

## Changes in mood state and recovery-stress perception after an HRV-guided running program in untrained women

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### Abstract

To determine the effects of HRV-guided running training on mood state and recovery-stress factors in untrained women. Thirty untrained women were randomized into two groups. The CG performed a pre-defined training program while the HRVG completed their running training regarding the intensity distribution according to the parasympathetic activity. The questionnaires of perception of recovery-stress and mood state were answered pre and post-training. The CG reported reduced emotional stress ( $-0.8 \pm 1.3$ ), conflicts/pressure ( $-0.8 \pm 0.8$ ), and increased sleep quality ( $0.9 \pm 1.1$ ), personal acceptance ( $0.9 \pm 1.6$ ), self-regulation ( $0.8 \pm 1.3$ ), specific recovery mean ( $0.6 \pm 0.9$ ), and total recovery mean ( $0.4 \pm 0.7$ ). The HRVG reported decreased general stress ( $-0.5 \pm 0.8$ ), emotional stress ( $-0.7 \pm 1.2$ ), social stress ( $-0.8 \pm 1.0$ ), lack of energy ( $-0.8 \pm 0.8$ ), general stress mean ( $-0.5 \pm 0.8$ ), and increased self-regulation ( $0.7 \pm 1.1$ ). This group also decreased tension ( $-2.8 \pm 3.7$ ), depression ( $-2.7 \pm 4.2$ ), anger ( $-2.8 \pm 4.4$ ) and fatigue ( $-2.7 \pm 3.7$ ) and TMD ( $-10.7 \pm 14.2$ ). HRVG reduced negative scales of mood state and stress factors that were not observed in the controls.

**Keywords:** Endurance; Parasympathetic Activity; Exercise

Heart rate variability (HRV) is a non-invasive measure related to autonomic nervous system activity that may be used to monitor training adaptations (Buchheit, 2014). Frequent measures ( $\geq 3$ -7 days/week) of HRV at rest is a potential tool to guide decisions related to training session intensity (Buchheit, 2014), since it accounts for the actual status of the runners' autonomic nervous system before the exercise. Moreover, there is some evidence that HRV guidance results in greater improvements in endurance running performance (Vesterinen et al., 2016). Although performance-related benefits have been demonstrated, there is a lack of information regarding the effects of HRV-guided training on mood state and perceptual stress-recovery responses.

Monitoring runners' perception of their training, in terms of stress and recovery, as well as their mood state changes with the training program, may serve as complementary information to physiological and performance adaptations and provide a deeper understanding of its holistic benefits (Halson, 2014). More importantly, greater improvements in psychological variables were also found to be associated with higher attendance rates to an exercise program (Annesi, 2004). Usually, these positive changes in psychological variables due to exercise could be explained by an inverted-U curve, since minimal/no exercise, as well as too intensive

exercise, may not produce any psychological benefit (Ekkekakis and Petruzzallo, 1999).

In addition, psychological variables, especially mood state, seem to be related to performance outcomes. Lane (2007) literature review identified studies in this field that contributed to the also known Lane and Terry (2000) conceptual model of mood state-performance interaction. This model hypothesized that the impact of anger and/or tension on performance were dependent on the relationship between these two scales with the depression scale (Lane and Terry, 2000). However, considering the chronic health-related benefits of aerobic exercise on psychological variables, it seems that this intervention is capable of reducing depression, anger, and fatigue (Petajan et al., 1996).

Stress-recovery factors and mood state may be important considerations for new female runners who are adopting a systematic training program for the first time since the running training is not necessarily the highest priority in their daily life and lack of recovery may hinder the future drive to participate. The number of recreational female runners participating in endurance events has increased in recent years, and so too has their performance (Cushman, Markert and Rho, 2014).

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As more women than ever are active members of the workforce, holding positions of great responsibility and leadership roles (Carli and Eagly, 2001), increased levels of stress in this population may be more closely associated with personal and work-related problems (Von Haaren et al., 2016). Negative personal/work events may increase stress levels and impair training routines (Otter, Brink, Diercks and Lemmink, 2016), which may lead to training attrition or attenuated responses to training stimuli. In this way, it might be particularly important to evaluate and ensure that training programs that women are engaged in do not contribute to, or compound other life stressors; otherwise, this might lead to less engagement or drop out altogether, mainly in long-term.

The purpose of guiding exercise training prescription according to autonomic cardiac regulation might contribute to improved stress profiles and is supported by the neurovisceral integration model (Thayer and Lane, 2000). Thayer and Lane (2000, 2009) developed this model considering the connection between heart and brain and proposed a consolidated functional/structural network associating neural structures, HRV, and psychological processes. According to them, HRV may be interpreted beyond its physiological significance alone, but act as a mediator of physiological and psychological processes (Thayer and Lane, 2009). HRV is considered a marker of autonomic nervous system activity, which is known to be involved in controlling our emotions. For instance, increased levels of anxiety and stress tend to reduce autonomic cardiac regulation (Meersman and Stein, 2007). Moreover, depression is strongly associated with mood changes and appears to influence the cardiovascular system via autonomic dysfunction (Grippio and Johnson, 2002). The treatment of depression symptoms with cognitive behavioural therapy increased the parasympathetic index of HRV called root Mean Squared of Successive Differences (rMSSD) in patients with cardiovascular disease (Carney et al., 2000). With that in mind, the use of questionnaires to track psychological changes related to an HRV-guided exercise training might add valuable and practical information for coaches and exercise professionals (Halson, 2014).

Thus, the objective of this study was to determine the effects of HRV-guided running training on mood state and recovery-stress factors in untrained women. We hypothesized that, an HRV-guided group, accounting for parasympathetic activity before the training session, would improve the psychological and stress-recovery perception more than the standardized pre-defined training group. The reason for that is the link between HRV and psychological processes previously suggested (Thayer and Lane, 2000, 2009).

## Method

### Participants

Thirty-six healthy women, aged 18-35 years, were recruited to participate in the study. The inclusion criteria are reported elsewhere (Da Silva, Ferraro, Adamo and Machado, 2019).

