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Heart Rate Variability and Emotional States in Basketball Players

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ABSTRACT

Paula Jr EP, Paza DLS, Pierozan GC, Stefanello JMF. Heart Rate Variability and Emotional States in Basketball Players. **JEPonline** 2016;19(6):111-122. Heart rate variability (HRV) is used for the assessment and understanding of the psychophysiological changes in athletes, particularly since it allows for the monitoring of the sympathetic and parasympathetic activation of the autonomic nervous system (ANS). This system is responsible for helping to meet the demands of training and competition. The purpose of this study is to analyze the relationship between HRV, mood states, precompetitive anxiety, and self-confidence level of basketball players at the beginning of a basketball season. The subjects were 36 athletes from three basketball teams of the category under-15, from the city of Curitiba/PR/Brazil. HRV was measured before a game, using biofeedback (BFB) equipment. The Brunel Mood Scale (BRUMS) was used to evaluate the subjects' mood states. The Competitive State Anxiety Inventory (CSAI-2R) was used to assess the pre-competitive anxiety of the subjects. The Sport Confidence Inventory (SCI) was used to evaluate the athletes' self-confidence. The normality of the data was assessed by the Shapiro-Wilk test. Given that the data were not normally distributed, a nonparametric analysis was performed. By quantile regression no correlation was found between HRV or moods states and precompetitive anxiety. Also, the Spearman correlation showed poor correlation between HRV and confidence levels. This is one of the first studies to present the HRV with variable moods states, anxiety, and self-confidence using the BFB CardioEmotion® and SCI inventory with athletes. In addition to presenting new research tools in psychophysiology, the research invites further investigation to assess the integrated psychophysiological processes in athletes.

Keywords: Biofeedback, HRV, Psychophysiology, Basketball

INTRODUCTION

Athletes are exposed to many types of stress during the athletic event itself (14,49) that are accompanied by psychophysiological changes (24) that, if not controlled, may become negative factors reducing the athletes' performance (7). One of the possible causes for this sporting performance outcome is the loss of the harmonious functioning of the autonomic nervous system (ANS). In this case, the predominance of sympathetic tone (53) that results from the athlete´s inability to manage the pressures inherent in the proximity of a competition or decisive situations can problematic. The sympathetic nervous system (SNS) activates the athlete by putting the body in a state of readiness, whether it is to meet the demands of training or competition (20,24). But, when the SNS response is exacerbated, the vagus nerve reduces its functionality whereby the athletes tend to lose their readiness. In particular, the athletes' body and the mental functions fail to respond more accurately and appropriately (13).

The inhibition of the vagus nerve reduces the frequency of the heartbeat, causing the loss of the Heart Rate Variability (HRV), which is the variation in the rate of the heartbeat (3,34). When the ANS branches are in homeostasis, the heart beats at different rates that vary its frequencies every minute (25). But when the body is in a psychophysiological imbalance that often occurs with stress and anxiety, the variation in the heart frequency is reduced and the heart beats in a more rhythmic and accelerated form (53).

Given the activation of the SNS due to the stress associated with sports participation, the athlete's heart rate and breathing are increased with a reduction in HRV that causes a loss of resonance (tuning) between the cardiac and respiratory systems (25) as well as some negative psychological states (emotional and cognitive) that may manifest (2). In this situation, the athlete can demonstrate tension, irritability, mood changes, and agitation (48) that may unnoticed by the athlete. There may be amnesia and insecurity (31,47,48). Studies have shown that changes in mood states can be associated with reduced HRV, thus resulting in tension (48), depression (23), anger (22), fatigue (51), confusion (26), and reduced vigor (42). Anxiety states have also been associated with low HRV in athletes (21) from different sports (29). Self-confidence, in particular, has been shown to be affected by changes in HRV (14).

