

ARE THERE RELATIONSHIP BETWEEN INTERNAL AND EXTERNAL LOAD OF AEROBIC TRAINING WITH HEART RATE VARIABILITY IN WOMEN?

HÁ RELAÇÃO DA CARGA INTERNA E EXTERNA DO TREINAMENTO AERÓBIO COM VARIABILIDADE DA FREQUÊNCIA CARDÍACA EM MULHERES?

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RESUMO

O objetivo foi investigar a relação da carga interna de treinamento (CIT), carga externa de treinamento (CET) e variabilidade da frequência cardíaca (VFC) em mulheres. 16 mulheres ($48,2 \pm 6,4$ anos) realizaram medidas de VFC em repouso (variável lnRMSSD – modulação cardiovagal) e o teste incremental de caminhada (TIC) antes e depois de 12 semanas de treinamento aeróbio. O limiar da VFC (LVFC) foi utilizado para prescrição da CET. A percepção subjetiva de esforço (PSE) foi utilizada para cálculo da CIT. O valor de CIT encontrado nas 12 sessões foi de 2878 ± 380 unidades arbitrárias e para CET de 36822 ± 5852 m. Foi observada diferença significativa para lnRMSSD ($3,14 \pm 0,30$ vs. $3,43 \pm 0,38$ ms⁻¹; $P = 0.001$). Verificou-se uma correlação grande entre lnRMSSD basal e TIC ($r = 0.73$, $P = 0.001$), LVFC ($r = 0.67$, $P = 0.004$) e CIT ($r = 0.62$, $P = 0.011$). Foi encontrada uma correlação muito grande entre a mínima diferença detectável individual do lnRMSSD após treinamento e CIT. Conclui-se que há uma forte relação entre VFC e performance aeróbia (LVFC e TIC_{distância}), VFC e acúmulo de CIT, porém, sem relação com a CET acumulada nas 12 semanas nas mulheres estudadas.

Palavras-chave: Modulação autonômica cardiovascular. RMSSD. Exercício. Treinamento aeróbio.

ABSTRACT

The purpose was to investigate the relationship between internal training load (ITL), external training load (ETL) and heart rate variability (HRV) in women. 16 women (48.2 ± 6.4 yrs) performed HRV recordings (i.e. lnRMSSD – cardiovagal modulation) and Incremental Shuttle Walk Test (ISWT) before and after 12 aerobic training sessions. HRV threshold (HRVT) were used to prescribe aerobic ETL. The session rating of perceived exertion (s-RPE) was analyzed and served as the measure of ITL. The score found for ITL in the 12 sessions was 2878 ± 380 arbitrary units and ETL were 36822 ± 5852 m. A significant difference was observed in the lnRMSSD (3.14 ± 0.30 vs. 3.43 ± 0.38 ms⁻¹; $P = 0.001$). There were observed large correlation between lnRMSSD at baseline vs ISWT ($r = 0.73$, $P = 0.001$), HRVT ($r = 0.67$, $P = 0.004$) and ITL ($r = 0.62$, $P = 0.011$). Very large correlation between individual smallest worthwhile change lnRMSSD after training and ITL ($r = 0.81$, $P = 0.0001$) was observed. There is a strong association between the HRV and aerobic performance (HRVT and ISWT_{distance}) and strong relationship between HRV and the potential to accumulate ITL, but not aerobic ETL in women.

Keywords: Cardiovascular autonomic control. RMSSD. Exercise. Aerobic training.

Introduction

Session rating of perceived exertion (s-RPE) has often been used as a subjective method to estimate internal training load (ITL)¹ in various training contexts^{2,3}. Indeed, it emerges as a valid and simple tool with low implementation cost⁴. The method proposed by Foster et al.⁵ represents the magnitude ITL by multiplying the s-RPE score by the volume of the entire training session in minutes. This method has been used and validated in athletes⁶⁻⁸ and non-athletes^{1,9}. An insufficient ITL might not provide an appropriate stimulus to induce positive adaptations and a detraining state might emerge⁷.