The reason for including women only is related to their greater interest for recreational endurance events in recent years (Cushman et al., 2014). As women are more active members of the workforce than ever (Carli and Eagly, 2001), interventions, such as exercise, are beneficial to improve psychological well-being, as levels of stress might be increased in this population due to personal and work-related issues (Craske and Stein, 2016).

The main aim of the study was explorative and was conducted to examine the effects of HRV-guided running training on psychological-related variables as it may provide new practical insights. *A priori* sample size calculation based on 80% power, a significance level of 5% and an effect size (ES) of 0.49 (derived from a pilot study; unpublished data) resulted in a minimal sample of 12 participants in each group (Da Silva et al., 2019).

The participants were informed about the risks and benefits of the study before signing an institutionally approved informed consent form (#409.162/2013 and #15/15E) and followed the declaration of Helsinki.

### Study design

The study protocol is described in Da Silva et al. (2019). Briefly, the study lasted 11 weeks, including assessments (weeks 1, 6 [for training prescription update], and 11) and eight weeks for the endurance running training program (weeks 2-5 and weeks 7-10). Previous HRV-guided training approaches had found that eight weeks of training (in addition to the assessments weeks) are sufficient to elicit benefits (Vesterinen et al., 2016; Kiviniemi et al., 2010).

Da Silva et al. (2019) aimed to provide the effects of HRV-guided running training on endurance performance markers (e.g., time to complete 5-km, peak treadmill running speed, time limit at peak treadmill running speed and parasympathetic activity). The results showed that HRV-guided running training improved time to complete 5-km and parasympathetic activity more than the control (non-HRV-guided group). A subset of published results from Da Silva et al. (2019) are shown here to demonstrate the importance of controlling the procedures followed (e.g., dietary habits, PMS frequency, types of exercise sessions frequency).

In the week after the baseline assessment, participants were randomly allocated in two training groups: 1) control group who trained with a pre-defined periodization (CG) (n=18) and 2) experimental group that was the HRV-guided group based on HRV responses before each session (HRVG) (n=18).

### Measures

Immediately after the end of the baseline assessment week and the post-training assessment week, participants were asked to complete two questionnaires related to their feelings over the past week: 1) The Profile of Mood State (POMS) (McNair, Lorr and Droppleman, 1971) and 2) The recovery-stress questionnaire (REST-Q) (Kellmann and Kallus, 2001). Both instruments have also been validated in Portuguese (Peluso, 2003; Costa and Samulski, 2005).

The POMS is a 65-item questionnaire developed to address six scales related to mood (tension, depression, anger, vigor, fatigue, and confusion). We opted to employ this instrument version to facilitate comparisons with other studies and follow recommendations from reviews related to monitoring training load and understanding fatigue in exercise/sports settings (Halson, 2014; Annesi, 2004). An additional overall score of total mood disturbance (TMD) is also calculated from the sum of the negative feelings minus the score of the vigor scale. To prevent a negative TMD score, a constant of 100 is added to the overall score. Each item is answered using a 5-point response scale that ranges from 0 (not at all) to 4 (extremely). A higher score corresponds to a stronger feeling (McNair et al., 1971). The internal consistency (*i.e.*, Cronbach's alpha) of the instrument varies from 0.73-0.90 for the Portuguese version of POMS questionnaire and from 0.84-0.95 for the English version depending on the scale (Costa and Samulski, 2005; McNair et al., 1971).

The REST-Q consists of 77 items on a 7-point response scale from 0 (never) to 6 (always) indicating how often one engaged in stress- and recovery-related activities in the past week. There are 12 general stress and recovery scales, as well as seven sport-specific scales (19 in total). Total stress and recovery-related scales are summed up and divided by the number of scales to provide a total stress and recovery score. General stress and recovery scores and sport-specific stress and recovery scores are also obtained (Kellmann and Kallus, 2001). The internal consistency (*i.e.*, Cronbach's alpha) of the REST-Q ranges from 0.58-0.85 in the Portuguese version and from 0.67-0.89 in the English version (Costa and Samulski, 2005). Only the scales "conflicts/pressure", "success", and "personal acceptance" scored below 0.70 in the Portuguese version, which is in accordance with the English version of the questionnaire (Kellmann and Kallus, 2001).

We assessed habitual diet through three, 24-hour dietary recalls and daily information regarding emotional and physical symptoms associated with pre-menstrual syndrome (PMS) (American College of Obstetricians and Gynecologist, 2000) during assessment weeks 1 and 11 to ensure that any variation would be accounted for in the analysis as covariates (Da Silva et al., 2019). Knowing that macronutrients, such as carbohydrate intake, are known to influence exercise performance and possibly HRV, we assessed habitual diet (Lima-Silva et al., 2010). Moreover, because of the controversies in the literature regarding hormonal fluctuation and its effects or not on HRV (Leitch, Hirning and Allen, 2003), we felt it necessary to measure and account for the presence of PMS. Nonetheless, controlling for these variables was an important step for Da Silva et al. (2019) study focussing on exercise performance and HRV, as previously mentioned.

## Procedure

Details of the training program can be found elsewhere (Da Silva et al., 2019), but in brief, the training sessions were performed three times per week and the same principles of

exercise prescription were followed in both CG and HRVG to allow comparisons. The guidance approach may lead to differences in the amount of each type of training session between CG and HRVG, which was previously observed in other studies (Vesterinen et al., 2016). However, we observed that this difference is very small (*e.g.*, roughly three sessions in total), and they were not associated with performance changes (Da Silva et al., 2019).

The training prescription was based on assessments of peak treadmill running speed (Machado, Kravchychyn, Peserico, Da Silva and Mezzaroba, 2013) according to a maximal incremental test and its time limit. Two types of training sessions were performed: 1) moderate-intensity continuous training (MICT) = continuous run at  $75 \pm 4\%$  of the peak running speed; 2) high-intensity interval training (HIIT) =  $X$  bouts of  $Y$  minutes at  $100 \pm 2\%$  of the peak running speed +  $Y$  minutes at passive recovery. The "Y" was determined as 60% of the time limit at peak treadmill running speed and "X" was the possible amount of bouts in a given training duration (Da Silva et al., 2019). The first two sessions were a MICT followed by a HIIT regardless of the experimental group to allow familiarization with the intensities required.