On the other hand, with an increase in HRV and high frequency states (HF) between 0.15 and 0.5 Hz, the activation of the parasympathetic (vagus nerve) branch of the ANS (3) produces a slowing of heart rate and respiration (4,16,30). Then, the individual reaches a state of cardiac coherence with a coupling between cardiac and respiratory systems that promotes a cardiac resonance state (11,12). In this state, the athlete's psychophysiological condition is consistent with facing stressful situations in training and in competition that favors a higher quality performance (28,39,52,53). Therefore, monitoring Heart Rate Variability (HRV) can provide information from the balance of ANS branches in athletes (8,39), allowing it to re-establish the balance from vagal nerve, allowing them to recover their sports performance (33).

Despite the scientific literature that suggests the sports training effect on HRV has a preventive and recovery effect of physical and psychological symptoms generated by the demands of the sport settings (28,33,39,52), there are only a few studies that have evaluated HRV in Brazilian athletes (24,30,32). Thus, the purpose of this study was to investigate the relationship between HRV and self confidence levels, mood states, and precompetitive anxiety at the beginning of a games season in basketball athletes.

METHODS

Subjects

The subjects consisted of 36 male basketball players between 13 and 15 yrs of age affiliated with three clubs in the city of Curitiba, Brazil. The average age was 14.0 ± 1.0 yrs. This age group was chosen due to the fact that novice athletes experience more stress and have less management skills and ability to deal with the challenges of athletic training and performance issues (37). This study was approved by a Research Ethics Committee (number 1475226), and the athletes who agreed to participate signed a Consent Agreement prior to the study getting underway.

Measurements

Heart Rate Variability

The subjects' HRV was determined and recorded using biofeedback cardiovascular equipment (CardioEmotion® - Neuropsicotronics/Brazil). The device consisted of a sensor (auricular or digital) connected to a signal converter (USB module - with the hardware) attached to a computer with CardioEmotion® software (10). The sensor was placed on the earlobe (or finger phalanx) that captures the blood flow in these regions. The software analyzes the subject's cardiac coherence state in real time showing it on the computer screen in the form of frequency waves. At the end of the session, the computer showed the score obtained (between 0.0 and 10.0), the average heart rate (AHR), the session time in minutes, and the percentage of time the athlete remained in each HRV state, which was classified as: (a) no coherent; (b) almost coherent; or (c) cardiac coherence (11). In the no coherent state, the frequency of heart rate oscillates close to 0.04 Hertz, HRV is low and there is a predominance of the sympathetic branch. In the almost coherent state, the oscillation is close to 0.1 Hz, indicating inhibition of the sympathetic system. In cardiac coherence, the HR oscillation was close to 0.5 Hertz (called the resonant state), when the HRV is maximum and there is balance between the sympathetic and parasympathetic branches (11,34).

Mood States

The mood states were measured using the Brunel Mood Scale (BRUMS) that was translated and adapted to the Brazilian athletes, with internal consistency (Cronbach´s alpha) above 0.70 for all items (43). This is an inventory with 24 statements that assess six characteristics of mood (tension, depression, anger, vigor, fatigue, and confusion) in athletes. The athlete fills out a form that indicates in a Likert scale of 5 levels (0 = none to 4 = extremely) feelings at the moment about each item of the instrument, for example, "terrified (item 1), exhausted (item 8) and alert (item 23)". As result, the inventory shows the emotional level of the athletes, ranging between 0 and 24 for each of the six dimensions.

Precompetitive Anxiety

Anxiety was measured with the Inventory of Pre-Competitive Anxiety (CSAI-2R), in the Brazilian version, with internal consistency (Cronbach´s alpha) above 0.70 for all items (17,18). The CSAI-2R consists of 16 statements that investigated three anxiety scales: somatic, cognitive, and self-confidence. For example: "I feel my body tense" (item 2), "I am confident that I can meet the challenge I face (item 7)". The 16 items were evaluated in three subscales (somatic anxiety, cognitive anxiety, and self-confidence) and three dimensions (frequency, intensity, and direction). The athletes' answers to the questionnaire indicated their frequency of anxiety with a Likert 7-point scale (1 = never; 7 = very often); the intensity in a Likert 4-point scale (1 = nothing; 4 = a lot); and its direction (characterized as debilitative or as facilitative) with a Likert scale of 7 points (-3 = very difficult; +3 = greatly facilitates performance). This was done to obtain the athletes' frequency, intensity, and direction of somatic anxiety, cognitive anxiety, and self-confidence.

