©Journal of Sports Science and Medicine (2017) **16,** 498-504
http://www.jssm.org

Research article

Influence of Competitive-Anxiety on Heart Rate Variability in Swimmers

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Abstract
The aim of this study was to analyze the relationship between competitive anxiety and heart rate variability (HRV) in swimming athletes. A total of 66 volunteers (41 male and 27 female) who swam the 400-m freestyle in the Brazilian Swimming Championships participated. Thirty minutes before the 400-m freestyle event, the athletes answered the Competitive Anxiety Inventory (CSAI-2R) questionnaire, then underwent anthropometric (body weight, height, and skinfold thickness) and HRV measurements. Then, at a second meeting, held 3 h after the 400-m freestyle event, the athletes returned to the evaluation room for HRV measurement (Polar® RS800cx, Kempele, Finland). Multiple linear regression was used to evaluate the relationship between competitive anxiety and HRV. The multiple linear regression was performed in three blocks (block 1: cognitive anxiety, block 2: somatic anxiety, and block 3: self-confidence), adopting the forward model. The results indicated a significant association between cognitive anxiety ($p = 0.001$) and HRV. An increased magnitude of the association was observed when somatic anxiety was inserted in the model ($p = 0.001$). In contrast, self-confidence showed, which was inserted in block 3, no relationship with HRV ($p = 0.27$). It was concluded that cognitive and somatic anxieties were associated with the HRV of swimmers. Athletes with a high magnitude of cognitive and/or somatic anxiety demonstrated more significant autonomic nervous system disturbance. Practically, psychological interventions are needed to improve anxiety states that are specific to perform well, and to improve HRV.

Key words: Athletes, sport psychology, anxiety, swimming.

Introduction

Swimming is an individual sport performed in an aquatic environment that is characterized by continuous and cyclic high-intensity efforts (Fortes et al., 2016; Nugent et al., 2017). Typically, an athlete competes in two to four events per competition. The official events of swimming include the following (FINA, 2016): 50-m freestyle, 100-m freestyle, butterfly, breast stroke, and backstroke, 200-m freestyle, butterfly, breast stroke, backstroke, and medley, 400-m freestyle and medley, and 1,500-m freestyle. It is important to note that an athlete can enter the water up to three times in the same competition (eliminatory, semifinal, and final events). Therefore, considering the short time interval (~2 h) between the swimming events in a championship (FINA, 2016), it is necessary for the athlete to start the competition with a low level of residual fatigue. In the scientific literature, heart rate variability (HRV) has been suggested as a good indicator of the stress-recovery balance state of athletes (Kiss et al., 2016; Nakamura et al., 2015; Plews et al., 2013).

HRV refers to the variation between consecutive heartbeats (Task Force, 1996), which provides information regarding the autonomic sympathetic and parasympathetic modulation of the heart. Scientific research has revealed a close relationship between HRV and sports performance (Flatt et al., 2017; Nakamura et al., 2015, Proietti et al., 2017). According to Esco, Flatt, and Nakamura (2016), athletes with improved performance show increased parasympathetic modulation and increased HRV. On the other hand, according to other researchers (D'ascenzi et al., 2014; Mateo et al., 2012; Morales et al., 2013), pre-competitive stress can lead to an increase disturbance in the autonomic nervous system, resulting in impaired HRV.

It is important to note that an increase in pre-competitive stress is accompanied by increased anxiety (Fortes et al., 2016; Raglin, 1992), and there is considerable variability in the optimal pre-competitive anxiety response among athletes (Raglin, 1992). Anxiety is a multidimensional construct that refers to the willingness to respond to stress and a tendency to perceive stressful situations (Fernandes et al., 2013). Raglin (1992) emphasized that the main stressor for athletes is competition. Swimming competition, in particular, has some specific characteristics that can increase competitive anxiety. The athlete's visual contact with his opponent moments before the competition (in the control room) and the possibility of hearing the announcer pronouncing his name and that of his opponents moments before entering the water to compete may potentiate competitive anxiety.