Training loads for each session were monitored throughout the protocol by session-rating of perceived exertion (Foster, 1998). The period between weeks 2 to 5 had the following characteristics: 10-15 min of warm-up + 30 min of the main activity of the session [MICT or HIIT] + 10-15 min of cooling down. From weeks 7 to 10, the characteristics were the following: 10-15 min of warm-up + 40 min of the main part [MICT or HIIT] + 10-15 min of cooling down.

**Control group running training.** The CG performed alternated MICT and HIIT throughout the protocol (50% each). Thus, in weeks 2, 4, 7 and 9 they performed 2 MICT and 1 HIIT and in weeks 3, 5, 8 and 10, 2 HIIT and 1 MICT.

**HRV-guided group running training.** During the baseline week (week 1), HRV at rest was measure over 5 minutes (2 minutes seated+3 minutes in the standing position) (Kiviniemi et al., 2010) at three different visits in the moment of the day in which the training sessions would be performed. Additionally, before the first MICT and HIIT, this measurement was conducted again. A heart rate monitor was used (RS800cx, Polar, Kempele, Finland), as it was previously validated for this purpose (Williams et al., 2016). Rate-to-rate intervals data expressed in milliseconds were transferred for the software (Polar Pro Trainer®) and analyzed by Kubios HRV analysis software® (Biosignal Analysis and Medical Imaging Group at the Department of Applied Physics, University of Eastern Finland, Kuopio, Finland). Outliers associated with ectopic, missed, or aberrant values were excluded, as previously recommended (Cipryan, Laursen and Plews, 2015; Buchheit, 2014). The parasympathetic index rMSSD was determined as mean and standard deviation (SD) of these five initial measures. Following this, training intensities were guided according to the comparison of the latest value of rMSSD (before training

session) and the mean of the previous values±SD until 10 measures were accumulated. After that, the oldest measured was always excluded (Kiviniemi et al., 2010).

We considered attenuated parasympathetic activity in cases when current value was > 1 SD below the mean of the previous measures. On these occasions, a MICT was prescribed. If not, the training session was HIIT (Kiviniemi et al., 2010).

**Statistical analysis**

The results are shown as means±SD. The normality of the data was assessed with the Shapiro–Wilk test. Group comparisons at baseline were performed using *t*-test for independent samples (normally distributed data) or Mann-Whitney tests (non-normally distributed data) and Pearson Chi-Square for continuous and categorical variables, respectively. The changes in the mood state and perception of stress-recovery after the training was examined using mixed repeated measures ANOVA followed by a Bonferroni post-hoc test. When a between-group baseline difference was observed, we used the appropriate baseline measure as a covariate in the analysis (mixed repeated measures ANCOVA) (Vickers and Altman, 2001). Statistical significance was set at *P* < 0.05. Also, Effect Sizes (ES) (Cohen, 1988) were calculated to express the magnitudes of changes after training (Hedges’ *g<sub>m</sub>*) and differences between groups (Hedges’ *g*). The threshold values for ES were: < 0.2 (trivial), 0.2 - < 0.6 (small), 0.6 to < 1.2 (moderate), ≥ 1.2 (large) (Hopkins, Marshall, Batterham and Hanin, 2009).

**Results**

Six participants dropped out during the study (n = 3/group). Drop out were related to personal issues and not related to

the study protocol or the training program itself. For the 30 participants who remained (15 each group), there were no differences in age (27.7±3.6 years for CG and 25.8±3.1 years for the HRVG; *P* = 0.145). No between-group differences were found for the frequency of completed training session during the protocol, as well as for mean training loads of MICT and HIIT. However, the amount of MICT was higher in the CG compared to the HRVG.

Dietary habits were not different between-groups at either the week 1 or week 11 time points. Moreover, no within-group difference was found for these variables. We also did not find differences in the frequency of women who presented symptoms related to the PMS between groups (*P* = 0.464), as previously described (Da Silva et al., 2019).

**General stress scales and general stress mean**

No between-group differences were observed for these scales at baseline. There was a time effect for general stress scale ( $F_{1,11} = 4.676$ ; *P* = 0.039), emotional stress ( $F_{1,11} = 10.271$ ; *P* = 0.003), social stress ( $F_{1,11} = 11.243$ ; *P* = 0.002), conflicts/pressure ( $F_{1,11} = 7.604$ ; *P* = 0.010), lack of energy ( $F_{1,11} = 11.142$ ; *P* = 0.002) and general stress mean (*i.e.*, combination of the stress scales) ( $F_{1,11} = 9.511$ ; *P* = 0.005). After adjusting for multiple comparisons, we found a significant decrease in general (-0.5±0.8; *P* = 0.038), emotional (-0.7±1.2; *P* = 0.046), and social stress (-0.8±1.0; *P* = 0.008), lack of energy (-0.8±0.8; *P* = 0.003) and general stress mean (-0.5±0.8; *P* = 0.032) for those in the HRVG. The CG saw a reduction in emotional stress (-0.8±1.3; *P* = 0.034) and conflicts/pressure (-0.8±0.8; *P* = 0.003) (Table 1). Figure 1 presents within-group ES for these scales.