The appropriate prescription of volume and intensity of exercise to induce a meaningful ITL for improving health and fitness have not been accurately described among sedentary individuals. The individual responses to training are related to fitness level and proportional to the magnitude of the provided ITL⁷. For example, post myocardial infarction

patients showed a similar improvement in functional capacity, ventilatory efficiency and metabolic adaptation between continuous versus interval aerobic trainings with ETL prescribed in order to result in similar individually tailored doses of ITL⁹. On the other hand, an insufficient ITL might not provide an appropriate stimulus to induce positive adaptations and a detraining state might emerge⁷.

As a result, the quantification of individual ITL response to a given external training load (ETL) is a vital component of training-related adaptive processes¹⁰. In this case, heart rate variability (HRV) has been used to monitor and guide individual aerobic training^{11,12}. Resting vagally-mediated HRV is positively associated to individual cardiorespiratory fitness^{13,14} and health-related quality of life for asymptomatic adults¹⁵. Subjects who display high cardiovagal modulation at baseline have been shown to display a greater propensity to improve aerobic peak capacity after a 16-week aerobic training program¹⁶. A dose-dependent curvilinear relationship exists between HRV indicators of ITL and fitness improvement in cardiac patients⁹ and athletes^{2,10,17,18}.

However, up to now, no previous study has analyzed the longitudinal dose-response relationship between ITL and HRV cardiovagal modulation in women. An important limiting factor in the establishment of the relationship between training load and physiological adaptation is the unique individual response to each training stimulus^{4,14}. The individual change can be assessed through a standard difference score and magnitude-based inferences which allows the comparison of a response to the smallest worthwhile difference (SWC)¹⁹. SWC definition is the smallest difference that researchers and subjects would care about in the dependent variable analyzed¹⁹. It needs to be recognized that the contributions documented at the group level may not fully apply individually, even when all members of the exercising group are exposed to the same standardized training program.

In this case, the issue of individual responses to a given treatment is one of the most important considerations in experimental research, yet attempts to quantify such responses are rare¹⁹. Furthermore, an important limiting factor in the establishment of the relationship between training load and physiological adaptation is the unique individual response to each training stimulus^{4,14}. Nevertheless, to date, there is no study that has analyzed the individual change in HRV and individual response in ITL from aerobic training. Thus, the aim of this study was to investigate a relation between ITL, aerobic ETL and physiological adaptation in heart rate variability in women. Additionally, the individual responses will be analysed and reported. The hypothesis of the study is that there will be a relationship between the accumulation of ITL and chronic adaptations in HRV.

Methods

Subjects

The sample size was calculated using Gpower software version 3.1.9.2 (Universität Kiel, Kiel, Germany). For this study design, 11 participants were required to result in a statistical power of 0.99, a moderate correlation ($r = 0.50$), and an overall level of significance of $p = 0.05$. Thus, a convenience sample of 16 healthy adult women normotensive (48.2 ± 6.4 years, 164 ± 10.8 cm, 72.5 ± 12.6 kg, $BMI = 25.8 \pm 5.1$ $\text{kg}\cdot\text{m}^{-2}$, heart rate variability threshold = 6.1 ± 1 $\text{km}\cdot\text{h}^{-1}$ and $\text{VO}_2\text{peak} = 32 \pm 9$ $\text{ml}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$) were selected to participate in the study. The participants were classified as sedentary according to the International Physical Activity Questionnaire (IPAQ - short version). All subjects were healthy, nonsmokers, and had a body mass index (BMI) under 35 $\text{kg}\cdot\text{m}^{-2}$. None of the subjects regularly consumed any substance that influenced autonomic control or currently undergoing hormone replacement therapy.