The individual zones of optimal functioning (IZOF) model (Hanin, 2004) are widely applied to the study of anxiety related to athletic performance. According to Hanin (2004), the level of competitive anxiety necessary to achieve good performance is subjective. Fazey and Hardy (1988) proposed the Inverted-U Hypothesis, known as the Catastrophe Theory, which attempted to clarify the relationship between the different anxiety components and performance. The model proposed that cognitive anxiety acts as a splitting factor that determines whether the effects of physiological arousal are small and smooth, large and catastrophic, or somewhere in between those two extremes. The Attention

Received: 14 June 2017 / Accepted: 15 September 2017 / Published (online): 01 December 2017

Control Theory, in turn, contends that anxiety manifests in impaired attentional control, which leads to performance deficits in tasks involving the central executive function of the working memory system, causing impaired sport performance (Coombes et al., 2009). Another theory framework that has been used is the Multidimensional Theory of Competitive Anxiety (Martens et al., 1990), which subdivides competitive anxiety into three dimensions: cognitive anxiety, somatic anxiety, and self-confidence. According to this theory (Martens et al., 1990), cognitive anxiety refers to negative thoughts, expectations, and/or self-verbalizations concerning the competitive event, whereas somatic anxiety refers to the affective and physiological elements that directly affect the central nervous system. Self-confidence, in turn, is related to the level of confidence and perceived readiness to compete (Martens et al., 1990).

Blásquez et al. (2009) investigated the relationship between competitive anxiety and HRV in 10 Spanish swimming athletes, verifying increased sympathetic predominance (sympathetic tone) in athletes with a higher level of competitive anxiety. By contrast, Mullen et al. (2012) did not identify an association between competitive anxiety and HRV among electronic game athletes. Likewise, the findings of Matteo et al. (2012) did not indicate a relationship between the respective variables in cyclists. Therefore, the relevant findings from the scientific literature remain inconsistent. It should be noted that although the aforementioned studies adopted an experimental design, they lacked the premise of investigating the relationship between pre-competitive anxiety and HRV tested a few hours after a competitive event. Moreover, interestingly, those studies all used relatively small sample sizes, which preclude the generalization of the results.

Practically speaking, research that analyzes the relationship between pre-competitive anxiety levels and HRV can generate important information for sports professionals. Indeed, if a negative association between competitive anxiety and HRV is identified, the coach can plan interventions with his athletes that demonstrate a high level of competitive anxiety with the aim of attenuating it and, consequently, inhibiting the vertiginous decrease in HRV in the hours following an athletic event. Therefore, the objective of this study was to investigate the interplay of competitive anxiety and HRV in swimming athletes. We hypothesized that competitive anxiety would be negatively associated with HRV.

Methods

Participants

The present study has a quasi-experimental design involving swimming athletes of both sexes. Participants were selected in a non-probabilistic manner, and a total of 68 volunteers (41 males and 27 females) aged 15 to 16 years (15.6 ± 0.2 years) who swam the 400-m freestyle event in the Brazilian Swimming Championship Juvenile category were included. Athletes trained for an average of two h per day, often five times per week. To qualify for inclusion in the study, athletes had to fulfill the following criteria: a) be a swimming athlete for at least two years; b) systematically train in swimming for at least 8 h per week; c) be enrolled in the 400-m freestyle event of the Brazilian Championship, organized by the Brazilian Confederation of Aquatic Sports; and d) be available to answer a questionnaire and participate in anthropometric and HRV measurements. The 400-m freestyle event was chosen because of the increased physiological stress when compared with that in the shorter distance events (100 or 200 m) (Nugent et al., 2017).

Two athletes were excluded because they did not participate in one of the research steps. Ultimately, a total of 66 swimming athletes (39 males and 27 females) participated in the study.

After receiving information on the procedures to which they would be submitted, participants signed a consent form. Those responsible for the athletes signed the informed consent form, agreeing with the methodological procedures of the investigation. The procedures adopted in this study met the standards of the Declaration of Helsinki. The project was approved by the local Ethics and Research Committee of the University.

Procedures

The researchers contacted the Brazilian Confederation of Aquatic Sports. The procedures, as well as the objectives of the study were thoroughly explained and authorization to collect data during the Brazilian Swimming Championship juvenile category was requested.