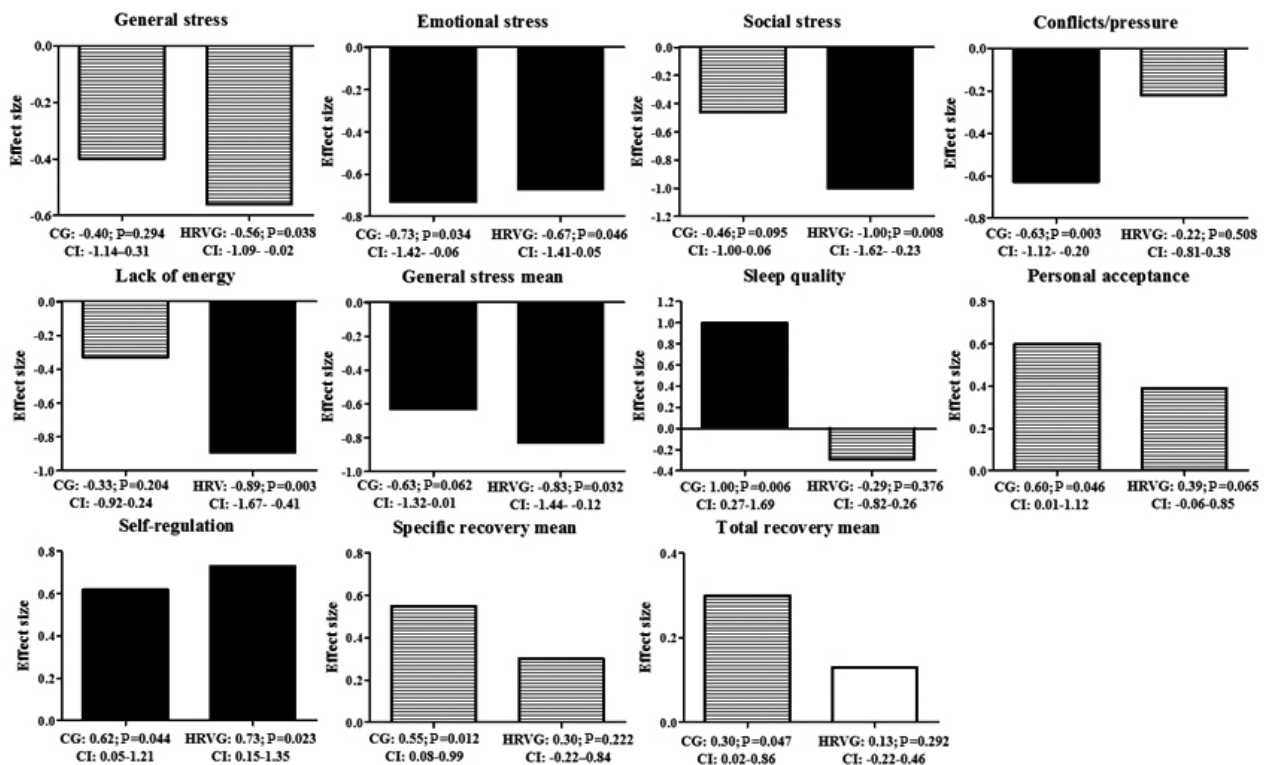
**Table 1.**

General stress scales and general stress mean from REST-Q before (week 1) and after (week 11) the running training program in CG and HRVG. Values are means±SD.

| Variable            | CG (n = 15) |          |                  | HRVG (n = 15) |         |                  | ES (HRVG vs CG) |
|---------------------|-------------|----------|------------------|---------------|---------|------------------|-----------------|
|                     | Week 1      | Week 11  | Variation (11-1) | Week 1        | Week 11 | Variation (11-1) |                 |
| General stress      | 1.5±1.0     | 1.1±0.9  | -0.4±1.3         | 1.6±1.1       | 1.1±0.6 | -0.5±0.8*        | -0.09 (trivial) |
| Emotional stress    | 2.0±1.2     | 1.2± 0.9 | -0.8±1.3*        | 2.0±1.0       | 1.4±0.7 | -0.7±1.2*        | 0.08 (trivial)  |
| Social stress       | 1.7±1.4     | 1.1±1.1  | -0.6±1.2         | 1.6±1.1       | 0.8±0.5 | -0.8±1.0*        | -0.18 (trivial) |
| Conflicts/pressure  | 2.9±1.1     | 2.2±1.0  | -0.8±0.8*        | 2.9±1.2       | 2.7±0.5 | -0.2±1.0         | 0.65 (moderate) |
| Fatigue             | 2.5±1.0     | 2.2±1.1  | -0.3±1.1         | 2.2±1.2       | 2.1±0.8 | -0.1±1.5         | 0.15 (trivial)  |
| Lack of energy      | 1.9±0.7     | 1.6±1.0  | -0.4±1.0         | 2.2±1.0       | 1.4±0.8 | -0.8±0.8*        | -0.43 (small)   |
| Physical complaints | 1.8±1.0     | 1.5±1.0  | -0.3±1.6         | 2.1±0.8       | 1.8±0.7 | -0.3±0.8         | 0 (trivial)     |
| General stress mean | 2.0±0.8     | 1.5 ±0.7 | -0.5±0.9         | 2.1±0.8       | 1.6±0.4 | -0.5±0.8*        | 0 (trivial)     |

Note. CG = control group; HRVG = HRV-guided group; ES = effect size. \**P* < 0.05 for the absolute variation between weeks 1 and 11.





**Figure 1.** Pre vs. Post effect sizes, confidence intervals and significance levels for the variables that changed after the training program in REST-Q questionnaire. Note: CG = control group; HRVG = HRV-guided group; CI = confidence interval for ES. The white, lined and black bars represent trivial, small and moderate effect sizes, respectively.

**General recovery scales and general recovery mean**

We found a between-group difference only for sleep quality at the baseline (CG: 3.1±1.0; HRVG: 4.2±0.6), thus this baseline value was included in the analysis of variance as a covariate. There was an interaction between

the covariate x time ( $F_{1,11} = 16.423; P < 0.001$ ) and a time effect ( $F_{1,11} = 20.550; P < 0.001$ ). Adjustment for multiple comparisons showed that sleep quality was increased in the CG only ( $0.9±1.1; P = 0.006$ ) (Table 2), with a moderate ES between week 1 and week 11 (Figure 1).