Self-Confidence

Self-confidence was measured with the Sport Confidence Inventory (SCI or QAE - Questionário de Autoconfiança no Esporte) (19), which was validated for the Brazilian population with internal consistency index (Cronbach´s alpha) of 0.6 for one of the components and greater than 0.7 for the other (19). This is an inventory with 14 statements about how the athlete feels when, for example, "Do you believe you can stay mentally focused throughout the match?" (Item 2) or "Do you believe that your physical training had prepared you enough to succeed in sport performance?" (Item 4). Each item is answered by the athlete on a Likert scale of 7 points (7 = absolutely; 1 = cannot do at all). The result demonstrates the level of confidence of athletes, ranging between 7 (low) to 96 (high).

Procedures

Athletes had their HRV monitored for 5 min (11) on the eve of the prior competition, or on the day of competition in the case of those who missed the previous measurement. The evaluations were performed in a controlled environment. Each athlete was led to a private room and instructed to sit comfortably in a chair. The sensor was placed on the earlobe or on one of the fingers, and then the athlete was instructed to remain peaceful and quiet. After 5 min of HRV monitoring, the athlete´s HRV was recorded that was then followed by athlete answering three inventories: the Mood States (BRUMS); the Pre-Competitive Anxiety (CSAI-2R); and the Sport Confidence Inventory (SCI), respectively.

Statistical Analyses

The Shapiro-Wilk test demonstrated a normal distribution of the data only for the self-confidence levels. For the other variables (i.e., states of mood, anxiety, and HRV), there was no normal distribution. The relationship between HRV, mood states, and pre-competitive anxiety was verified by quantile regression. The Spearman correlation tested the relationship of HRV with self-confidence. All analyses were performed with Stata / MP 14 software (Stata Corp - USA).

RESULTS

Heart Rate Variability and Mood States

Table 1 presents the results of the regression analysis conducted to examine the relationship between HRV and the moods of the young male basketball athletes at the beginning of a sports season. The Table shows no association between HRV and the mood states of the athletes ($P>0.05$). In this case, the lack of resonance or cardiorespiratory coherence expressed by athletes (VFC = 3.14 ± 1.20) was not associated with low scores found for the mood states (tension = 4.06 ± 3.00, depression = 0.64 ± 1.22, anger = 1.08 ± 1.56, fatigue = 2.81 ± 2.38 and mental confusion = 2.03 ± 1.90, nor with moderate score found for the vigor state = 9.78 ± 2.66).

Table 1. Quantile Regression between HRV and Mood States.

VFC	Min Value	Max Value	Coef	Standard Error	P	t
T	0	13	-0.015	0.980	0.879	-0.15
D	0	6	0.117	0.278	0.676	0.42
A	0	6	0.164	0.204	0.428	0.8
V	3	15	0.127	0.090	0.168	1.41
F	0	9	-0.046	0.112	0.684	-0.41
C	0	8	-0.125	0.137	0.369	-0.91

T = Tension; **D** = Depression; **A** = Anger; **V** = Vigor; **F** = Fatigue; **C** = Confusion

Heart Rate Variability and Pre-Competitive Anxiety

Table 2 shows the results of the quantile regression analysis between HRV and the athletes' Pre-Competitive Anxiety (as measured by CSAI-2R). As shown in Table 2, the results of this study showed no relationship between HRV and the three dimensions (frequency, intensity, and direction) of the pre-competitive anxiety scales (P>0.05). That is, the lack of resonance found to HRV (3.14 ± 1.20) had no association with the frequency (12.97 ± 6.83) and intensity (9.67 ± 2.92) of the moderate scales of somatic anxiety, which showed a positive direction (facilitative) (1.08 ± 4.99) and with moderate frequency (16.03 ± 6.05) and low intensity (10.81 ± 2.42) of the cognitive anxiety, who presented negative effect (-2.50 ± 5.74). Neither was there any relationship between the confidence scale with moderate frequency (23.03 ± 5.57), low intensity (15.58 ± 2.65), and positive direction (7.75 ± 4.18) with HRV.