Data collection was performed at two different times (Figure 1) at the competition site. At the first meeting, which was performed 30 min before the 400-m freestyle event, the athletes answered the Competitive Anxiety Inventory (CSAI-2R), then participated in the anthropometric (body weight, height, and skinfold thickness) and HRV measurements. Then, at the second meeting,

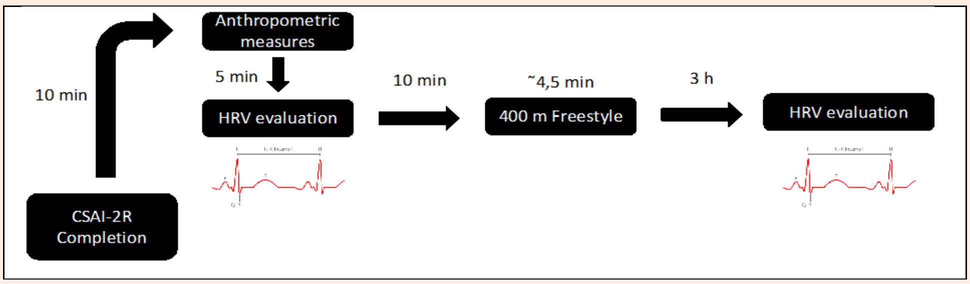

Figure 1. Procedures of investigation.

held 3 h after the 400-m freestyle event, the athletes returned to the evaluation room for HRV measurement. The 400-m freestyle event was the last event in the morning of the competition. Thus, HRV measurements were performed after the 400-m freestyle event and before the start of the afternoon stage of the competition, resulting in a 3-h interval between the two HRV assessments.

Measures

Heart rate variability (HRV)

Evaluations were performed under the same conditions. The HRV analysis was performed 30 min before and 3 h after the 400-m freestyle event. The R-R intervals were obtained using a portable heart rate monitor (Polar® RS800cx, Kempele, Finland) with sampling at 1,000 Hz, continuously for 10 min, with the athlete sitting in a room with a temperature of 27°C. It is important to note that the level of aerobic fitness (VO_2max) can modulate HRV data (Esco, Flatt, & Nakamura, 2016), although it was not evaluated in the present study. Data were visually inspected to identify ectopic beats (<3%), which were removed and replaced by interpolation of the adjacent R-R ranges. The R-R values were transferred to the computer via Polar Software (Polar® ProTrainer, Kempele, Finland) and exported for HRV time-domain analyses using the Kubios v2 Software (Polar® Kubios v2, Kuopio, Finland). The variables analyzed were as follows: the standard deviation of all NN intervals (SDNN), the successive percentage of R-R interval differences greater than 50 ms (pNN50), and the difference of the quadratic mean of the successive R-R normal intervals (RMSSD), which was converted by logarithmic transformation (InRMSSD) to avoid outliers and simplify the analyses, as indicated by Nakamura et al. (2015) and adopted by Panissa, Abad, Julio, Andreato, and Franchini (2016). The SDNN and InRMSSD values were presented in milliseconds (ms). As recommended by Ravé and Fortrat (2016), frequency domain HRV analysis involved the spectral components of Low (LF) (0.04 Hz ≤ LF ≤ 0.15 Hz) and High (HF) (0.15 Hz ≤ HF ≤ 0.40 Hz) frequencies to establish the spectral power (ms2/Hz). The LF and HF spectral component values were normalized (LFnu and HFnu) and the LF/HF ratio was established. According to Task Force (1996), the HF falls under parasympathetic supervision, while the LF is under the influence of both the parasympathetic and sympathetic nervous systems. The LF/HF ratio is an indicator of the autonomic balance between the sympathetic and parasympathetic nervous systems.

