Association Between Heart Rate Variability and Psychophysiological Factors During Competition in Health and Performance in Athletes

Keywords: Heart rate variability, Psychophysiological factors, Athletes

Authors:

Henrique Monteiro Lapo (Scientific Initiation student) [UNICAMP]

Drª Amanda Veiga Sardeli (Co-supervisor) [UNICAMP and University of Birmingham, UK]

Profª Drª Mara Patrícia Traina Chacon-Mikahil (Supervisor) [UNICAMP]

INTRODUCTION

Heart rate Variability (HRV), through the analysis of oscillations between heart rate consecutive intervals (R-R intervals), informs about the function of autonomic nervous system (ANS), associated with intern organism function (VANDERLEI et al., 2009). Changes in HRV can predict some factors associated with the health and performance of athletes. For example, the HRV is inversely associated with the level of pre-competitive anxiety (FORTES et al., 2017).

Exist evidence that the recurrent cases of infection in athletes are not dependent of alterations in volume or intensity of the training, but yes because occurring for many other multifactorial aspects present in the sports area, principally in competition environments that involve travels, sleep interruption, psychological stress, and the contact with a mass of population (SIMPSON et al., 2020).

Among these multifactorial aspects presents in competition, we can focus in a few factors that possibly interfere in the final performance of athletes, like stress, sleep deprivation, fatigue, muscular soreness and mood, that need to have yours association with HRV during the training and competition better investigated, being able to be the principals responsible for the reduction of HRV in the frequency domine together with the reduction of RESTQ-sports (principally in the sports specific variables).

Against these possible factors interfere with HRV, our objective was to identify, through a systematic review and meta-analyses, whether some of these psychophysiological factors analyzed during the sport training (fatigue, soreness, stress, mood, sleep and cortisol) may be associated with alteration in heart rate variability.

METHODS

Search in literature

In this Project we made a search in the data bases of PUBmed, SCOUPUS, COCHRANE and WEB OF SCIENCE, utilizing syntaxes for the words RMSSD, athletes and psychometric variables. The same syntaxes constructed for PUBmed was utilized as a model for the others bases, being this search the actualization of the scientific initiation of the last year present in this respective PROSPERO (code: CRD42020181966).

Eligibility Criteria

We include interventions or observational studies that evaluate the HRV in athletes before and/or after a period of training, in rest condition and that presented association data's with fatigue, soreness, stress, mood, sleep and cortisol.

Study Selection

All the articles selected passed for two processes of exclusion, the first was by the reading of the abstract and title and the second was during the complete reading of this articles.

Inclusion Criteria: 1) studies that presented athletes of any modality sports; 2) presented data of association between HRV and psychophysiological variables in any period of training or competition and 3) HRV analysed in rest.

Exclusion Criteria: 1) Non-original studies; 2) studies with athletes with disabilities; 3) Studies that analysed HRV in an acute way; 4) studies that did not show any psychophysiological variable.

Data's extraction: we collected data of the association (r values) between RMSSD and psychophysiological markers, being since basal until delta before and after a training period and the psychological variables (fatigue, soreness, stress, mood, sleep, and cortisol), the position of HRV analyses, the number of participants, the modality practiced, sex of the participants and the time of HRV analyses.

From that we made two distinct meta-analyses, one for each type of data collected (basal and delta), associating the psychophysiological variables with the RMSSD index. These analyses occurred with the use of Comprehensive Meta Analyses 3.0 software. When the heterogeneity between the studies was significant ($p = < 0,05$) we adopted the random effect for the data of the respective subgroups with heterogeneity. For the other side, when the heterogeneity was not significant ($p = > 0,05$) we maintained the fixed effect of the studies.

RESULTS AND DISCUSSION

Were Included 13 studies and 28 subgroups, being 4 studies with 9 subgroups of data analysed by the delta of the post moment minus the pre moment of analyses period (FLATT; ESCO; NAKAMURA, 2017; MORALES et al., 2019; SOLANA-TRAMUNT et al., 2018; T. LIZUKA ET AL., 2020) and 9 studies with 19 subgroups with data analysed in a basal form (BOTEK; KREJČÍ; WEISSER, 2014; FLATT et al., 2017; HAUER et al., 2020; LIMA-BORGES et al., 2018; MISHICA et al., 2021; NÚÑEZ-ESPINOSA et al., 2021; SANCHEZ; ROMERO; ORTIS, 2013; SEKIGUCHI et al., 2019).