**Table 2.**

General recovery scales and general recovery mean from REST-Q before (week 1) and after (week 11) the running training program in CG and HRVG. Values are means±SD.

| Variable              | CG (n = 15) |         |                  | HRVG (n = 15) |         |                  | ES (HRVG vs CG)  |
|-----------------------|-------------|---------|------------------|---------------|---------|------------------|------------------|
|                       | Week 1      | Week 11 | Variation (11-1) | Week 1        | Week 11 | Variation (11-1) |                  |
| Success               | 3.3±1.0     | 3.3±1.2 | -0.1±1.1         | 3.2±0.7       | 3.1±0.9 | -0.1±0.7         | 0 (trivial)      |
| Social recovery       | 3.6±1.3     | 3.4±1.3 | -0.2±1.0         | 3.4±0.9       | 3.7±0.9 | 0.3±0.7          | 0.54 (small)     |
| Physical recovery     | 3.0±0.8     | 3.1±1.4 | 0.0±1.2          | 3.3±1.3       | 3.2±1.1 | -0.1±0.8         | 0.11 (trivial)   |
| General well-being    | 3.8±1.1     | 3.8±1.1 | 0.1±0.9          | 3.8±1.1       | 3.8±0.9 | 0.0±0.8          | -0.10 (trivial)  |
| Sleep quality         | 3.1±1.0     | 4.0±0.8 | 0.9±1.1*         | 4.2±0.6       | 4.0±0.8 | -0.2±0.8         | -1.07 (moderate) |
| General recovery mean | 3.4±0.8     | 3.5±1.0 | 0.2±0.7          | 3.6±0.7       | 3.6±0.8 | 0.0±0.5          | -0.32 (small)    |

Note. CG = control group; HRVG = HRV-guided group; ES = effect size. \* $P < 0.05$  for the absolute variation between weeks 1 and 11.

**Specific stress and recovery scales, specific and total stress mean and specific and total recovery mean**

We did not observe any baseline between-group differences in the specific or total scales. There was a time effect on personal acceptance ( $F_{1,11} = 8.790; P = 0.006$ ), self-regulation ( $F_{1,11} = 11.186; P = 0.002$ ), specific recovery mean ( $F_{1,11} = 8.165; P = 0.008$ ) and total recovery mean ( $F_{1,11} = 5.748;$

$P = 0.023$ ). After adjusting for multiple comparisons, we found that self-regulation increased in both HRVG ( $0.7 \pm 1.1; P = 0.023$ ) and CG ( $0.8 \pm 1.3; P = 0.044$ ). The CG also increased personal acceptance ( $0.9 \pm 1.6; P = 0.046$ ), specific recovery mean ( $0.6 \pm 0.9; P = 0.012$ ), and total recovery mean ( $0.4 \pm 0.7; P = 0.047$ ) (Table 3). The within-group ES is presented in Figure 1.

**Table 3.**

*Specific stress and recovery scales, specific and total stress mean and specific and total recovery mean from REST-Q before (week 1) and after (week 11) the running training program in CG and HRVG. Values are means  $\pm$  SD.*

| Variable               | CG (n = 15)   |               |                  | HRVG (n = 15) |               |                  | ES (HRVG vs CG) |
|------------------------|---------------|---------------|------------------|---------------|---------------|------------------|-----------------|
|                        | Week 1        | Week 11       | Variation (11-1) | Week 1        | Week 11       | Variation (11-1) |                 |
| Disturbed breaks       | 1.3 $\pm$ 1.1 | 1.2 $\pm$ 1.0 | -0.2 $\pm$ 1.2   | 1.1 $\pm$ 0.7 | 1.5 $\pm$ 0.9 | 0.4 $\pm$ 1.2    | 0.50 (small)    |
| Injuries               | 1.9 $\pm$ 1.1 | 2.2 $\pm$ 1.6 | 0.4 $\pm$ 1.9    | 1.9 $\pm$ 1.2 | 2.0 $\pm$ 0.9 | 0.1 $\pm$ 1.6    | 0.17 (trivial)  |
| Emotional exhaustion   | 1.0 $\pm$ 0.8 | 0.8 $\pm$ 0.7 | -0.2 $\pm$ 0.9   | 1.1 $\pm$ 0.9 | 1.2 $\pm$ 0.8 | 0.2 $\pm$ 1.3    | 0.36 (small)    |
| Specific stress mean   | 1.4 $\pm$ 0.8 | 1.4 $\pm$ 1.0 | 0.0 $\pm$ 1.1    | 1.3 $\pm$ 0.7 | 1.6 $\pm$ 0.6 | 0.2 $\pm$ 1.1    | 0.17 (trivial)  |
| Total stress mean      | 1.8 $\pm$ 0.8 | 1.5 $\pm$ 0.7 | -0.3 $\pm$ 0.9   | 1.9 $\pm$ 0.7 | 1.6 $\pm$ 0.4 | -0.3 $\pm$ 0.7   | 0 (trivial)     |
| Being in shape         | 3.3 $\pm$ 1.0 | 3.5 $\pm$ 1.3 | 0.3 $\pm$ 1.2    | 3.5 $\pm$ 1.0 | 3.4 $\pm$ 0.9 | -0.1 $\pm$ 1.1   | -0.32 (small)   |
| Personal acceptance    | 2.8 $\pm$ 1.7 | 3.7 $\pm$ 1.4 | 0.9 $\pm$ 1.6*   | 2.6 $\pm$ 1.7 | 3.3 $\pm$ 1.8 | 0.8 $\pm$ 1.5    | -0.06 (trivial) |
| Self-efficacy          | 3.0 $\pm$ 1.3 | 3.6 $\pm$ 1.0 | 0.7 $\pm$ 1.2    | 3.2 $\pm$ 1.1 | 3.2 $\pm$ 1.1 | -0.1 $\pm$ 1.7   | -0.52 (small)   |
| Self-regulation        | 3.3 $\pm$ 1.3 | 4.1 $\pm$ 1.2 | 0.8 $\pm$ 1.3*   | 3.1 $\pm$ 1.0 | 3.9 $\pm$ 1.1 | 0.7 $\pm$ 1.1*   | -0.17 (trivial) |
| Specific recovery mean | 3.1 $\pm$ 1.2 | 3.7 $\pm$ 1.0 | 0.6 $\pm$ 0.9*   | 3.1 $\pm$ 0.9 | 3.4 $\pm$ 1.0 | 0.3 $\pm$ 1.0    | -0.29 (small)   |
| Total recovery mean    | 3.2 $\pm$ 0.9 | 3.6 $\pm$ 0.9 | 0.4 $\pm$ 0.7*   | 3.4 $\pm$ 0.7 | 3.5 $\pm$ 0.9 | 0.1 $\pm$ 0.5    | -0.49 (small)   |

Note. CG = control group; HRVG = HRV-guided group; ES = effect size.

\* $P < 0.05$  for the absolute variation between weeks 1 and 11.