Competitive anxiety

The Brazilian version of the CSAI-2R (Martens et al., 1990) was used to evaluate the competitive anxiety of athletes. The CSAI-2R is composed of 16 items that measure three subscales: cognitive anxiety, somatic anxiety, and self-confidence. The score for each subscale is calculated by the sum of the responses for the items of each factor divided by the respective number of items. The frequency dimension of CSAI-2R was adopted as a criterion for assessing competitive anxiety, which is arranged on a 4-point Likert scale, ranging from 1 (nothing) to 4 (quite). We chose to use the frequency dimension of CSAI-2R owing to the capacity to analyze the magnitude of competitive anxiety at the exact moment of its completion. The CSAI-2R was validated for Brazilian athletes and demonstrated excellent psychometric properties (Fernandes et al., 2013). For the present sample, an internal consistency (evaluated by Cronbach's alpha) of .79 was identified.

Competitive performance

The times reached in the 400-m freestyle event were converted into International Point Score (IPS). The IPS is recognized by the Fédération Internationale Natation Amateur (FINA, 2016) and is used to evaluate the performances of the athletes. The evaluation system varies between 0 and 1.100 points. World record performances correspond to 1.000 points; therefore, the closer the score is to that number, the better the athlete's performance. The performance comparison can be calculated at the following website http://www.swimnews.com/ipspoints.

Anthropometry

A portable digital scale (Tanita® BC-601, São Paulo, Brazil) and a portable stadiometer (Welmy®, Santa Bárbara do Oeste, Brazil) were used to determine body weight and height. Body mass index (BMI) was determined by the ratio between body weight (kg) and height squared (m). The skinfold thickness was measured using a Lange (Lange©, Washington, USA) adipometer to estimate body density using the predictive equation proposed by Slaughter et al. (1988). The International Society for Advancement for Kineanthropometry (2013) was used to measure the skinfolds. Relative body fat was estimated by the Siri equation (1961).

Data analysis

The Levene test was used to test for homoscedasticity, and the Mauchly test was used to evaluate the sphericity of the data. The Kolmogorov-Smirnov normality test confirmed the parametric distribution of the variables. Measures of central tendency (mean) and dispersion (standard deviation) were used to describe the variables of the investigation: HRV, CSAI-2R, body fat percentage, and age. Multiple linear regression was used to evaluate the relationship between competitive anxiety and HRV. The multiple linear regression was performed in three blocks (block 1: cognitive anxiety, block 2: somatic anxiety, and block 3: self-confidence), adopting the forward model. For this analysis, the InRMSSD was adopted as a criterion variable. In addition, athletes were divided into two groups according to the 50^{th} percentile of the CSAI-2R score: low (<28.00) and high (28.00) competitive anxiety. Therefore, the multivariate analysis of covariance (MANOVA) was used to compare all the HRV indicators (SDNN, pNN50, InRMSSD, LFnu, HFnu and LF/HF) according to competitive anxiety (low vs. high groups), adopting the baseline HRV and IPS measures as covariates, with the premise of statistically control the HRV before of the 400-m freestyle and the level of 400-m freestyle performance, respectively. The effect size (ES) was used to reveal differences from the practical point of view. The following criteria were used according to the

Rhea (2004) notes for highly trained individuals: ES <0.25 = trivial, 0.25≤ ES >0.50 = low effect size, 0.50≤ ES >1.0 = moderate effect size and ES ≥1.0 = large effect size. All data were analyzed using SPSS 21.0 software, with the level of significance set at 5%.

Results

The descriptive data of HRV, CSAI-2R, body fat percentage, age, and training regimen are presented in Table 1.

The regression model can be observed in Table 2. The results showed a significant relationship between cognitive anxiety ($F_{(1, 65)} = 28.09$; *Wilks' Lambda* = 0.83; $R^2 = 0.24$; $p = 0.001$) and HRV. An increase in the magnitude of the relationship in block 2 was observed when somatic anxiety was inserted in the model ($F_{(2, 64)} = 37.25$; *Wilks' Lambda* = 0.89; $R^2 = 0.36$; $p = 0.001$). By contrast, self-confidence, which was inserted in block 3, showed no relationship with HRV ($F_{(3, 63)} = 23.46$; *Wilks' Lambda* = 0.56; $R^2 = 0.19$; $p = 0.27$).