These studies included athletes of masculine and feminine sex, of different sports modalities, since soccer and swimming to Brazilian jiu-jitsu, lacrosse, and synchronized swimming. All the articles had association values of RMSSD index and psychophysiological aspects analysed and had different protocols between then, being that some of these studies analysed these data in a training period, pre-competition, competition, or tests. The HRV data were collected during rest conditions in all studies, with exception of two that collected HRV during the sleep (MISHICA et al., 2021; SEKIGUCHI

et al., 2019). Preferentially this HRV analyses occurred in supine position, but two studies only analysed in seated position (FLATT; ESCO; NAKAMURA, 2017; T. LIZUKA ET AL., 2020) and one in a orthoclinostatics way (BOTEK; KREJČÍ; WEISSER,2014).

Figure 1. Forest plot 1: Association between HRV and psychophysiological factors basal Data's: CP: competition period; GP: general period; SP: specific period.

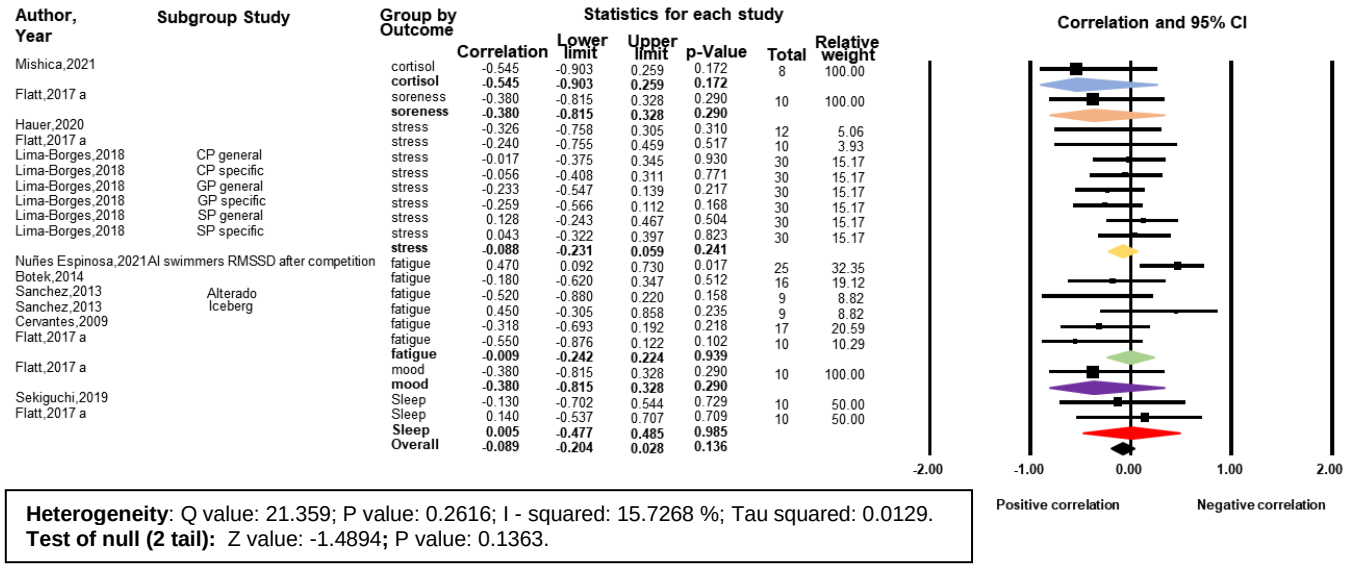
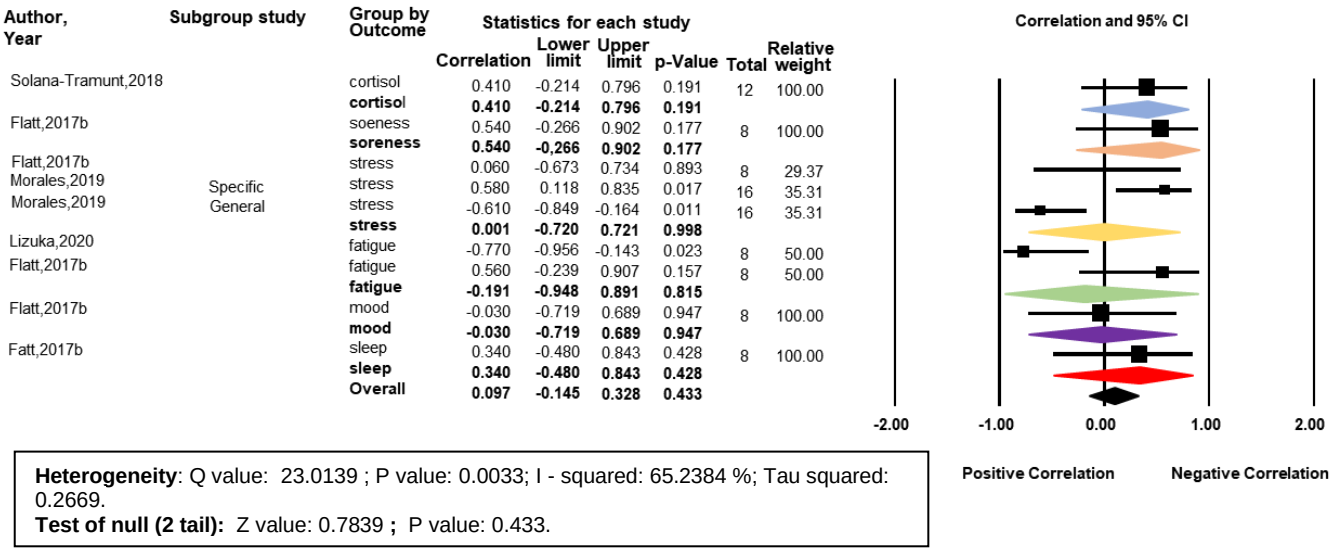