Table 2. Quantile Regression between HRV and Precompetitive Anxiety.

VFC	Min Value	Max Value	Coef	Standard Error	P	t
SAF	6	37	-0.026	0.051	0.617	0.51
SAI	6	18	-0.040	0.132	0.767	-0.3
SAD	-8	13	0.032	0.061	0.598	0.53
CAF	5	33	0.050	0.067	0.46	0.75
CAI	7	16	-0.251	0.136	0.077	-1.84
CAD	-11	12	-0.054	0.054	0.326	-1.00
SCF	14	34	0.009	0.056	0.875	0.16
SCI	10	20	0.211	0.153	0.18	1.38
SCD	-6	15	-0.080	0.089	0.377	-0.9

SAF = Somatic Anxiety Frequency; **SAI** = Somatic Anxiety Intensity; **SAD** = Somatic Anxiety Direction; **CAF** = Cognitive Anxiety Frequency; **CAI** = Cognitive Anxiety Intensity; **CAD** = Cognitive Anxiety Direction; **SCF** = Self-Confidence Frequency; **SCI** = Self-Confidence Intensity; **SCD** = Self-Confidence Direction

Heart Rate Variability and Self-Confidence

A Spearman correlation coefficient was used to test the relationship between HRV and the levels of self-confidence in the male basketball players, which was measured by the Sport Confidence Inventory (SCI). The results indicate a weak correlation of HRV with the self-confidence of the athletes (r=0.338 and P=0.046). This demonstrates that the athletes who have more self-confidence are at increased cardiac coherence, that is, they had more balance between the sympathetic and parasympathetic branches.

DISCUSSION

This study investigated the relationship between HRV, mood states, pre-competitive anxiety, and self-confidence in young male basketball athletes. In the pre-competitive stage, the HRV, as measured by biofeedback CardioEmotion®, indicated lack of resonance or cardiorespiratory coherence, signaling an imbalance between the sympathetic and parasympathetic branches with a sympathetic dominance (11).

The assessment of HRV using biofeedback provided immediate information about behavior in several psychophysiological areas (27,45,50). A wide HRV indicates the balance between the sympathetic and parasympathetic branches and, when in its maximum amplitude, it may promote a better sport performance (5,15,36). Although the literature (24,27,40,46,47) indicates that the HRV can be an important resource to the athletes in training and in competitions, because it shows instantly the athletes' physical and psychological condition (36), there are still few studies on this issue. There are also few studies that relate the use of HRV in monitoring the mood states (26), as well as anxiety (16,24) and self-confidence. Besides, the results are still controversial (3,16), highlighting the difficulty of understanding the interaction between the cardiovascular function and the ANS (2).

Heart Rate Variability and Mood States

In the present study, there was no relationship between low HRV and the athletes' mood states. Although monitoring of HRV (6) can act in a complementary fashion to the actual state of the athlete by assisting in the evaluation of the athlete's perception of control (1), the results appear to show that the athlete is either not conscious of his physiological state or is not under his perceptional subjectivity (28). Thus, the data brings attention to the possible problem of the interference of subjectivity on psychological instruments that despite scientifically validated still need to be clarified to describe the perception of the athlete's real condition (42).

Considering that the relationship between HRV and mood states (such as stress, anger, and vigor) can be understood by the activation of the sympathetic branch (1), the lack of relationship between these variables in this study may demonstrate that the young male athletes are well-adapted (5) or, on the other hand, were not able to accurately perceived their real emotional state (43). Regarding the variables depression, fatigue, and confusion, they are not expected to be at high levels in pre-competitive situations in beginner athletes (especially since such symptoms refer to signs of overtraining) (30).

We also emphasize that the tension is related to the tone, stiffness, and muscle contraction (42) and, despite being related to sympathetic activation may or may not be a positive factor, depending on the sport (6). The fact that the athletes in this study demonstrated low tension is a positive sign of the adequacy of their training (42).