Table 3 presents the results of the HRV and IPS comparisons between the competitive anxiety groups. Statistically significant differences ($p < 0.01$) were found for all HRV indicators (SDNN, pNN50, InRMSSD, LFnu, HFnu and LF/HF), with superior values for the low anxiety group ($p = 0.01$), indicating a negative relationship between competitive anxiety and HRV. The results did not revealed differences of the IPS between groups ($p = 0.28$).

Table 1. Descritive values (mean and standard deviation) of research in baseline.

Variables	Mean (SD)
SDNN (ms)	64.2 (23.7)
pNN50 (%)	21.7 (4.8)
InRMSSD (ms)	3.6 (0.5)
LF (n.u.)	51.7 (20.2)
HF (n.u.)	52.2 (18.6)
LF/HF	1.0 (0.2)
CSAI-2R	30.1 (5.6)
IPS (points)	754.3 (72.6)
Age (years)	15.6 (0.2)
BMI (kg/m²)	21.8 (1.7)
%BF	20.4 (4.5)
Training regimen (years)	10.6 (0.7)

Note. SDNN = standard deviation of all N-N intervals; pNN50 = successive percentage of differences in R-R intervals greater than 50 ms; InRMSSD = logarithm of the difference of the quadratic mean of the successive normal R-R intervals; LFnu = corrected low frequency spectral component; HFnu = corrected high frequency spectral component; LF/HF = ratio between LF and HF; CSAI-2R = Competitive Anxiety Inventory; IPS = International Point Score; BMI = body mass index; %BF = body fat percentage.

Table 2. Multiple linear regression analyzing the influence of competitive-anxiety on HRV variance in swimmers.

Variable	Block	B	R	R²	R²*	p
Cognitive anxiety	1	.14	-.42	.18	.17	.01
Somatic anxiety	2	.17	-.56	.31	.28	.02
Self-confidence	3	.11	.37	.14	.12	.34

R²* = R² adjusted.

Table 3. Mean (±standard deviation) of HRV and IPS according to competitive-anxiety group (Low and High).

Variable	Low (n = 31)	High (n = 35)	F	*p*	ES
SDNN (ms)*	66.1 (22.3)	57.9 (25.2)	36.3	.01	.6
pNN50 (%)*	24.2 (5.5)	20.1 (4.0)	45.6	.01	.9
InRMSSD (ms)*	3.9 (.3)	3.3 (.4)	52.7	.01	1.0
LFnu*	45.8 (9.7)	55.0 (20.3)	52.8	.01	1.0
HFnu*	56.4 (21.2)	47.1 (20.4)	40.6	.01	.6
LF/HF*	.9 (.1)	1.0 (.1)	53.0	.01	.9
IPS (points)	775.1 (76.0)	769.5 (71.4)	5.6	.28	.1

Note. SDNN = standard deviation of all N-N intervals; pNN50 = successive percentage of differences in R-R intervals greater than 50 ms; InRMSSD = logarithm of the difference of the quadratic mean of the successive normal R-R intervals; LFnu = corrected low frequency spectral component; HFnu = corrected high frequency spectral component; LF/HF = ratio between LF and HF; IPS = International Point Score; ES = effect size; $^{*}p < 0,05$ between Low and High Groups.

Discussion

The present investigation aimed to analyze the influence of competitive anxiety on HRV in swimming athletes. The main results suggest that pre-competitive cognitive and somatic anxieties are negatively associated with the post-event HRV of swimmers, which corroborates the hypothesis of the present investigation.

