Dissimilar responses of autonomic function and strength to different periodizations in aging adults

Respostas dissimilares da função autônoma e força para diferentes periodizações em adultos idosos

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RESUMO  
Diferentes tipos de programas de treinamento resistido resultam em diferente estresse metabólico e demandas cardiovasculares, o que poderia influenciar adaptações na modulação autonômica cardíaca. O estímulo preciso do treinamento resistido e os mecanismos responsáveis por promover a melhora na variabilidade da frequência cardíaca (VFC) não são claros. Para examinar os efeitos na VFC após dois modelos de periodização de treinamento resistido em adultos idosos. Vinte e dois sujeitos foram divididos em dois grupos: periodização de sessão mista (MSP, n = 11) e periodização tradicional (TP, n = 11). Os sujeitos foram testados antes e após 24 sessões de treinamento resistido para VFC (tempo, frequência e análise não linear), cinco repetições máximas (5-RM) para o leg press e flexora sentada. Apenas o TP melhorou a VFC. O RR médio possivelmente aumentou com prováveis melhorias em RMSSD, SD1 e APEN. Muito provavelmente mudanças positivas foram observadas em HF. As diferenças foram associadas a tamanhos de efeito variando de 0,16 a 0,69. Para todos esses parâmetros autonômicos cardíacos no grupo MSP, a magnitude das mudanças foi classificada como trivial. A abordagem MSP resultou em prováveis ajustes autonômicos inferiores em RR, HF, RMSSD, HF, SD1 e APEN médios. Ambos os grupos provavelmente aumentaram o desempenho de força no leg press e na flexora sentada com possivelmente e provavelmente maiores melhorias observadas no grupo MSP, respectivamente. Aumentos graduais na intensidade prescrita pela abordagem TP podem fornecer melhores ajustes autonômicos do que as intensidades repentinamente mais altas sugeridas pelo MSP. TP parece ser mais eficaz para melhorias da função autonômica, enquanto MSP para força em adultos idosos.

Palavras-chave: regulação cardíaca, função autonômica, modelo de treinamento, treinamento resistido.

ABSTRACT  
Different types of resistance training programs result in different metabolic stress and cardiovascular demands, which could influence adaptations in the cardiac autonomic modulation. The precise resistance training stimulus and mechanisms responsible for promoting improvement in heart rate variability (HRV) are unclear. To examine the effects on HRV following two resistance training periodization models in aging adults. Twenty-two subjects were divided into two groups: mixed session periodization (MSP,
n=11) and traditional periodization (TP, n=11). Subjects were tested before and after 24 sessions of resistance training for HRV (time, frequency, and nonlinear analysis), five repetitions maximum (5-RM) for the leg press and seated leg curl. Only TP improved HRV. The mean RR possibly increased with likely improvements in RMSSD, SD1, and APEN. Very likely positive changes were observed in HF. The differences were associated with effect sizes ranging from 0.16 to 0.69. For all these cardiac autonomic parameters in the MSP group the magnitude of changes were rated as unclear. The MSP approach resulted in likely inferior autonomic adjustments in mean RR, HF, RMSSD, HF, SD1, and APEN. Both groups most likely increased strength performance in the leg press and seated leg curl with possibly and likely higher enhancements observed in the MSP group, respectively. Gradual increases in intensity prescribed by the TP approach could provide better autonomic adjustments than the suddenly higher intensities suggested by MSP. TP seems to be more effective for autonomic function improvements whereas MSP for strength in aging adults.

Keywords: cardiac regulation, autonomic function, training model, resistance training.

1 INTRODUCTION

Heart rate variability (HRV) corresponds to the RR interval variations deriving from the QRS wave on electrocardiographic tracings. HRV has been considered an acceptable method to non-invasively estimate cardiac autonomic system function in different situations (e.g., seated rest and ambulatory activity) (KIVINIEMI et al., 2004). A reduction in HRV is related to decreased parasympathetic activity and/or elevated sympathetic modulation; thus, low levels of HRV are found to be associated with higher values of blood pressure, autonomic dysfunction, cardiovascular diseases, and the risk of acute cardiovascular events (SCHROEDER et al., 2003; THAYER; YAMAMOTO; BROSSCHOT, 2010). Factors such as sedentary behavior, advanced age, unhealthy diets, and psychological stress are well known to have detrimental effects on HRV. Non-pharmacological interventions and lifestyle changes, including regular physical exercise, can promote improvement in cardiac autonomic function in participants of different ages and fitness levels (KIVINIEMI et al., 2007; MCKUNE et al., 2017). However, differently from aerobic training, less evidence has been reported for resistance training regarding the beneficial effects on HRV of healthy young people, and even less explored in older individuals (FIGUEROA et al., 2008; KARAVIRTA et al., 2013; MADDEN; LEVY; STRATTON, 2006).