**Mood state scales**

No between-group differences were noted at baseline. We found a time effect for tension ( $F_{1,11} = 6.559; P = 0.016$ ), depression ( $F_{1,11} = 10.305; P = 0.003$ ), anger ( $F_{1,11} = 8.820; P = 0.006$ ), fatigue ( $F_{1,11} = 10.956; P = 0.003$ ), vigor ( $F_{1,11} = 7.870; P = 0.009$ ) and total mood disturbance ( $F_{1,11} = 9.710; P = 0.004$ ). The adjustment for multiple comparisons indicated that the CG saw a reduction in vigor from week 1

and week 11 ( $-1.9 \pm 3.1; P = 0.030$ ). On the other hand, the HRVG reduced tension ( $-2.8 \pm 3.7; P = 0.011$ ), depression ( $-2.7 \pm 4.2; P = 0.027$ ), anger ( $-2.8 \pm 4.4; P = 0.026$ ), fatigue ( $-2.7 \pm 3.7; P = 0.015$ ), and total mood disturbance ( $-10.7 \pm 14.2; P = 0.011$ ) (Table 4).

Figure 2 presents the within-group ES for the mood state scales.

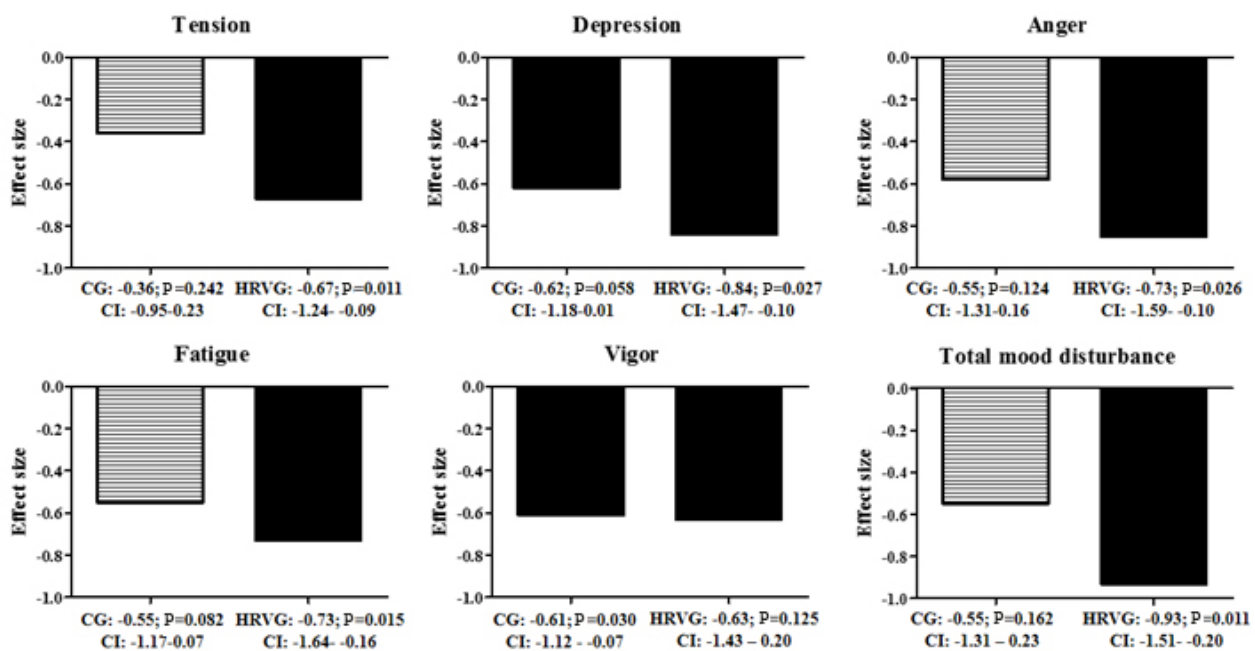
**Table 4.**

Mood state scales from POMS before (week 1) and after (week 11) the running training program in CG and HRVG. Values are means±SD.

| Variable               | CG (n=15) |           |                  | HRVG (n=15) |           |                  | ES (HRVG vs CG) |
|------------------------|-----------|-----------|------------------|-------------|-----------|------------------|-----------------|
|                        | Week 1    | Week 11   | Variation (11-1) | Week 1      | Week 11   | Variation (11-1) |                 |
| Tension                | 5.9±5.4   | 3.9±5.5   | -1.9±6.1         | 6.1±5.1     | 3.3±2.2   | -2.8±3.7*        | -0.18 (trivial) |
| Depression             | 5.0±3.0   | 3.3±2.7   | -1.7±3.1         | 4.9±4.3     | 2.2±2.1   | -2.7±4.2*        | -0.26 (small)   |
| Angry                  | 9.7±2.5   | 8.3±2.3   | -1.4±3.3         | 9.7±3.6     | 6.9±2.9   | -2.8±4.4*        | -0.35 (small)   |
| Fatigue                | 8.7±3.0   | 7.1±2.7   | -1.6±3.3         | 7.9±3.5     | 5.3±2.0   | -2.7±3.7*        | -0.30 (small)   |
| Confusion              | 8.4±3.2   | 7.8±2.4   | -0.6±3.7         | 9.1±2.8     | 7.8±2.0   | -1.3±3.6         | -0.18 (trivial) |
| Vigor                  | 8.9±3.6   | 6.9±3.0   | -1.9±3.1*        | 9.1±2.4     | 7.6±2.4   | -1.5±3.6         | 0.12 (trivial)  |
| Total mood disturbance | 128.7±9.9 | 123.5±9.0 | -5.3±13.8        | 128.5±16.3  | 117.8±6.6 | -10.7±14.2*      | -0.38 (small)   |

Note. CG = control group; HRVG = HRV-guided group; ES = effect size.

\*P < 0.05 for the absolute variation between weeks 1 and 11.



**Figure 2.** Pre vs. Post effect sizes, confidence intervals and significance levels for the variables that presented significant changes after the training program in POMS questionnaire. Note: CG = control group; HRVG = HRV-guided group; CI = confidence intervals. The lined and black bars represent small and moderate effect sizes, respectively.