As mentioned previously, the relationship between competitive anxiety and HRV remains somewhat controversial in the literature. While Mullen et al. (2012) and Mateo et al. (2012) did not reveal a relationship between competitive anxiety and HRV, the findings of Blásquez et al. (2009) demonstrated that competitive anxiety was linked to HRV. It should be noted that these studies had cross-sectional designs, which limits the data regarding the direct effect of competitive anxiety on the autonomic nervous system after a competitive event. HRV is considered an important indicator of physiological disturbance from physical exercise (Ferreira and Zanesco, 2016; Panissa et al., 2016). Therefore, HRV impairment may indicate that the athlete needs more rest time in order to compete again at a high level, although competitive performance is indirectly related to HRV. While competitive anxiety can lead to a greater physiological disturbance, which can lead to impaired HRV after competition, it does not necessarily lead to impaired competitive performance. Considering that a swimming athlete competes in several events during a competition, it is reasonable to assume that the swimming athlete will need of psychological interventions (e.g., imagery or biofeedback) to reduce anxiety between one event and another if he/she demonstrates high competitive anxiety. It should also be noted that the change in HRV may be strongly associated with the VO2max (Esco et al., 2016). Considering that VO2max is related to performance in the 400-m freestyle (Nugent et al., 2017), it is reasonable to assume that athletes with better competitive performance have higher VO2max. It should be noted, however, that the findings of the present study did not revealed a statistically significant difference in IPS between athletes with low and high competitive anxiety. Therefore, it is not feasible to associate the differences found in HRV (low vs high) with the VO2max of swimming athletes.

The findings of the present study are suggestive of an association between cognitive and somatic anxiety and HRV. More specifically, 36% of the HRV variance after the 400-m freestyle event could be attributed to cognitive and somatic anxiety. According to Morales et al. (2013), negative thoughts concerning competitive performance (cognitive anxiety) and high activation of sympathetic tone moments before competition (somatic anxiety) may cause an increase in autonomic nervous system disturbance, which leads to disturbances in HRV. D'Ascenzi et al. (2014) emphasized that pre-competitive stress causes the increased serum secretion of norepinephrine and cortisol, along with a reduction in the vagal tonus. Moreover, it is important to note that during competition, HRV is more or less zero in all athletes because the sympathetic tone is maximally forced. Considering that pre-competitive stress engenders high competitive anxiety, it is possible to assume that the anxious athletes at pre-start competition event will continue to experience decreased HRV for hours after the competition event, which corroborates the findings of the comparison of HRV between athletes with low and high competitive anxiety. It should also be noted that the results showed a moderate ES in the comparison of all HRV indicators among athletes with low and high competitive anxiety.

In terms of self-confidence, according to Fortes et al. (2016), the athletes with a high level of confidence have the potential to achieve positive competitive results. It was expected that self-confidence would be positively related with HRV, though this was not indicated in the results of the present study. Competitive performance does not appear to be dependent on HRV, though HRV is a surrogate marker related to performance and modulated by mental stress. Therefore, although self-confidence is related to competitive performance, it is reasonable to assume that self-confidence is not linked to HRV, as demonstrated in the present study. Perhaps self-confidence does not sufficiently modulate the activation of efferent vagal tonus and the β-adrenergic responses, which are associated with HRV improvement (Dong, 2016).

Studies have shown that athletes with high HRV demonstrate superiority in competition (Nakamura et al., 2015, Proietti et al., 2017), which can be partly explained by the higher VO_2max found in athletes with better HRV (Esco et al., 2016). More specifically, in sports involving multiple events in a short time interval, as in the case of swimming, the athlete who reveals impaired HRV before or after an event will experience a compromised performance. In light of the impairment in HRV caused by an increase in competitive anxiety, as demonstrated in the present study, it may be interesting to subject swimming athletes to interventions that could attenuate the magnitude of competitive anxiety, such as imagery training (Battaglia et al., 2014; Di Rienzo et al., 2015; Fortes et al., 2016).

Although the present study reveals interesting and original findings, it is important to note its limitations. The lack of benchmarking of stress markers (norepinephrine and cortisol) may be cited as a limitation. The absence of the evaluation of brain electrical waves (theta, beta, and alpha) can be considered another limitation. Therefore, the results should be interpreted cautiously, and future research should investigate the effect of competitive anxiety on HRV by controlling for the stress markers and brain electrical waves.

Conclusions

Cognitive and somatic anxiety was determined to be negatively related with HRV, and athletes with a high magnitude of cognitive and/or somatic anxiety demonstrated a greater degree of autonomic nervous system disturbance. Practically, psychological interventions are needed to improve anxiety states that are specific to perform well, and to improve HRV. It is worth mentioning that to repeat performance with short interval between events, a high aerobic capacity may be important.

