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Original article

Effects of functional training on geometric indices of heart rate variability

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Abstract

Background: Geometric methods provide an analysis of autonomic modulation using the geometric properties of the resulting pattern, and represent an interesting tool in the analysis of heart rate variability (HRV). The aim of this study was to evaluate the impact of functional training on cardiac autonomic modulation in healthy young women using the geometric indices of HRV.

Methods: Data were analyzed from 29 women, and were stratified into a functional training group (FTG, n = 13; 23.00 ± 2.51 years; 21.90 ± 2.82 kg/m^2) and a control group (CG, n = 16; 20.56 ± 1.03 years; 22.12 ± 3.86 kg/m^2). The FTG received periodized functional training for 12 weeks. The cardiac autonomic modulation of both groups was evaluated before and after this training, and a qualitative analysis was performed using the Poincaré plot.

Results: There was a significant increase in the difference of the triangular index (RRTri), SD1, SD2, and RR intervals in the FTG as compared to the CG, and the qualitative analysis from the Poincaré plot showed an increase in the dispersion of beat-to-beat and long-term RR intervals in the functional group after training. No changes were observed in the triangular interpolation of RR interval histogram (TINN) or SD1/SD2.

Conclusion: Functional training had a beneficial impact on autonomic modulation, as characterized by increased parasympathetic activity and overall variability, thus highlighting the clinical usefulness of this type of training.

Keywords: Autonomic nervous system; Exercise; Heart rate; Resistance training; Young adult

1. Introduction

Functional training,[1–5] a type of resistance training which has been heavily implemented in recent years,[2] provides several benefits with the purpose of adapting training to be more specific for certain movement patterns or actions in the daily activities of athletes and non-athletes.[1,6] Although widely used in clinical practice,[1,3,4] there are few studies in the literature investigating the cardiovascular parameters in a young population for this specific type of resistance training.[7] Furthermore, its effect on autonomic modulation is still unknown, and this represents a gap in the literature.

One method of assessing autonomic modulation is through heart rate variability (HRV), a noninvasive measure with good reproducibility when performed in a standardized manner.[8] HRV describes the oscillations in the intervals between consecutive heart beats (RR intervals), which are related to the effects of the autonomic nervous system (ANS) on the sinus node, and can evaluate both cardiac health and the state of the ANS responsible for cardiac regulation.[7–10]

The methods used for analyzing HRV include geometric methods the triangular index (RRTri), the triangular

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interpolation of RR interval histogram (TINN), and the Poincaré plot which converts the RR intervals into geometric patterns and allows for the analysis of HRV through their geometric properties or graphs of the resulting pattern.[9,11–14]

The RRTri and TINN indices are calculated based on the construction of a density histogram of normal RR intervals containing the length of the RR intervals on the *x* axis, and the frequency with which they occur on the *y* axis.[9,11–14] The Poincaré plot is a 2-dimensional graphical representation of the correlation between consecutive RR intervals, where each interval is plotted against the next interval. The analysis can then be performed qualitatively by assessing the shape formed by the attractor, which shows the degree of complexity of the RR intervals, or quantitatively by fitting an ellipse to the shape formed by the plot, from which the following indices are obtained: SD1, SD2, and the ratio SD1/SD2.[10,15–17] Furthermore, the analysis of the Poincaré plot is considered by some authors to be based on nonlinear dynamics.[9,10,18]

Nonlinear methods of HRV analysis have been gaining interest, since there is evidence that the mechanisms involved in cardiovascular regulation probably interact in a nonlinear manner.[10,19] Furthermore, nonlinear analysis has given new insights into the abnormalities of heart rate (HR) behavior in various conditions, thus providing additional information for physiological interpretation and prognostics, as compared with traditional methods.[20]

Considering that HRV analysis using geometric methods can provide clinically relevant information, to better understand the influence of functional training in a healthy population, the aim of this study was to evaluate the effects of functional training on cardiac autonomic modulation in healthy young women.

2. Methods

2.1. Experimental approach

This was a randomized clinical trial, and the training and data collection were performed in a private clinic at the Salus Studio Physical Rehabilitation and Longevity locating in Presidente Prudente, Brazil. Prior to this clinical trial, a pilot study was performed with the same descriptions as noted below. All volunteers underwent an initial assessment which included: anthropometric measurements (height and weight), an assessment of autonomic modulation, and a muscle strength evaluation by means of a 1RM test to determine the load which would be used during training for each of the exercises. The autonomic modulation assessments for both groups were repeated 24 h after the completion of the training period in the functional training group (FTG).

The FTG underwent a periodized functional training program for 12 weeks with a frequency of 3 sessions per week, totaling 30 sessions of training. The loads during the exercises began at 30% of the 1RM load achieved on the assessment test, and were gradually increased until they reached 100% in the final week of training.

2.2. Subjects

The initial sample consisted of 32 healthy volunteers aged 18–26 years who had not performed any regular physical activity or strength training in the previous 6 months.

Volunteers who presented any of the following characteristics were excluded: smokers, alcoholics, users of drugs or medications that could influence ANS activity, subjects with known cardiovascular, respiratory or metabolic diseases, subjects who presented with any inflammatory and/or infectious process or episodes of the musculotendinous junction, and subjects who presented with musculoskeletal injuries of the upper or lower limbs, and/or the spine.

The volunteers were informed about the procedures and aims of this study, and after agreeing to participate, signed a written informed consent form. In addition, each volunteer attached a copy of a medical certificate confirming them to be in sufficient physical condition to perform the exercises. All procedures utilized in this study were approved by the Committee for Ethics and Research of the Institution (CAAE Process. No. 01310212.4.0000.5402).

2.3. Experimental groups

The volunteers were randomly assigned to the following 2 groups consisting of 16 subjects each:

a) Control group (CG): the participants received all evaluations, but were not enrolled in the functional training program;

b) Functional training group (FTG): the participants received all evaluations, and were enrolled in the functional training program.

At the end of the experimental protocol, the CG still contained 16 volunteers. However, the FTG had been reduced by 3 subjects: 1 voluntarily dropped out, and the other 2 presented with a series of RR intervals with errors of more than 5%, and therefore the final FTG was composed of 13 subjects.

The anthropometric values of each group and their *p* values to verify the homogeneity between control and experimental groups were: age (20.56 ± 1.03 *vs*. 23.00 ± 2.51 years; $p = 0.01$), weight (58.42 ± 10.43 *vs*. 58.32 ± 8.72 kg; $p = 0.977$), height (1.62 ± 0.04 *vs*. 1.63 ± 0.05 m; $p = 0.0788$), and body mass index (BMI) (22.12 ± 3.86 *vs*. 21.90 ± 2.82 kg/m^2; $p = 0.862$).

2.4. Procedures

2.4.1. Training program

The FTG was enrolled in the periodized training program with a frequency of 3 sessions per week, with 60 min each one, totaling 30 sessions of training with recuperative intervals of 24–72 h between sessions. The program included 2 sets of exercises (A and B), which encompassed the majority of the muscle groups such as: flexors/extensors/adductors/abductors of the leg, hip, arm, and shoulder, scapular stabilizers, gluteals, abdominals, lumbar spine, chest and back muscles. The exercise sets were alternated