## Discussion

The main findings were that engagement in the HRVG decreased general stress, emotional stress, social stress, lack of energy, general stress mean, and increased self-regulation. Moreover, HRVG improved tension, depression, anger, and fatigue scales of mood state, as well as decreased

total mood disturbance. While, standardized training (CG) significantly reduced emotional stress, conflicts/pressure, and increased sleep quality, personal acceptance, self-regulation, specific recovery mean, and total recovery mean. The HRVG presented larger ES in the week 1 vs. week 11 comparison than the CG for six variables (social stress, lack of energy, tension, anger, fatigue, and total mood

disturbance), while the CG presented larger ES only for three variables (conflicts/pressure, sleep quality, and total recovery mean). Each strategy for training prescription influenced different aspects of mood state and perception of recovery-stress factors, but HRVG resulted in more improvements.

The HRV-guided strategy has some interesting aspects that could be psychologically beneficial for untrained women who are first engaging in systematic exercise training. Women tend to be more anxious than men (Craske and Stein, 2016), and it may increase their stress levels, especially for something that is new in their routines. Since HRV responses may be considered as a stress level outcome (Buchheit, 2014), its application as a tool to control the distribution of training intensity throughout a training program could contribute to better psychological outcomes than standardized pre-defined training distribution.

In fact, according to the neurovisceral integration model, the HRV may be interpreted beyond its physiological significance and act as a mediator between physiological and psychological processes (Thayer and Lane, 2009). The HRV is a non-invasive indication of the autonomic nervous system activity and is responsible for cognitive/emotional control measures related to voluntary actions performed according to the environmental demands (*i.e.*, situation in which the individual is exposed during the day) (Thayer and Lane, 2009). These aspects may be why individuals with significantly higher current levels of anxiety and stress tend to present reduced HRV (Meersman and Stein, 2007). Thus, a pre-training session resting HRV measure seemed to indicate to the coach information about the individual that can be accounted for deciding running training intensity.

To test whether or not HRV would help improve psychological outcomes, we needed to use appropriate tools/variables for monitoring changes after training. According to Halson (2014), the use of POMS and REST-Q questionnaires is recommended to better understanding exercise training effects. In the present study, stress-related perceptions decreased significantly in HRVG only, such as general stress, social stress, lack of energy, and general stress mean. These are all domains where a decrease is considered good, as they are all stress-related. Besides, the HRVG training also resulted in improved levels of tension, depression, anger, fatigue, and total mood disturbance. The perceived stress in the routine has different origins, and the balance of positive and negative feelings is a key component in the daily life that influences stress levels (Otter et al., 2016). We believe this balance is a factor contributing to positive changes in aspects measured by both instruments in those participating in the HRVG.

Lane and Terry (2000) conceptual model based on mood states assessed by POMS shows that depression moderates the association between tension/anger with performance. In this way, being more depressed would lead to a negative association between anger/tension

with performance and being less depressed, would lead to a positive association between anger/tension with performance. Interestingly, as mentioned previously, the HRVG reduced depression and improved performance (Da Silva et al., 2019). However, anger and tension also reduced in the HRVG. It worth mentioning that the psychological variables were not measured before the performance *per se*, and they represented the mood state for the assessment week. Adding to Lane and Terry (2000) model, it seems that the increased anger and/or tension are more immediately important for performance just before it occurs, and less of these negative feelings in the week before the event occurs might be beneficial, as aerobic exercise can reduce anger (Petajan et al., 1996).

Even though the HRVG group showed greater improvements on stress-related scales and mood state than the CG, additional improvements were noted in this group as well. For instance, some recovery scales and conflicts/pressure were improved in CG only. The CG increased sleep quality, personal acceptance, self-regulation, specific, and total recovery mean. The outcomes for conflicts/pressure and personal acceptance should be seen with caution, because they did not present satisfactory scores for internal consistency in the English and Portuguese REST-Q versions (ranges from 0.58 to 0.85 in the Portuguese version and from 0.67 to 0.89 in the English version). Both conflicts/pressure and personal acceptance are dependent on participants' characteristics and may present lower reliability for individual sports than for team sports since the questions are related to problems with colleagues in the sport (Kellmann and Kallus, 2001; Costa and Samulski, 2005).

The improvement in sleep quality in the CG was a relevant finding. Sleep is an important component of habitual routines given the potential negative impact sleep quality could have on training (Halson, 2014). However, it is important to mention that the CG began the training program with lower sleep quality than the HRVG, and by the end of the training protocol both groups were at similar levels, suggesting a ceiling effect was reached for the CG. In this case, the ceiling is based on the highest scores observed in the literature for this domain in different populations including cyclists, female tennis players, and non-athletes (Filho et al., 2015; Filaire, Ferreira, Oliveira and Massart, 2013; Cortis, Tessitore, Meeusen and Capranica, 2010), in which the scores are usually close to 4 (*i.e.*,  $4.0 \pm 0.8$  in both HRVG and CG).

Self-regulation is a factor that plays an essential role in maintaining good mental, and physical health (Filho et al., 2015), and this specific recovery scale increased in both groups, with similar ES. We interpreted this to mean that the participants of the study have psychosocially increased stress and recovery regulation (Kellmann and Kallus, 2001). In the long-term, this could contribute to keeping them engaged in the training; however, future studies are necessary to fully characterize these relationships.



Fatigue, defined as a lower energy level in which the individual presents signs of tiredness, exhaustion, and apathy, which is associated with a perturbation of the steady state of the internal environment (Ament and Verkenke, 2009). Women in the HRVG reported lower levels of fatigue, as measured by POMS. It worth pointing out that fatigue is not the direct opposite of vigor, as the feelings involving in their description are not necessarily opposing each other (*e.g.*, lively, cheerful for vigor; worn-out, listless for fatigue) and they present relatively different internal consistency (McNair et al., 1971). Despite the HRVG performed more HIIT, their feelings of fatigue were decreased after the training, corroborating the idea that HRV-guided training may moderate perceived fatigue across the training program (Kiviniemi et al., 2010). Previously, participants with greater reduction in fatigue score presented significantly higher attendance rates in an exercise training program (Annesi, 2004), thus it is possible to speculate that HRV-guided training could result in greater long-term exercise compliance.