The lack of evidence on resistance training responses can be explained due to few variations in experimental protocols. For example, healthy young and adult men submitted to constant load (COOKE; CARTER, 2005) and linear periodization
(HEFFERNAN et al., 2007) did not demonstrate any alterations in HRV. In spite of some criticisms (LOTURCO; NAKAMURA, 2016), training periodization strategies have been used in different populations. Conversely, it is not uncommon for improvements in parasympathetic modulation in middle-aged (27–60 y) or elderly (>60 y) populations following a resistance training intervention (CARUSO et al., 2015; FIGUEROA et al., 2008; RICCI-VITOR et al., 2013; TAYLOR et al., 2003). A plausible explanation for these different effects is that several studies applied constant load (i.e., 2x15 reps; 50 to 60% of 1RM) (WANDERLEY et al., 2013) or 3x10 repetitions (COLLIER et al., 2009) with under-reporting of load adjustments during the experimental protocol. Another potential explanation for the lack of changes could be related to the baseline HRV (i.e., the presence of autonomic dysfunction) (KINGSLEY; FIGUEROA, 2014). Only one study performed load adjustments using a linear periodization model (i.e., initial intensity was set at 50% to 60% and progressed to 75% to 85% of 1RM), although there was no modification in sets or number of repetitions (3x12 reps) (KINGSLEY; MCMILLAN; FIGUEROA, 2010).

Training periodization in resistance training for older persons is usually designed to optimize different types of skeletal muscle adaptations (e.g., muscle hypertrophy, maximum strength, and power) (BEZERRA et al., 2018). While the precise resistance training stimulus and mechanisms responsible for promoting improvement in HRV are unclear (CARUSO et al., 2015; RICCI-VITOR et al., 2013; TAYLOR et al., 2003), different types of RT programs result in different metabolic stress and cardiovascular demands (IGLESIAS-SOLER et al., 2015), which could result in different adaptations in the cardiac autonomic modulation. To the best of our knowledge, no studies have analyzed the chronic effects of different high-intensity periodization models on resting HRV in older individuals.

The use of mixed session periodization (MSP) would improve maximum strength, power, functional capacity, and body composition enhancement in aging subjects. This type of training progression plan is characterized by mixing, within the same training session, hypertrophic, maximum strength, and power training methods, differently from traditional periodization (TP), which is characterized by training each one of these methods in different training periods (e.g., weeks or months). Using the MSP loading, contraction velocity, and repetitions volume vary within the same days, whereas in TP these vary after each training period (BEZERRA et al., 2018). Therefore, the purpose of the present study was to examine the effects of a resistance training program consisting
of two distinct periodization models (TP and MSP) on HRV and muscle strength in older adults. It was hypothesized that the MSP model should be similar to the TP model for strength parameter(s). Furthermore, considering the age and presence of autonomic dysfunction, both groups would present increases in HRV.

2 MATERIALS AND METHODS

2.1 STUDY DESIGN

This study was a randomized trial aiming to compare different training organization schemes on HRV and muscle strength in older participants. The selected participants were randomly assigned into two different groups according to the training method adopted during the experimental period: TP and MSP. Pre-training heart rate variability measures, repetition maximum tests were taken. Test and retest were performed on 2 nonconsecutive days in a randomized order. Following the pre-training test, 27 training sessions of either the TP or MSP scheme were performed over nine weeks. Post-testing was conducted in the same order as pre-testing for each participant, and all tests were performed at least 48 hours after the final training session.