Procedures

An introductory session was held to familiarize the volunteers with the procedures before the commencement of data collection. Body composition (body weight, height, and fat) and blood pressure were measured on the same day between 8:00 to 10:00 AM. Pre-training HRV evaluations were conducted 48 hrs after the familiarization session. Forty-eight hrs later, the first training session began. The study lasted 5 weeks with a total of 12 sessions with 48 to 72 hrs recovery between the training sessions. Post-training HRV evaluation was performed 48 hrs after the end of session 12, in the morning between 7:30 to 8:30 AM. The room temperature of the experiment was kept between 22 and 25°C with relative humidity between 40 and 60%. In both experimental conditions days (pre- and post-training), the subjects had been previously instructed to: (a) not drink stimulating caffeinated or alcoholic beverages 48 hrs before testing; (b) not perform strenuous physical exercise; and (c) eat a light meal 2 hrs prior to the testing and sessions trainings. All research was conducted ethically according to international standards²⁰. The current study was approved by the Research Ethics Committee of the Local Institution, as recommended by Resolution 466/12 of the National Health Council (950.277/2015).

HRV Analysis

The subjects were kept in supine position for 10 min with no talking or moving. Heart rate data was recorded while spontaneous breathing was monitored¹¹. Heart rate data was obtained with a Polar RS800CX[®] heart rate monitor, which was previously validated to record HRV both at rest and during exercise²¹. Then, heart rate signals were processed to calculate HRV using the Kubios HRV[®] version 3.0.1 (Biomedical Signal Analysis Group, University of Kuopio, Finland). All R-R intervals with differences greater than 20% of the previous adjacent interval were automatically filtered and inappropriate heart beats were eliminated (low filter). The root mean square of the successive differences between the normal adjacent RR intervals (RMSSD) were used in the study. This metric was chosen as it is more reliable than other HRV indexes²² and can be obtained during spontaneous breathing²³. RMSSD is more robust for changes in breathing frequency than high-frequency power²³. Due to the skewed nature of HRV recordings, the RMSSD data were transformed into their natural logarithm ($\ln\text{RMSSD}$)¹⁸.

Incremental Shuttle Walk Test

The Incremental Shuttle Walk Test (ISWT) was performed in a 10-meter-long covered and airy hallway marked by cones. The initial cadence of 0.5 m·s⁻¹ was increased by 0.17 m·s⁻¹ every minute until the subjects showed exhaustion. The heart rate variability threshold (HRVT) was obtained by the SD1 index calculated by *Poincaré* plot during the ISWT²⁴. Next, the ISWT phase speed was matched with the SD1 values. The HRVT in ISWT corresponded to the first phase of the incremental exercise test in which the difference between the SD1 of two consecutive phases was less than 1 millisecond²⁴. The HRVT was identified by visual inspection performed by 3 independent examiners, and it was defined when at least 2 concordant assessments occurred.

Aerobic training sessions

Three different intensity zones were used to prescribe aerobic external training load (ETL), as follows: Zone 1 occurred at an intensity level below the heart rate variability threshold (HRVT); Zone 2 occurred at an intensity level at the HRVT; and Zone 3 occurred at an intensity level above the HRVT. HRVT was used for the prescription of the 12 training sessions with 3 variations (session 1 [S1], 2 [S2] and 3 [S3]). In S1, the subjects jogged or walked for 30 min at intensity 20% below HRVT in Zone 1. In S2, they performed 3 sets of 8

min in HRVT with 2 min of active recovery at intensity 20% below HRVT, totalling 30 min. In S3, they performed 3 sets of 6 x 1-min repetitions at 20% above HRVT, with 1 min of active recovery at 20% below HRVT, totalling 36 min. All the 16 subjects participated in 5 S1, 4 S2, and 3 S3 (398 minutes). The total ETL corresponded to the sum of the distance in meters in Zone 1, 2 and 3 during the 12 sessions. The sessions were separated by 48 hours and took place on Mondays, Wednesdays and Fridays at the same time (8:00 to 10:00 AM).