Figure 2. Forest plot 2: Association between HRV and psychophysiological factors Delta Data's.



Not was founded any significant association between the HRV and psychophysiological aspects in the analyses of basal data's (LL= - 0.204; UL = 0.28; r = 0.088; p = 0.136) (Figure 1 - forest plot 1) in one homogeneous analyse (I^2 = 15.726) and neither in the delta analyse (LL= -0.145; UL = 0.328; r = 0.097; p = 0.433) (Figure 2 - forest plot 2) in one analysis heterogeneous (I^2 = 65.23), when considered all the types of psychophysiological aspects together.

From the above, one of the factors that may had contributed for these result is the fact that a lot of athletes developed a ability to coping with any type of stress because of diverse strategies, for example, form methods of visualisation and simulation of positive feelings (LITWIC-KAMINSKA, 2020), this could assistant the no alteration of HRV in stress and/or fatigue moments, because of no sympathetic activation.

Other physiologic aspect that can explain the result founded is that the activity regulation of autonomic nervous system (ANS) is complex, suffering regulations of a diversity of brain areas, like the limbic system, form by hypothalamus, amygdala, and medial pre-frontal cortex (KIM et al., 2018). As for the complexity of these system, Hans Seyle (1956), presents a model of three stages to respond a one stress situation, the first one is the alarm reaction where the organism react for one stress situation with a fight or run answer (sympathetic activity); in the second stage, called resistance stage, the body start to adapted his self to the stress situation, this is characterized by the return of a lot of physiological function to theirs basal values by the parasympathetic reactivation, even though the level of glucose, cortisol and adrenaline still have high concentration; and to finish the third stage is the exhaustion one, they occurs when the adaptation needed to the resistance stage are loosed.

Is possible that because of a parasympathetic predominance present in athletes (SUBRAMANIAN et al., 2019), caused by the high training level, these population presents a better stage two of these coping stages created by Hans Seyle (1956), and this prevent the reduction in the HRV in a chronic way during big an long situation of stress, like a training or competition period.

Together with the indicated above, the physical training can promote peripherical alterations, that can promote a bigger resistance to copping with a stress situation. In fact, are evidence in animals (DELP; MCALLISTER; LAUGHLIN, 1993; WIEGMAN et al., 1981) that showed alterations caused by physical training in the organism answers in relation to the presence of concentration of noradrenaline, these happened by a reduction in the sensibility of the adrenergic receptors alpha caused by the excess of norepinephrine and epinephrine during the exercise, promoting a reduction in the vasoconstriction mediated for these catecholamines (DELP, 1995) and preventing HRV reduction.

CONCLUSION

We concluded that did not have associations between psychophysiological aspects and the HRV in rest conditions, like their variation after a training period. Possibly are psychophysiological factors (copping with stress situations), central aspects (ANS adaptation) and peripherical factors (like norepinephrine resistance) that influence these association of HRV and psychophysiological aspects that should continuing being investigated in future works.

REFERENCES

BOTEK, M.; KREJČÍ, J.; WEISSER, R. Autonomic cardiac regulation and morpho-physiological responses to eight week training preparation in junior soccer players. **Acta Universitatis Palackianae Olomucensis, Gymnica**, v. 44, n. 3, p. 155–163, 2014.

DELP, M. D. Effects of exercise training on endothelium-dependent peripheral vascular responsiveness. **medicine and science in sports and exercise**, 1995.

DELP, M. D.; MCALLISTER, R. M.; LAUGHLIN, M. H. Exercise training alters endothelium-dependent vasoreactivity of rat abdominal aorta.

Journal of Applied Physiology, v. 75, n. 3, p. 1354–1363, 1993.

FLATT, A. A. et al. Interpreting daily heart rate variability changes in collegiate female soccer players. **The Journal of sports medicine and physical fitness**, v. 57, n. 6, p. 907–915, jun. 2017 (a).