Acknowledgements

The authors gratefully acknowledge the contributions of participants (swimmers) and Luiz Marques in their indispensable role as research assistants in this study. The authors report no conflicts of interest with this manuscript. The experiments comply with the current laws of the Brazil.

References

Battaglia, C., D'Artibale, E., Fiorilli, G., Piazza, M., Tsopani, D., Giombini, A., Calcagno, G. and di Cagno, A. (2014). Use of video observation and motor imagery on jumping performance in national rhythmic gymnastics athletes. *Human Movement Science* **38(2),** 225-234.

Blásquez, J.C.C., Font, G.R. and Ortís, L.C. (2009) Heart-rate variability and precompetitive anxiety in swimmers. *Psicothema* **21(4),** 531-536.

Coombes, S.A., Higgins, T., Gamble, K.M., Cauraugh, J.H. and Janelle, C.M. (2009) Attentional Control Theory: Anxiety, emotion, and motor planning. *Journal of Anxiety Disorders* **23(8),** 1072–1079.

D'Ascenzi, F., Alvino, F., Natali, B.M., Cameli, M., Palmitesta, P., Boschetti, G., Bonifazi, M. and Mondillo, S. (2014) Precompetitive assessment of heart rate variability in elite female athletes during play offs. *Clinical Physiology Functioning Imaging* **34(3),** 230-236.

Di Rienzo, F., Blache, Y., Kanthack, T.F.D., Monteil, K., Collet, C. and Guillot, A. (2015) Short-term effects on integrated motor imagery practice on muscle activation and force performance. *Neuroscience* **305(2),** 146-156.

Dong, J. G. (2016). The role of heart rate variability in sports physiology. *Experimental Therapy Medicine* **11(5),** 1531-1536.

Esco, M.R., Flatt, A.A, and Nakamura, F.Y. (2016) Initial weekly HRV response is related to the prospective change in VO2max in female soccer players. *International Journal of Sports Medicine,* **37(6),** 436-441.

Fazey, J.A. and Hardy, L. (1988) *The Inverted-U Hypothesis: A Catastrophe for Sport Psychology.* British Association of Sports Sciences Monograph no. 1. Leeds: The National Coaching Foundation.

Fernandes, M.G., Nunes, A.S., Raposo-Vasconcelos, J., Fernandes, H.M. and Brustad, R. (2013) The CSAI-2: An examination of the instrument's factorial validity and reliability of the intensity, direction and frequency dimensions with Brazilian athletes. *Journal of Applied Sport Psychology* **25(4),** 377-391.

Ferreira, M., & Zanesco, A. (2016). Heart rate variability as important approach for assessment autonomic modulation. *Motriz, 22*(2), 3-8. doi: 10.1590/S1980-65742016000200001

Flatt, A.A., Hornikel, B. and Esco M. R. (2017) Heart rate variability and psychometric responses to overload and tapering in collegiate sprint-swimmers. *Journal of Science and Medicine in Sport* **20(6),** 606-610.

Fortes, L.S., Lira, H.A.A.S., Lima, R.C.P., Almeida, S.S. and Ferreira, M.E.C. (2016) Mental training generates positive effect on competitive anxiety of young swimmers? *Revista Brasileira de Cineantropometria e Desempenho Humano* **18(3),** 353-361.

FINA. (2016) Federation Internationale de Natation. Available from URL: http://www.fina.org/.

Hanin, Y.L. (2004) Emotions in sport: An individualized approach. In: *Encyclopedia of Applied Psychology*. Ed: Spielberger, C.D. Oxford: Elsevier Academic Press. Vol. 1, pp. 739-750.

Kiss, O., Sydo, N., Varha, P., Czimbalmos, C., Des, E., Zima, E., Apponyil, G., Merkely, G., Sydo, T., Becker, D., Allison, T.G. and Merkely, B. (2016) Detailed heart rate variability analysis in athletes. *Clinical Autonomic Research* **26(2),** 245-252.

Kovacs, R. and Bagish, A.L. (2016) Cardiovascular adaptation in athletes. *Trends in Cardiovascular Medicine* **26(1),** 46-52.