Monitoring the Internal Training Load using s-RPE (ITL)

The ITL was monitored according to Foster method⁵. The s-RPE score was obtained 30 min after the end of each session, in all 12 sessions. The subjects individually indicated the degree of perceived exertion according to the Borg CR10 s-RPE. The perceived score reported by the subjects was multiplied by the total session time in minutes in order to calculate the ITL⁵. The total ITL corresponded to the sum of the load calculated in the 12 sessions. The data were expressed in arbitrary units (AU).

Statistical Analysis

The normality were verified using the Shapiro-Wilk. Data are shown as means \pm standard deviations (DP) or 95% confidence intervals. The paired *t*-test was used to check the lnRMSSD difference from baseline (lnRMSSD_{baseline}) to post-training. The magnitude of the differences was examined using the standardized differences based on Cohen's *d* units by means of effect sizes (ES)¹⁹. The ES results were qualitatively interpreted using the following thresholds: <0.2, trivial; 0.2-0.6, small; 0.6-1.2, moderate; 1.2-2.0, large; 2.0-4.0, very large and; >4.0, extremely large. The smallest worthwhile change (SWC) was set as 0.2 x between subject DP. According to Buchheit²⁵ the thresholds for trivial, small, moderate, large, and very large standardized changes (Cohen *d*) being <0.2, 0.2, 0.6, 1.2, and 2, respectively, means that any change of <1x, 1x, 3x, 6x, and 10x SWC can be considered trivial, small, moderate, large, and very large. Data analysis was performed using a modified statistical Excel spreadsheet¹⁹. The relation between lnRMSSD_{baseline} and ITL, lnRMSSD_{baseline} and HRVT, lnRMSSD_{baseline} and ISWT distance (ISWT_{distance}), lnRMSSD_{baseline} and ETL, individual change in SWC lnRMSSD after training vs ITL and ETL was determined through the Pearson's correlation using the SPSS software (version 22.0; IBM Corp., Armonk, NY, USA). The confidence interval (95% CI) of the association between variables was calculated in Bioestat software (version 5.3; Instituto Mamirauá, Tefé, AM, Brazil). The following criteria were adopted in order to interpret the correlation magnitude: ≤ 0.1 , trivial; >0.1-0.3, small; >0.3-0.5, moderate; >0.5-0.7, large; >0.7-0.9, very large; and >0.9-1.0, extremely large¹⁹. The adopted significance was $P \leq 0.05$.

Results

The total ITL in the 12 sessions were 2878 ± 380 AU (IC95%= 2692 to 3065 AU; average per session 240 ± 32 AU) and ETL were 36822 ± 5852 m (Zone 1 = 20041 ± 3140 m, Zone 2 = 10586 ± 1729 m; Zone 3 = 5956 ± 973 m). Table 1 displays the HRV results at baseline and after 12 sessions of aerobic training. A significant difference was observed between baseline and after aerobic training in the log-transformed root mean square of successive R-R intervals (lnRMSSD).

Table 1. Heart rate variability results in baseline and after 12 sessions of aerobic training in women

| Variable | Baseline (mean ± SD) | After (mean ± SD) | <i>P</i> | ES (±90% CL) <i>classification</i> |
|--------------|-------------------------|----------------------|----------|--|
| lnRMSSD (ms) | 3.14 ± 0.30 | 3.43 ± 0.38 | 0.001 | 0.85 (0.57 to 1.13) <i>Moderate</i> |

Notes: lnRMSSD = log-transformed root mean square of successive R-R intervals; ES= Effect Size; CL= Confidence Limits; Chances = rate of having better/similar/poorer chances

Source: The authors

Figure 1 shows individual comparison between subjects ITL (1A) and change in lnRMSSD (1B) after aerobic training. Of the 16 subjects, 14 presented a substantial difference effect after aerobic training in lnRMSSD (small improvement = 2 subjects [1 and 14]; moderate improvement = 7 subjects [2, 5, 7, 10, 12, 13 and 16]; large improvement = 5 subjects [3, 4, 8, 9 and 11]). Only subjects 6 and 15 presented trivial difference. The subject 15 presented lower ITL (2350 AU) and changes in lnRMSSD (0.7 xSWC) compared to all subjects (1A).