Since depression involves the reduction in some aspects of emotional activity, reduced initiative, and low energy (42), a direct relationship of HRV with depression was not expected. Although it is related to the low tone of the vagus nerve, its prevalence in athletes with rigid training conditions is small. Besides, regular physical activity is known to decrease depression (1).

Anger is characterized by the athlete's aggressive behavior and/or hostility, signal impulsivity, and lack of control. It commonly arises during a competition or after a bad personal or team performance in association with the failure to win or to play well (42). Since it is was not expected to witness the manifestation of anger in precompetitive conditions (42), the absence of the relationship with HRV appears to be coherent (26).

With respect to fatigue, which is characterized by the athlete's low physical energy, lack of motivation, and general tiredness, researchers (51) have warned of the need to develop evaluation protocols based on the HRV (51) to prevent the athlete's subjectivity to interfere or change the perception of the athlete' status (42).

Regarding the mental confusion that is linked to uncertainty states, obnubilation, and indecision (42), the findings indicate that the athletes' normal status was expected (6). As to the athletes' vigor, since vigor is characterized by activation of the body, giving mood, and energy (42) and the sympathetic division of the ANS generates general activation of the organism (44), the finding is inconsistent with the observed data in the present study that showed low HRV and high scores for vigor. On the other hand, the results found in this study are similar to those found by other researchers (1,2,6,26,44), in which the adaptation of the athletes to training is characterized by positive mood states, with high vigor, and reduced negative emotions (42). This finding suggests a good emotional adjustment from the athletes to the competition situation (5).

Heart Rate Variability and Pre-Competitive Anxiety

No correlation was found in the present study between HRV and the pre-competitive anxiety, considering the scales of cognitive and somatic anxiety, and self-confidence in the three dimensions investigated (intensity, frequency, and direction). These results are in agreement with the findings of Parrado et al. (38), although they used another version of the CSAI. They found low scores for the scales of cognitive and somatic anxiety and high scores for self-confidence, attributing the lack of correlation between the variables to the perception of athletes on their emotional state. On the other hand, the results found in another study (39) indicated a relationship of anxiety with HRV in the athletes, but the authors did not justify the relationship (39). Chalmers et al. (9) demonstrated that pre-competitive anxiety is correlated, mild to moderate, with low HRV. They assigned the effect of reducing anxiety in HRV to cognitive factors (such as worry) and behavioral (such as avoidance). Dziembowska et al. (14) also found a relationship between anxiety and HRV in athletes who went through HRV training. In this study, the authors argue that reducing anxiety was linked to a mechanism of brain waves (i.e., *Theta* waves in the frontal cortex) at the same time HRV was improved (4).

The absence of a relationship between anxiety and HRV found in the present study appears to be related to the fact that the athletes were new and novice competitors who did not realize or understand the actual essence or meaning of their anxiety (42). Furthermore, the fact that the self-confidence of the athletes was high may have contributed to their perception of less pressure. They may have interpreted the competitive situation as less threatening and, therefore, responded with less anxiety (19). Regardless, given the controversial data, there is the need for more research with tighter controls on the variables (9).

Heart Rate Variability and Self Confidence

The correlation, as determined by the SCI, between HRV and the self-confidence levels of athletes in the present study is weak. This finding suggests that the self-confident athletes may represent a better balance between the sympathetic and parasympathetic branches, which tends to confirm the good psychological state of the athletes and their responses to competitive demands (14.34,35,41).

CONCLUSIONS

This study showed no significant correlation between HRV, mood states, and pre-competitive anxiety in young male basketball athletes and a weak correlation between HRV and the self-confidence. However, it is noteworthy that monitoring the athletes' HRV and its relationship to psychological states is still incipient with few studies. With more work in this and, in particular, with increased attention of using biofeedback to evaluate and train the ANS, it may become an important tool in the improvement of psychophysiological factors in athletes. Hence, despite the weak evidence found in this study, monitoring and training HRV through cardiovascular biofeedback appears to be a promising tool for delineating the actual psychophysiological status of athletes along with other somatic/physiological markers to help them to understand the difference between perceived psychological processes (how they feel - informed in inventories) and results (manifest psychological processes - indicated by HRV).

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