FLATT, A. A.; ESCO, M. R.; NAKAMURA, F. Y. Individual Heart Rate Variability Responses to Preseason Training in High Level Female Soccer Players. **Journal of strength and conditioning research**, v. 31, n. 2, p. 531–538, fev. 2017 (b).

FORTES, L. S. et al. Influence of competitive-anxiety on heart rate variability in swimmers. **Journal of Sports Science and Medicine**, v. 16, n. 4, p. 498–504, 2017.

HAUER, R. et al. Lacrosse Athletes Load and Recovery Monitoring: Comparison between Objective and Subjective Methods. **International journal of environmental research and public health**, v. 17, n. 9, maio 2020.

KIM, H. G. et al. Stress and heart rate variability: A meta-analysis and review of the literature. **Psychiatry Investigation**, v. 15, n. 3, p. 235–245, 2018.

LIMA-BORGES, D. S. et al. Autonomic modulations of heart rate variability are associated with sports injury incidence in sprint swimmers. **PHYSICIAN AND SPORTSMEDICINE**, v. 46, n. 3, p. 374–384, 2018.

LITWIC-KAMINSKA, K. Types of cognitive appraisal and undertaken coping strategies during sport competitions. **International Journal of Environmental Research and Public Health**, v. 17, n. 18, p. 1–11, 2020.

MISHICA, C. et al. Relationships between Heart Rate Variability, Sleep Duration, Cortisol and Physical Training in Young Athletes. **Journal of sports science & medicine**, v. 20, n. 4, p. 778–788, dez. 2021.

MORALES, J. et al. Physiological and Psychological Changes at the End of the Soccer Season in Elite Female Athletes. **Journal of human kinetics**, v. 66, p. 99–109, mar. 2019.

NÚÑEZ-ESPINOSA, C. et al. Fatigue and conformist traits in the performance of young swimmers . **Revista Andaluza de Medicina del Deporte**, v. 14, n. 3, p. 176–180, 2021.

SANCHEZ, J. M.; ROMERO, E. P.; ORTIS, L. C. HEART RATE VARIABILITY AND PSYCHOPHYSIOLOGICAL PROFILES IN HIGH-PERFORMANCE TEAM SPORTS. **REVISTA DE PSICOLOGIA DEL DEPORTE**, v. 22, n. 2, p. 345–352, 2013.

SEKIGUCHI, Y. et al. Relationships between resting heart rate, heart rate variability and sleep characteristics among female collegiate cross-country athletes. **Journal of sleep research**, v. 28, n. 6, p. e12836, dez. 2019.

SEYLE, H. **The stress of life**. [s.l: s.n.].

SIMPSON, R. J. et al. Can exercise affect immune function to increase susceptibility to infection? **Exercise immunology review**, v. 26, p. 8–22, 2020.

SOLANA-TRAMUNT, M. et al. “Heart Rate Variability in Elite Synchronized Swimmers” by Solana-Tramunt M et al. International Journal of Sports Physiology and Performance Section: Original Investigation Article Title: Heart Rate Variability in Elite Synchronized Swimmers Title: Heart. **Journal: International Journal of Sports Physiology and Performance**, 2018.

SUBRAMANIAN, S. K. et al. Comparison of Baroreflex Sensitivity and Cardiac Autonomic Function Between Adolescent Athlete and Non-athlete Boys – A Cross-Sectional Study. **Frontiers in Physiology**, v. 10, n. August, p. 1–8, 2019.

T. LIZUKA ET AL. Morning Heart Rate Variability as an Indication of. 2020.

VANDERLEI, L. C. M. et al. Noções básicas de variabilidade da frequência cardíaca e sua aplicabilidade clínica. **Brazilian Journal of Cardiovascular Surgery**, v. 24, n. 2, p. 205–217, 2009.

WIEGMAN, D. L. et al. Decreased vascular sensitivity to norepinephrine following exercise training. **Journal of Applied Physiology Respiratory Environmental and Exercise Physiology**, v. 51, n. 2, p. 282–287, 1981.

Note about the authors

Lapo, H.M., Scientific Initiation student, PIBIC-CNPq, student of Physical Education at UNICAMP, Campinas. h217806@dac.unicamp.br
Sardeli, A.V., Doctor in Gerontology - FCM - Unicamp, and Collaborating Researcher at FISEX-FEF- UNICAMP, Campinas. Researcher at the University of Birmingham (United Kingdom) Co-supervisor of this IC project.
Chacon-Mikahil, M.P.T., Professor at the Department of Adapted Physical Activity Studies and Researcher at Fisex-FEF-Unicamp, School of Physical Education, UNICAMP, Campinas. Research Productivity Fellow at CNPq. Supervisor of this IC project.

Support and Acknowledgments

CNPq, PIBIC-CNPq. Acknowledgements to Fisex and Newton International Fellowship (UK).