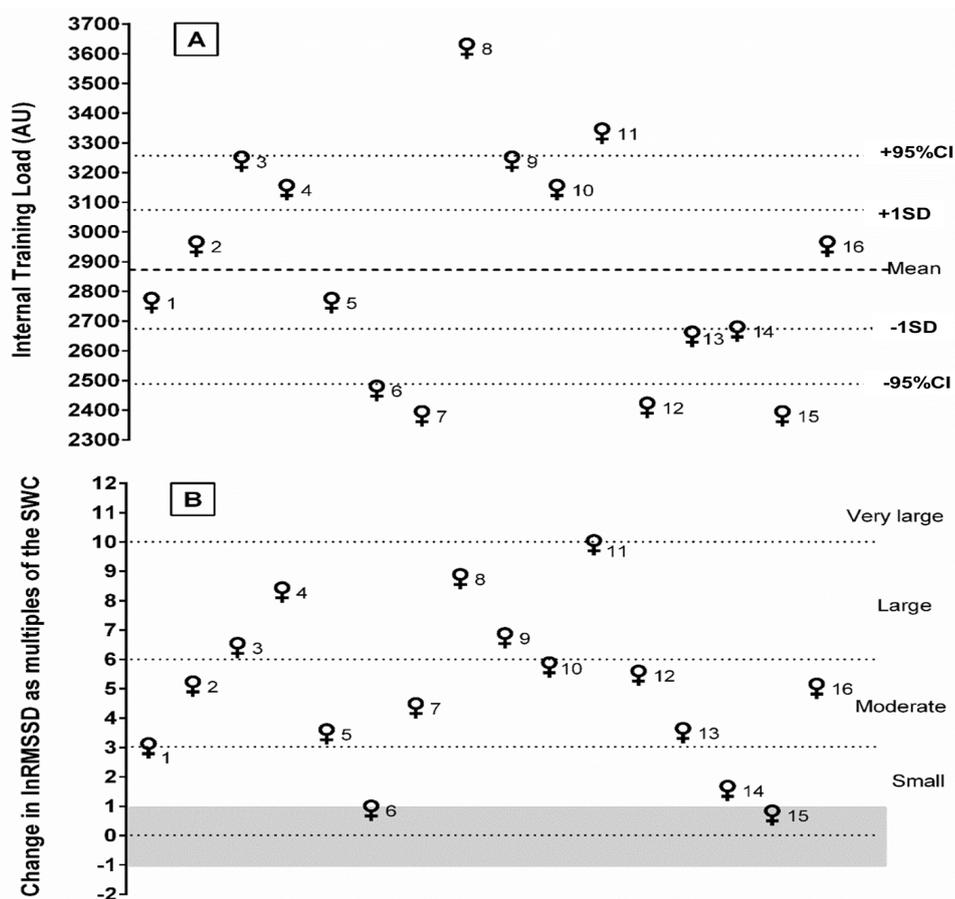


Figure 1. Individual comparison between subjects in internal training load (A) and change in lnRMSSD as a multiple of the SWC (see methods) after 12 sessions of aerobic training (B). The grey area in graphic B represents the zone trivial of the SWC

Notes: lnRMSSD = log-transformed root mean square of successive R-R intervals; SD= standard deviation; 95%CI= 95% confidence interval; ♀1-16=Subject number.