2.2 SUBJECTS

Twenty-two older adults (men=15 and women=7) were randomly assigned to the TP (n=11, men=8 and women=3; 65.0±4.2 years; 74.6±16.0 kg and 1.66±0.1 m) or MSP (n=11, men=7 and women=4; 64.3±5.3; 1.70±0.1 and 81.0±15.7 kg) groups. All subjects completed a specific health history and physical activity questionnaires and met the following inclusion criteria: age ≥55 years, physically independent, controlled cardiac disease (i.e. no cardiovascular disease that could make the exercise harmful to their health), free from orthopedic dysfunction, and not performing any regular resistance exercise for the six months preceding the beginning of the study. All subjects performed 100% of the total sessions. Three subjects in the MSP group and two in the TP group did not take hypertensive or diabetic medicine; however, for those who did take this medication, the dosing was not controlled. Moreover, six subjects reported hypertension associated with diabetes (TP=3, MSP=3), four subjects stated the use of beta-blockers (TP=2, MSP=2), and one reported diabetes alone (TP=1). No subject reported any changes in medication intake during the intervention period. Subjects were oriented not to change their habitual exercise practice during the intervention. Written informed consent was obtained from all subjects after a detailed description of study procedures.
had been provided. All procedures performed in this study were approved by a local Institutional Ethics Committee (#1.657.414) and followed the ethical guidelines of the Declaration of Helsinki (64th WMA General Assembly, Fortaleza, Brazil, October 2013).

2.3 HEART RATE VARIABILITY

The RR-interval recordings were obtained using a heart rate sensor H7 Polar® (Polar Electro Oy, Finland) continuously for 10 minutes (5-minutes of stabilization followed by 5-minutes of recording) in the seated position. The data transmission was intermediated by a simple pair of earphones attached to the central region of the heart rate sensor. These were connected to a Pavillion HP® portable computer (Hewlett-Packard, USA) at the entrance to the microphones, so the headsets transmitted the data at a sampling rate of 44.1 KHz to the open-source software for cardiovascular biofeedback Biomind© (Florianópolis, Brazil). The data processing and final values were performed according to the recommendations available on the developers’ website of the (http://www.neuroacademia.org/). Different measures of HRV were obtained to compare modifications in autonomic cardiac regulation. The mean RR interval, root mean square of successive differences (RMSSD) corresponding to difference in variation between adjacent RR intervals, and the percentage of adjacent RR differing more than 50 ms (pNN50) were used as time domain measures of HRV. The high frequency (HF-0.15 to 0.40 Hz) spectral power (ms²) was derived by default using Fast Fourier Transformation (FFT). The HF band reflects the respiratory sinus rhythm from centrally mediated cardiac vagal control (MALIK et al., 1996). In the non-linear domain, the SD1 value which is similar in mathematical calculation to the RMSSD, is able to provide a measure of instantaneous beat-to-beat variability, while the approximate entropy (APEN) was utilized to identify the regularity of the RR interval series with irregularity resulting in high and regularity resulting in low values) (CARUSO et al., 2015; SHAFFER; MCCRATY; ZERR, 2014). The room was isolated, with the temperature set at 25±1°C. The subjects were advised to maintain their normal routine during the day before assessment. All assessments occurred between 8 and 11 a.m.

2.4 REPETITION MAXIMAL TEST

Five-repetitions maximum (-RM) tests for the leg press and seated leg curl and 12-RM testing for the seated row were performed (Righetto®, São Paulo, SP, Brazil). RM tests were performed to determine changes in muscle strength after 27 sessions. 5-RM
and 12-RM were performed as described previously by Bezerra et al., (DE SOUZA BEZERRA et al., 2018). Prior to the assessment all subjects were familiarized during 3 sessions (48h between them) that consisted of 3 sets (15, 10, and 5 repetitions) for each lower limb exercise and 3 sets of 12 repetitions for upper limb exercises, not performed to concentric failure.

2.5 TRAINING PROCEDURES

Following the pre-testing assessments, both groups trained for 9 weeks, completing 27 sessions (at least 48h between them). All training sessions were preceded by mobility and body weight exercises for both groups.

The TP and MSP groups performed the leg press and seated leg curl exercises as suggested by Bezerra et al., (2018). Training method sets were classified into three types according to their goal: Hypertrophy (10-12 RM); Strength (3-5 RM), and Power (4-6 repetitions). During the first period of training, the TP group (1st to 9th sessions) performed 3 sets of the hypertrophy method per exercise per session, in the second period (10th to 18th sessions) the TP performed 3 sets of the strength method per session, and in the final period (19th to 27th sessions) the TP performed 3 sets of the power method. The MSP group performed 1 set of each different method per exercise for all sessions (1st to 27th).

The hypertrophy and strength methods were performed with sets to voluntary concentric failure. During these methods, verbal encouragement was provided to ensure concentric failure and control the training cadence. The power method was performed with as fast as possible concentric contractions, with verbal encouragement to perform contractions as fast as possible in all repetitions.

A two minute rest interval was adopted between sets for both groups, for all methods, periods, and exercises. During all sessions, physical education professionals personally supervised subjects to help ensure consistent and safe performance. A complementary resistance-training program was performed by both groups, which consisted of three sets of 12 RM of the seated row, cable crossover chest press, biceps and triceps curl with 1 minute between sets. The absolute volume load was calculated (sets*repetitions*weight lifted kg) (SCOTT et al., 2016).

