical Analyses**

The SPSS version 19.0 (Statistical Package for the Social Sciences, Chicago, IL, USA) was used for database and statistical analysis. The results were expressed as mean and standard deviation (SD). The normal distribution of the data was tested using the Shapiro-Wilk’s test. The assessment of the means between the two groups was carried out with the Student’s \( t \)-test for 2 independent samples. The alpha level of \( P<0.05 \) was considered statistically significant.

**RESULTS**

Table 1 shows the baseline characteristics of the SG and IRCG groups. There were no statistically significant differences in age, height, weight, and BMI between the groups. The HRV analysis both in time and frequency domains are presented in Table 2. When compared, the data of HRV in the time domain between the SG and IRCG groups, there were significant differences in the RR interval and RMSSD indexes. Furthermore, in the nonlinear evaluation method, there was a significant difference between the groups in the amount of SD1 (Figure 1).
Table 1. Descriptive Data of the Subjects.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Sedentary Group (n = 9)</th>
<th>Indoor Rock Climbers Group (n = 7)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M ± SD</td>
<td>M ± SD</td>
<td></td>
</tr>
<tr>
<td>Age (yrs)</td>
<td>22.8 ± 3.0</td>
<td>25.4 ± 6.0</td>
<td>0.41</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>75.4 ± 5.0</td>
<td>73.9 ± 6.9</td>
<td>0.12</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>176 ± 3.0</td>
<td>174 ± 4.0</td>
<td>0.69</td>
</tr>
<tr>
<td>BMI (kg·m⁻²)</td>
<td>24.7 ± 10.0</td>
<td>21.3 ± 1.7</td>
<td>0.94</td>
</tr>
</tbody>
</table>

BMI = body mass index.

Table 2. Time and Frequency Domain Analysis of Heart Rate Variability in Sedentary and Trained Rock Climbers Subjects.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Sedentary Group (n = 9)</th>
<th>Indoor Rock Climbers Group (n = 7)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M ± SD</td>
<td>CI (95%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CI (95%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RR</td>
<td>704.3 ± 56.1</td>
<td>667.2; 741.4</td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>56.1 ± 5.9</td>
<td>51.5; 60.6</td>
<td></td>
</tr>
<tr>
<td>SD 1</td>
<td>18.6 ± 3.8</td>
<td>15.7; 21.5</td>
<td></td>
</tr>
<tr>
<td>SD 2</td>
<td>76.3 ± 7.9</td>
<td>70.3; 82.4</td>
<td></td>
</tr>
<tr>
<td>RMSSD</td>
<td>26.6 ± 5.2</td>
<td>22.6; 30.6</td>
<td></td>
</tr>
<tr>
<td>PNN50</td>
<td>7.7 ± 4.8</td>
<td>4.0; 11.4</td>
<td></td>
</tr>
<tr>
<td>Variance RR</td>
<td>3380.9 ± 747.5</td>
<td>2908.7; 3933.3</td>
<td></td>
</tr>
<tr>
<td>LF (ms²)</td>
<td>519.9 ± 141.1</td>
<td>411.5; 628.3</td>
<td></td>
</tr>
<tr>
<td>HF (ms²)</td>
<td>181.5 ± 82.7</td>
<td>118.0; 245.1</td>
<td></td>
</tr>
<tr>
<td>LF/ν</td>
<td>75.3 ± 4.2</td>
<td>72.1; 78.6</td>
<td></td>
</tr>
<tr>
<td>HF/ν</td>
<td>24.7 ± 4.2</td>
<td>21.4; 27.9</td>
<td></td>
</tr>
<tr>
<td>LF/HF</td>
<td>3.5 ± 0.8</td>
<td>2.8; 4.1</td>
<td></td>
</tr>
</tbody>
</table>

CI 95% = confidence interval; LF = low frequency; HF = high frequency; LF/ν = normalized low frequency; HF/ν = normalized high frequency; LF/HF = ratio between LF and HF components; *P-value ≤0.05 indicate difference between group
Regarding the HRV analysis in the frequency domain, the SG subjects showed lower values of absolute indexes LF and HF and variance RR compared with the IRCG. The balance sympatho-vagal and standardized LF and HF component of HRV were similar between the groups.

**DISCUSSION**

The main findings of the present study indicated that IRCG showed a higher cardiovascular autonomic control of the heart when compared to the sedentary group. It was observed by the increase in absolute values in the RR interval, increase in SD1, variance RR, LF (ms²), and HF (ms²). These data demonstrate a predominance of parasympathetic modulation in IRCG when compared to the sedentary subjects. These changes were observed independently of individual characteristics such as weight, height, age, and BMI. Interestingly, only a few studies demonstrated the benefits of climbing activity in autonomic modulation at rest.

HRV is a variable that can be affected by many factors (such as exercise training), which is a sufficient stimulus to cause significant changes in cardiovascular function and autonomic adjustments. Thus, alterations in heart rate and respiratory sinus arrhythmia are associated with exercise by alternating vagal activity over sympathetic (5).

Some studies have shown that a noncompetitive climb is a typical aerobic activity because the intensity is comparable to what the American College of Sports Medicine recommends to maintain a good cardiorespiratory performance (18). Also, it has been described that temporal and non-linear analysis of HRV may be related to training level and can be used as an index for autonomic cardiovascular control (12).
However, Rodio et al. (18) claim that there is a linearity between the increase in the difficulty of the climb and the increase in oxygen consumption, given the increase in energy expenditure and heart rate for each meter of rise (18). Thus, when a disproportion between heart rate and oxygen consumption is observed, it may be related to the peripheral adaptations caused by the increase in isometric contraction time, and the increased metabolic and reflex activity causing a sympathetic response (7).

Additionally, according to Ferguson and Brown (7), noncompetitive climbers have a higher conductance both during and after the rhythmic exercise when compared to the sedentary. It is likely that the decrease in the subjects' blood pressure values during isometric exercise during climbing is partly part due to the increase in vasodilation capacity. Such an adjustment would enable supporting a greater resistance during rhythmic exercise, thus allowing for a higher functional hyperemia between phases of contraction (10).

It is reasonable to speculate that the increase in heart rate, increased oxygen consumption, and muscular adaptations that result from the practice of climbing contributes to the increase in heart rate variability (as evidenced by higher rates in the time domain and the frequency observed in this study). These adjustments are likely to have a positive influence on the climbers' performance and cardiovascular homeostasis.

**CONCLUSIONS**

The assessment of autonomic modulation by analyzing the HRV using a time/frequency-domain method exhibited higher HRV values in the IRCG subjects when compared with the sedentary subjects. Thus, the results of this study suggest that the long-term practice of sport climbing produces some cardiovascular benefit.

**Address for correspondence:** Renato A Souza, PhD, Federal Institute of Education, Science and Technology of the South of Minas Gerais, Muzambinho-MG, Brazil, Rua Dinah, 75, Canaã, 37890-000, Email: tatosouza2004@yahoo.com.br

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