Source: The authors

Figure 2 illustrates the correlation between lnRMSSD_{baseline} and ISWT_{distance} (2A),

$\ln\text{RMSSD}_{\text{baseline}}$ and HRVT (2B), $\ln\text{RMSSD}_{\text{baseline}}$ and ITL (2C), individual change in $\ln\text{RMSSD}$ (measured in multiples of SWC) and ITL (2D). At baseline, large and very large correlations between $\ln\text{RMSSD}_{\text{baseline}}$ vs HRVT ($r = 0.67$, 95% CI = 0.27 to 0.88, $P = 0.004$, $r^2 = 0.45$), and between $\ln\text{RMSSD}_{\text{baseline}}$ vs $\text{ISWT}_{\text{distance}}$ ($r = 0.73$, 95% CI = 0.37 to 0.90, $P = 0.001$, $r^2 = 0.53$) were observed, respectively. During the training period, a large correlation between $\ln\text{RMSSD}_{\text{baseline}}$ vs ITL ($r = 0.62$, 95% CI = 0.18 to 0.85, $P = 0.011$, $r^2 = 0.38$) was noticed. Finally, in response to training, a very large correlation between ITL vs individual changes in $\ln\text{RMSSD}$ ($r = 0.81$, 95% CI = 0.53 to 0.93, $P = 0.0001$, $r^2 = 0.65$) was observed, while no significant correlation between $\ln\text{RMSSD}_{\text{baseline}}$ vs individual change in $\ln\text{RMSSD}$ ($r = 0.33$, 95% CI = -0.19 to 0.71, *unclear*, $P = 0.206$, $r^2 = 0.11$) and between ETL and individual change in $\ln\text{RMSSD}$ ($r = 0.25$, 95% CI = -0.28 to 0.67, *unclear*, $P = 0.343$, $r^2 = 0.06$) were noted.

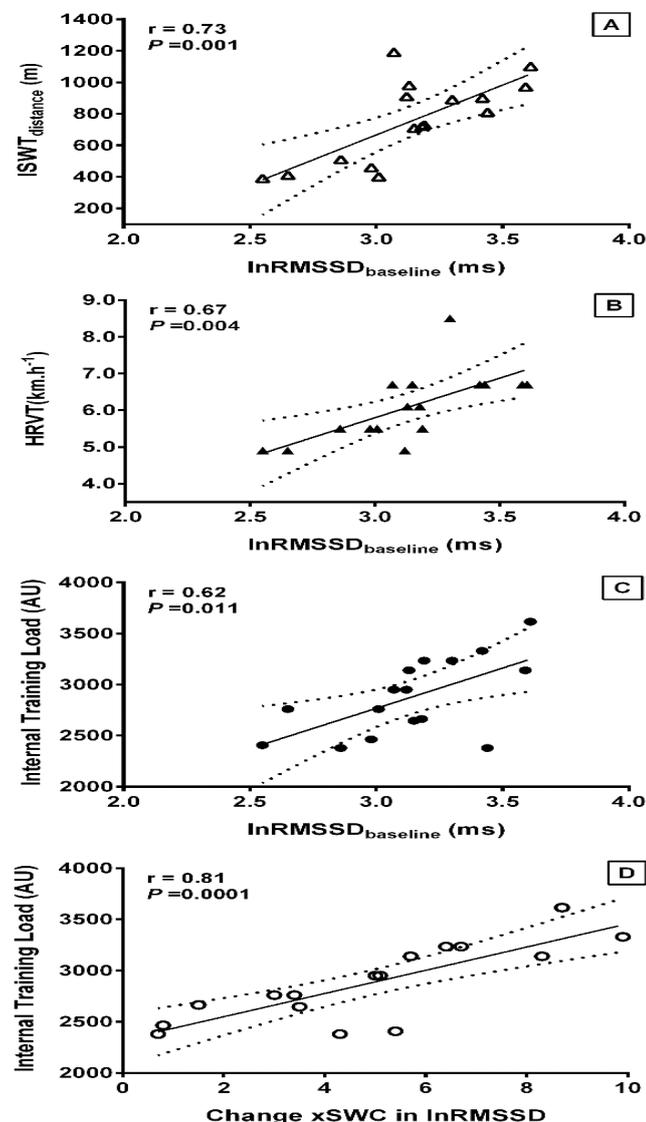


Figure 2. Result of individual values of correlation among $\text{ISWT}_{\text{distance}}$ and $\ln\text{RMSSD}_{\text{baseline}}$ (A, white triangles), HRVT and $\ln\text{RMSSD}_{\text{baseline}}$ (B, black triangles), $\ln\text{RMSSD}_{\text{baseline}}$ and ITL (C, black circle), ITL and individual SWC $\ln\text{RMSSD}$ after training (D, white circle). The dashed line represents the confidence interval at 95% and the continuous line represents the V-slope of the correlation between variables