2.6 STATISTICAL ANALYSIS

Data are presented as mean ± standard deviation (SD). Data in the Figures are presented with SD or confidence intervals (CI). The distribution of each variable was
examined with the Shapiro-Wilk normality test. Thereafter, all data were log-transformed to reduce bias arising from non-uniformity errors.

Main training effects within and between groups were assessed by a mixed model (time [pre vs. post] x two groups [TP vs. MSP]). An alpha level of p ≤ 0.05 was used to determine statistical significance. All statistical procedures were completed utilizing SPSS 21 for Windows (Statistical Package for the Social Science, IBM, Chicago, Ill, USA).

Additionally, data were then analyzed for practical significance using magnitude-based inferences (MBI) (26). We used this qualitative approach as traditional statistical approaches (null-hypothesis significance testing) often do not indicate the magnitude of an effect, which is typically more relevant to clinical outcomes than any statistically significant effect. MBI analysis was also used to examine the differences in autonomic cardiac function pre- to post-intervention using a customized spreadsheet [http://www.sportsci.org/]. The smallest worthwhile change was calculated (i.e., 0.2 x by the between-subjects standard deviation SD) and 90% confidence intervals (CI) were determined. The quantitative chances of higher, similar, or lower differences were evaluated qualitatively as follows: <1%, almost certainly not; 1% to 5%, very unlikely; 5% to 25%, unlikely; 25% to 75%, possible; 75% to 95%, likely; 95% to 99%, very likely; >99%, almost certain. The true difference was assessed as unclear when the chances of having positive and negative results were both >5%. Threshold values for Cohen’s effect size (ES) statistics were >0.2 (small), >0.5 (moderate), and >0.8 (large) (HOPKINS et al., 2009).

3 RESULTS

According to the qualitative statistical analysis method, mean RR possibly increased together with likely improvements in RMSSD, SD1, and APEN. Very likely positive changes were rated for HF. There were no differences in cardiac autonomic parameters for the MSP group at rest in the seated position. With the exception of the variable PNN50, the subjects of the TP group demonstrated increases in all parasympathetic parameters after the training period (table 1). The pre to post assessment revealed most likely improvements in all strength parameters for both groups, with a higher effect size shown by the MSP.

Between-groups differences in the change in cardiac autonomic and strength parameters between treatments (±90%CI) are displayed in figure 1. The MSP approach
resulted in possibly inferior autonomic results in mean RR (ES=-0.28, 90%CI=-0.65 to 0.09), RMSSD (ES=-0.28, 90%CI=-0.74 to 0.17), HF (ES=-0.28, 90%CI=-0.75 to 0.19), SD1 (ES=-0.36, 90%CI=-0.82 to 0.10), and APEN (ES=-0.16, 90%CI=-0.50 to 0.19), in addition to possibly and likely superior adaptation in the leg press (ES=0.15, 90%CI=-0.13 to 0.43) and seated leg curl (ES=0.46, 90%CI=0.19 to 0.73), respectively, when compared to the TP. Unclear effects were rated for pNN50 (ES=-0.11, 90%CI=-0.56 to 0.33) and the seated row (ES=0.01, 90%CI=-0.55 to 0.57).

The absolute volume load did not show meaningful difference between groups after the training period (MSP: 15065±2667 a.u. vs. TP: 12696±3987 a.u, p=0.14).

**Figure 1**- Comparisons of the heart rate variability–derived indices and strength parameters using an approach based on standardized differences between the 2 periodization models. Right column, percentage (%) chance rating as (positive effect to TP/trivial/positive effect to MSP). TP, traditional periodization group; MSP, mixed session periodization group; LPress, leg press 5-RM; SLC, seated leg curl 5-RM; *SR, seated row 12-RM.
### Table 1. Heart rate variability and strength parameters evaluated pre- and post-intervention. Mean ± standard deviation.