The noted improvements in the scales assessing tension, depression and anger in the HRVG demonstrated the potential protective effect of exercise against negative mood changes, as well as symptoms of depression and anxiety (Salmon, 2001) and the role of individually-guided exercise prescription in individuals with low fitness level. The scales related to tension, depression and anger are associated with high somatic tension and involve psychomotor reflexes (*e.g.*, restlessness), personal inadequacy, and apathy connected to herself and others. Similar to the fatigue scale, Annesi (2004) also showed that greater reduction in tension and depression scores led to higher adherence to the program.

Apart from the contributions, the present study also presents limitations. Although we measured resting HRV before each training session, to minimize issues identified in previous studies in which HRV was taken by the participant at home (Kiviniemi et al., 2010), this may introduce psychophysiological effects. To minimize this, we enhanced comfort and familiarization of the participant with a familiarization meeting. Also, the questionnaires measure psychometric properties related to feelings and perceptions that can be modified by factors other than the exercise program (*e.g.*, work or family issues). To reduce factors associated with these other issues, the questionnaires were administered under similar circumstances and in the same context at the baseline and post-training assessment periods. We did not follow up with the participants after

completing the study to assess if changes in psychological variables were associated with long-term adherence and compliance to the running training program, thus higher compliance was only a speculation based on previous findings combined to ours (Annesi, 2004). Perhaps these results were only applicable to those undertaking a systematic training program for the first time. We recommend this topic for future investigations.

## Conclusions

We concluded that HRV-guided running training reduced tension, depression, anger, fatigue, and total mood disturbance scales of mood state, and stress factors of the recovery-stress questionnaire that were not observed in the CG. Greater effect sizes were found in the HRVG than in the CG for six variables, while the CG had greater effects only for three variables. These outcomes have important practical implications and suggest that an individualized approach for training periodization may benefit mood state and stress-related factors, even in untrained women who embark on a guided running program. These results cannot be generalized to different sports and/or exercises as people have different preferences with some disliking the monotonous nature of running. Thus, future studies should also look into the effects of HRV guidance in other sports/exercises.

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## Cambios en el estado de ánimo y la percepción del estrés de recuperación después de un programa de carrera guiado por HRV en mujeres sin entrenamiento

### Resumen:

Determinar los efectos del entrenamiento de carrera guiado por la VFC sobre el estado de ánimo y los factores de recuperación-estrés en mujeres no entrenadas. Treinta mujeres sin entrenamiento fueron separadas en dos grupos al azar. El GC realizó un programa de entrenamiento predefinido, mientras que el GVFC completó su entrenamiento de carrera con respecto a la distribución de intensidad según la actividad parasimpática. Los cuestionarios de percepción de recu-

peración-estrés y estado de ánimo se respondieron antes y después del entrenamiento. El GC presentó una reducción del estrés emocional ( $-0,8\pm 1,3$ ), conflictos / presión ( $-0,8\pm 0,8$ ) y una mayor calidad del sueño ( $0,9\pm 1,1$ ), aceptación personal ( $0,9\pm 1,6$ ), autorregulación ( $0,8\pm 1,3$ ), media de recuperación específica ( $0,6\pm 0,9$ ) y media de recuperación total ( $0,4\pm 0,7$ ). El GVFC presentó una disminución del estrés general ( $-0,5\pm 0,8$ ), estrés emocional ( $-0,7\pm 1,2$ ), estrés social ( $-0,8\pm 1,0$ ), falta de energía ( $-0,8\pm 0,8$ ), media de estrés general ( $-0,5\pm 0,8$ ), y aumento de la autorregulación ( $0,7\pm 1,1$ ). Hubo disminución de la tensión ( $-2,8\pm 3,7$ ), depresión ( $-2,7\pm 4,2$ ), ira ( $-2,8\pm 4,4$ ), fatiga ( $-2,7\pm 3,7$ ) y TAT ( $-10,7\pm 14,2$ ) en el GVFC. El GVFC mejoró el estado de ánimo y factores de estrés que no se observaron en los controles.

**Palabras clave:** resistencia; actividad parasimpática; ejercicio

### **Alterações no estado de humor e na percepção do estresse na recuperação após um programa de corrida guiada pela VFC em mulheres não treinadas**

#### **Resumo:**

Determinar os efeitos do treinamento de corrida guiado pela VFC sobre o estado de humor e fatores de recuperação-estresse em mulheres não-treinadas. Trinta mulheres não-treinadas foram randomizadas em dois grupos. O GC realizou um programa de treinamento pré-definido, enquanto que o GVFC completou seu treinamento de corrida no que diz respeito à distribuição das intensidade segundo a atividade parasimpática. Os questionários de percepção da recuperação-estresse e estado de humor foram respondidos antes e após o programa de treinamento. O GC apresentou redução do estresse emocional ( $-0,8\pm 1,3$ ), conflitos/pressão ( $-0,8\pm 0,8$ ) e uma maior qualidade do sono ( $0,9\pm 1,1$ ), aceitação pessoal ( $0,9\pm 1,6$ ), auto-regulação ( $0,8\pm 1,3$ ), média da recuperação específica ( $0,6\pm 0,9$ ) e média da recuperação total ( $0,4\pm 0,7$ ). O GVFC apresentou diminuição do estresse geral ( $-0,5\pm 0,8$ ), estresse emocional ( $-0,7\pm 1,2$ ), estresse social ( $-0,8\pm 1,0$ ), falta de energia ( $-0,8\pm 0,8$ ), média do estresse geral ( $-0,5\pm 0,8$ ), e aumento da auto-regulação ( $0,7\pm 1,1$ ). Houve diminuição da tensão ( $-2,8\pm 3,7$ ), depressão ( $-2,7\pm 4,2$ ), raiva ( $-2,8\pm 4,4$ ), fadiga ( $-2,7\pm 3,7$ ) e THT ( $-10,7\pm 14,2$ ) no GVFC. O GVFC reduziu as escalas negativas de humor e fatores de estresse que não foram observados nos controles.

**Palavras-chave:** resistência; atividade parasimpática; exercício.

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