Source: The authors

Discussion

The main aim of the present study was to investigate the relationship between ITL and changes in HRV in women submitted to a standardized training program based on their individual HRVT. The major findings in the present study were: 1) the strong association between the $\ln\text{RMSSD}_{\text{baseline}}$ and pre-training aerobic performance (i.e., HRVT and $\text{ISWT}_{\text{distance}}$), 2) the strong relationship between $\ln\text{RMSSD}_{\text{baseline}}$ and the potential to accumulate ITL during a standardized aerobic training program and, 3) the meaningful change in the group's mean HRV, which was very largely correlated with the accumulated ITL, but not to ETL.

In the present study, there were large positive correlations between $\ln\text{RMSSD}_{\text{baseline}}$ and HRVT ($r = 0.67$; $P < 0.05$), and between $\ln\text{RMSSD}_{\text{baseline}}$ and ISWT ($r = 0.73$; $P < 0.05$). The fact that higher individual $\ln\text{RMSSD}_{\text{baseline}}$ implies in higher HRVT (Figure 2B) likely explains why larger cardiovagal modulation at rest is associated with greater “mechanical work” during aerobic exercise (i.e, distance in meters or watts) guided by the HRVT intensity. Hypothetically, basal HRV might indicate the readiness to accumulate ETL during training sessions, possibly needing consideration prior to the onset of training. In fact, some studies have suggested that higher parasympathetic activity at baseline was associated with higher responsiveness to the cardiorespiratory fitness to training^{26,27}. The cardiovascular system of subjects with good vagal functioning may have a better capacity to adapt to various external stimuli (e.g., aerobic training) and this adaptive capacity may cause an improvement in overall cardiovascular performance¹⁴. Such hypothesis needs to be further addressed while prescribing training based on an exercise intensity determined by the withdrawal of vagal activity during progressive exercise (i.e., HRVT).

Larger distances covered by the participants during each training session was associated with greater sRPE. Accordingly, a progressive increase in sRPE was related to an increased distance walked during a 12-week training program in patients with chronic heart failure (CHF)¹. Furthermore, sRPE was also significantly correlated to the distance walked during the 6 minute walking test ($r = 0.85$). Therefore, more mechanical work in exercise seems to be related to an increased sRPE score. This is related to the fact that the sense of effort is centrally generated by forwarding neural signals, termed corollary discharges from motor to sensory areas of the cerebral cortex²⁸. Since ETL was guided by the HRVT, fitter participants who also possessed higher baseline vagal activity were capable of accumulating longer training distances (ranging between 29.455 to 51.515 meters in 12 sessions). Due to this greater accumulated “mechanical work”, sRPE (and ITL) was predictably higher in the participants with higher HRVT.

The change in $\ln\text{RMSSD}$ was significantly associated with ITL accumulated throughout the 12 aerobic training sessions during the 4-week period ($r = 0.62$ and 0.81 , respectively). This is a novel finding of our study. Previously, many investigations have reported significant relationships between accumulated ITL and increased VO_2max or performance^{2,18,29-31}. Of note, ITL is modulated by both intensity and duration of exercise and despite different content (high-intensity and short duration vs low-intensity and long duration), training responses may be identical when ITL is equated³². These results suggest that improvements in HRV by aerobic training are related to ITL, but in our case it was associated with the amount of ITL accumulated across the participants. It remains to be determined whether ITL is associated with changes in VO_2max and with changes in $\ln\text{RMSSD}$ in the same sample. In fact, previous studies have found significant correlations between changes in VO_2max /performance and changes in $\ln\text{RMSSD}$ ^{33,34}.