<table>
<thead>
<tr>
<th></th>
<th>Traditional periodization</th>
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<th>Mixed Session periodization</th>
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<tbody>
<tr>
<td></td>
<td>PRE</td>
<td>POST</td>
<td>ES</td>
<td>% chance (Rating)</td>
<td>PRE</td>
<td>POST</td>
</tr>
<tr>
<td>Mean RR</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RMSSD</td>
<td>16.8±10.4</td>
<td>24.6±5.6</td>
<td>0.69</td>
<td>93/06/01 (Likely)</td>
<td>17.4±11.3</td>
<td>19.5±7.0</td>
</tr>
<tr>
<td>pNN50</td>
<td>3.3±5.2</td>
<td>4.2±4.6</td>
<td>0.16</td>
<td>45/43/12 (Unclear)</td>
<td>2.6±4.1</td>
<td>2.6±3.8</td>
</tr>
<tr>
<td>HF (ms²)</td>
<td>103.2±112.7</td>
<td>178.6±11.3</td>
<td>0.62</td>
<td>96/04/00 (Very Likely)</td>
<td>106.7±117.3</td>
<td>123.0±98.5</td>
</tr>
<tr>
<td>SD1</td>
<td>11.9±7.4</td>
<td>17.4±4.0</td>
<td>0.69</td>
<td>93/06/01 (Likely)</td>
<td>13.2±7.3</td>
<td>13.8±4.9</td>
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<tr>
<td>APEN</td>
<td>0.95±0.19</td>
<td>1.03±0.10</td>
<td>0.40</td>
<td>79/20/02 (Likely)</td>
<td>1.00±0.15</td>
<td>1.03±0.12</td>
</tr>
<tr>
<td>LPress</td>
<td>93.7±28.7</td>
<td>122.3±36.6</td>
<td>0.82</td>
<td>100/00/00 (Most Likely)</td>
<td>108.8±25.1</td>
<td>138.6±28.4</td>
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<tr>
<td>SLC</td>
<td>72.6±20.9</td>
<td>87.6±23.1</td>
<td>0.66</td>
<td>100/00/00 (Most Likely)</td>
<td>75.6±17.8</td>
<td>99.8±18.1</td>
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<tr>
<td>SR</td>
<td>35.9±9.8</td>
<td>51.0±13.6</td>
<td>1.43</td>
<td>100/00/00 (Most Likely)</td>
<td>34.4±7.5</td>
<td>49.6±12.3</td>
</tr>
</tbody>
</table>

Mean RR= mean RR interval; RMSSD = root mean square of successive differences of intervals between heart beats; Pnn50= percentage of adjacent RR differing more than 50 ms; HF= high-frequency bands; SD1= the standard deviation of the RR intervals; APEN= approximate entropy; LPress= leg press; SLC=seated leg curl; SR= seated row; ES= effect size; % chance (Rating), Beneficial/Trivial/Harmful.
4 DISCUSSION

The main finding of this study is that when comparing the post-intervention period to baseline, TP demonstrated more favorable outcomes on parasympathetic-related indices of HRV in the resting state than the MSP model. While the TP showed a possible increment in mean RR, likely increase in RMSSD, SD1, APEN, and very likely improvement in the spectral index HF, no change was found in the MSP group. TP demonstrated a possibly superior delta change compared to the MSP for mean RR, RMSSD, HF, SD1, and APEN. Furthermore, after the training intervention, the strength of lower limbs showed likely superior values for both exercises and periodization models, however, in contrast to the HRV pattern, the MSP showed delta change values possibly superior in the leg press and likely superior in the seated leg curl exercises.

This is the first study to investigate the effects of different models of resistance training periodization with total volume equalized on autonomic nervous system function. Improvement in the autonomic control was only evidenced in the TP, with no variation in the MSP group. The mechanisms that explain these improvements are not clear, although it is known that exercise intensity and type of contraction present different cardiovascular overload. Moreover, although the total overload imposed did not differ between groups at the end of the training intervention, significant differences were found between phases, where the TP was submitted to markedly higher overload than the MSP group in the first phase, and this was inverted in the final phase.