Martens, R., Vealey, R.S. and Burton, D. (1990) Competitive anxiety in sport. Champaign, IL: Human Kinetics.

Mateo, M., Blasco-Lafarga, C., Martınez-Navarro, I., Guzman, J.F. and Zabala, M. (2012) Heart rate variability and pre-competitive anxiety in BMX discipline. *European Journal of Applied Physiology* **112(1),** 113-123.

Morales, J., Garcia, V., García-Massó, X., Salvá, P., Escobar, R. and Buscà, B. (2013) The use of heart rate variability in assessing precompetitive stress in high-standard judo athletes. *International Journal of Sports Medicine* **34(1),** 144-151.

Mullen, R., Faull, A., Jones, E.S. and Kingston, K. (2012) Attentional focus and performance anxiety: effects on simulated race-driving performance and heart rate variability. *Frontiers in Psychology* **3(1),** 1-10.

Nakamura, F.Y., Flatt, A.A., Pereira, L.A., Ramirez-Campillo, R., Loturco, I. and Esco, M.R. (2015) Ultra-short-term heart rate variability is sensitive to training effects in team sports players. *Journal of Sports Science Medicine* **14(3),** 602-605.

Nugent, F.J., Comyns, T.M., Burrows, E. and Warrington, G.D. (2017) Effects of low-lolume, high-intensity training on performance in competitive swimmers: A systematic review. *Journal of Strength and Conditioning Research* **31(3),** 837-847.

Panissa, V.L.G., Abad, C.C.C., Julio, U.F., Andreato, L.V. and Franchini, E. (2016) High-intensity intermittent exercise and its effects on heart rate variability and subsequent strength performance. *Frontiers in Physiology* **7(1),** 81.

Plews, D.J., Laursen, P.B., Stanley, J., Kilding, A.E. and Buchheit, M. (2013) Training adaptation and heart rate variability in elite endurance athletes: opening the door to effective monitoring. *Sports Medicine* **43(9),** 773-781.

Proietti, R., De Fronso, S. Pereira, L.A., Bortoli, L. Robaza, C., Nakamura, F.Y. and Bertoldo, M. (2017) Heart rate variability disminates competitive levels in professional soccer players. *Journal of Strength and Conditioning Research* **31(6),** 1719-1725.

Raglin, J.S. (1992) Anxiety and sport performance. *Exercise and Sport Science Review* **20,** 243-274.

Ravé, G. and Fortrat, J.O. (2016) Heart rate variability in the standing position reflects training adaptation in professional soccer players. *European Journal of Applied Physiology* **116(8),** 1575-1582.

Rhea, M.R. (2004) Determining the magnitude of treatment effects in strength training research through the use of the effect size. *Journal of Strength and Conditioning Research* **18(6),** 918-920.

Siri, W.E. (1961) The gross composition of the body. In: *Advances in biological and medical physics.* Eds: Tobias, C.A., Lawrence, J.H. New York: Academic Press. 239-80.

Slaughter, M.H., Lohman, T.G., Boileau, R., Hoswill, C.A., Stillman, R. J. and Yanloan, M.D. (1988) Skinfold equations for estimation of body fatness in children and youth. *Human Biology* **60(3),** 709-723.

Task Force. (1996) Heart rate variability: Standards of measurement, physiological interpretation, and clinical use. Task Force of the European Society of Cardiology and the North American Society of Pacing and Eletrophysiology. *European Heart Journal,* **17(3),** 354-381.

The Internacional Society for Advancement for Kineanthropometry. (2013) *Australia: National Library of Australia.* Available from URL: http://www.isakonline.com.

Vilamitjana, J.J., Lentini, N.A., Pérez-Júnior, M.F. and Verde, P.E. (2014) Heart rate variability as biomarker of training load in professional soccer players. *Medicine Science in Sports and Exercise* **46(5),** 1-7.

Key points

- The level of competitive-anxiety can predict HRV's response after competition in young swimming athletes.
- Young swimming athletes who demonstrate higher competitive-anxiety, may present high autonomic nervous system disorder, which can be evaluated by HRV.
- Coaches are encouraged to periodically evaluate the competitive-anxiety of young swimming athletes.

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