However, no significant correlation between individual ETL and individual change in $\ln\text{RMSSD}$ ($r = 0.25$, *unclear*) was noted. These results are probably related to the

standardization of training intensity based on individual HRVT of the subjects. Iellamo et al.⁹ ensured that total ITL was similar between groups (i.e. interval vs continuous aerobic training), without standardizing the “external” intensity. The ETL was adjusted every week to ensure similar ITL in both groups, therefore, the adaptations between groups were similar⁹. Ultimately, it is the ITL that determines the training outcome⁴. Indeed, it has already been demonstrated by Taylor et al.³⁵ that ITL (sRPE and TRIMP), but not ETL (total distance and high-speed distance $>18 \text{ km}\cdot\text{h}^{-1}$), was significantly correlated to improvements in aerobic fitness. These results are in agreement to our study, confirming the hypothesis that there would be a dose-response relationship between the ITL and cardiovagal modulation (i.e., higher ITL leading to higher lnRMSSD after training), but not with ETL. In practical terms, aerobic training prescription to women should consider more heavily the internal, perceptual responses to each training session than distances covered in order to foresee the training-related adaptations (fitness and HRV).

In this sense, increase in lnRMSSD is associated with high parasympathetic modulation, low sympathetic output and high fitness (Baynard et al., 2014; Hautala et al., 2009). A poor cardiovagal modulation (low lnRMSSD) has been associated with sleep disturbance, chronic fatigue, depression, chronic pain and increased risk of cardiovascular disease and mortality^{9,15,16}. The positive HRV change induced by training may be associated with a lower vagal withdrawal and/or less sympathetic-adrenal activation during rest¹¹. These adaptations are important to increase cardiopulmonary performance resulting in a cardio-protective effect, as well as improving physical fitness¹³.

Figure 1 showed individual comparisons among subjects regarding ITL and changes in lnRMSSD. This individual presentation of the data showed that subjects 6 and 15 presented trivial differences in HRV and lower ITL (2464 and 2379 AU) compared to the other subjects. It is common for individuals to show a wide range of responses to the same intervention^{14,36}. Subjects 6 and 15 were also the ones that presented lower ITL, referring to the fact that the same training can promote different ITL responses (i.e. subjects 8 and 11; 3616 and 3330 AU; respectively). It is common for individuals to show a wide range of responses to the same intervention^{14,36}. This phenomenon is typified by high responders and low responders (or high responsiveness and low responsiveness) to a standardized physical training intervention and may provide helpful insights into the mechanisms of training adaptation, as well as assisting with appropriate exercise prescription³⁶. Thus, the negative response found for lnRMSSD in the present study is attributed to the fact that these subjects perceive less ITL than the others (figure 2D, $r=0.81$, $P<0,05$) and thus might be exposed to sub-optimal loads.

In interpreting the results of this study, readers should take into account its inherent limitations. The current study cannot provide information on possible gender-related differences, since subjects involved in the study were healthy females. Therefore, the presented data should be analysed with caution when interpreting and applying the current results to other populations. In addition, the study did not compare different quantification methods of ITL (i.e. TRIMP, TRIMPi¹⁰(Manzi et al., 2009) or TLHRV³²). For these reasons, the link between different methods of internal training load and improvement in physical fitness in sedentary women should be further elucidated.

Conclusions

The results of the current study suggest that the significant improvement in HRV is related to the accumulated ITL during short-term aerobic training. In addition, there is a strong relationship between the baseline cardiovagal modulation and the ITL. This means that the identification of lnRMSSD at the beginning of the training program for this population may indicate to practitioners which subject may achieve higher performance in

aerobic test and subsequently sustain a higher ITL during the aerobic training program. These measurements of HRV can easily be assessed in a practical setting, without requiring expensive equipment and level of expertise.

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