Considering the fundamental role of arterial stiffness on arterial baroreflex sensitivity and therefore on HRV (SHAFFER; MCC RATY; ZERR, 2014), controversial results have been reported regarding changes in arterial stiffness induced by resistance training (MIYACHI, 2013). Previous meta-analysis reported an association between high-intensity resistance training and an increase in arterial stiffness (MIYACHI, 2013), with no alteration for moderate intensities, and, interestingly, the model of overload could have affected the observed results. For instance, healthy adults that performed high volume and high intensity resistance training (CORTEZ-COOPER et al., 2005; MIYACHI et al., 2004) demonstrated an increment in arterial stiffness, whereas healthy subjects submitted to resistance training with progressive intensity during the sessions did not show any change related to the central arterial compliance and cardiac dimension (RAKOBOWCHUK et al., 2005). Acutely, a resistance training session which reaches muscle failure or higher relative intensities could support the higher arterial stiffness observed (KINGSLEY et al., 2016).
Among the studies which reported an increase in HRV indices after resistance training interventions, women with fibromyalgia syndrome, classified as pre-hypertensive, submitted to 16 weeks of training consisting of a single set of 8-12 repetitions at 50-80% 1RM in nine multi-joint exercises, demonstrated an increase in physiological indices related to the regulation of the cardiac autonomic nervous system RMSSD, and a tendency to increase in spectral HF (p=0.08) (MALIK et al., 1996). Aging adults with chronic obstructive pulmonary disease reported increments in LF (ms²), HF (ms²), SDNN, and RMSSD (p=0.08) following 24 training sessions with progressive intensities of 60-80% 1RM. In addition to the improvement in parasympathetic activity, the authors also reported an increment in strength and functional tests (RICCI-VITOR et al., 2013). The geometric indices of HRV (TINN, SD1, and SD2) were also sensitive to predict the improvement in autonomic modulation for this population after a resistance training intervention (SANTOS et al., 2017). Higher values of normalized HF (HFnu) were shown after three months of resistance training of moderate intensity (controlled by HR monitoring: 3 sessions/week) with efforts ranging from 0.5-2 minutes of arm and leg cycling and stair climbing, elbow extension/flexion (30s), knee extension/flexion (30s), and shoulder press/pull (30s) in patients with chronic heart failure (SELIG et al., 2004).

Several studies (FORTE; DE VITO; FIGURA, 2003; GERHART et al., 2017; KARAVIRTA et al., 2013; KINGSLEY; FIGUEROA, 2014; MELO et al., 2008) have reported increments in strength levels after resistance training, however, with no improvements in the autonomic condition in healthy elderly. Thus, the presence of autonomic dysfunction has been suggested as a possible pre-training condition capable of explaining the improvement in HRV after a resistance training intervention (FIGUEROA et al., 2008; KINGSLEY; FIGUEROA, 2014). In agreement with Kingsley and Figueroa (KINGSLEY; FIGUEROA, 2014), it is probable the presence of autonomic dysfunction provides a favorable environment for positive changes in HRV after resistance training interventions. However, even considering this condition, we demonstrated that the different stress levels induced by different overloads of resistance training programs could provide divergent results on HRV in elderly patients.

Considering that low HRV is associated with a progression of atherosclerosis (HUIKURI et al., 1999) and diabetes (SCHROEDER et al., 2005), we assumed here not the reestablished of cardiac health or inhibition of a specific cardiac disorder but the reduction of progression derived from the low HRV condition. The relevance is still higher when investigated the dose response as measured in a meta-regression study that reported 1% increase of SDNN capable to reduces the risk of fatal or non-fatal cardiovascular disease at the
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same extent (HILLEBRAND et al., 2013). Moreover, individuals with lowered HRV have an increased risk of cardiovascular mortality 24-h after out-of-hospital cardiac arrest when compared with subjects with high HRV (CHEN et al., 2009) and higher incidence stroke for diabetic individuals (FYFE-JOHNSON et al., 2016).

Interestingly, in contrast to the expected results, the MSP presented higher increases in strength than TP. This outcome could be explained by the frequent exposure to elevated overload during all training periods, which was markedly different from the TP that trained with elevated overload only in the second period of training. Higher increases in maximum strength are observed when training intensities are performed at near maximal relative intensities (BUCKNER et al., 2016). A limitation of the current study resides in the fact that we did not evaluate the dosage of medication, as we were not allowed to interfere in the treatment of the patients. We also understand that homogenization of the sample profile and control of medication during the intervention would increase the external validity of the study. Another possible limitation was the absence of HRV measures during the intervention, mainly to understand the load variation effect. Moreover, the lack of a true control group and the small sample could limit extrapolation of the outcomes to the aging population.

Results of this study have potential implications for exercise prescription and progression with respect to the resistance training. We provide evidence indicating that different periodization models can result in different outcomes in strength and autonomic function. The TP seems to demonstrate better results for HRV indices. Improvements in the cardiac autonomic system after resistance training interventions result in higher autonomic control due to the increase in parasympathetic activity in the resting condition.

5 CONCLUSIONS

In conclusion, the TP adopted in the present study seems to be more effective for autonomic function improvements whereas MSP is more effective for dynamic strength improvements in aging adults. These results indicate that TP should be prioritized when the objective is to improve autonomic function. On the other hand, MSP should be emphasized for strength gain purposes.

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