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Original Research Article

Effects of autonomic control on performance of Archers: A comparative study on novice and experienced archers

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Abstract

Background: The beats of the healthy heart are not absolutely regular. It varies due to several factors, such as exercise, and physical and mental stress. This variability in the heart rate is mainly modulated by the autonomous nervous system. Higher parasympathetic activity and better balance between the sympathetic and parasympathetic system are beneficial to the performance of archery. A correlation analysis of HRV with scoring of archers will give an insight to the effects of HRV on performance of archery.

Methods: A total of 26 archers were divided into two groups, Group 1 (n=13) were the novice archers and Group 2 (n=13) were experienced archers. Heart rate variability (HRV) was measured for both the groups at resting for 10 minutes and during shooting with the help of Biofeedback equipment (Biograph Infiniti, Thought Technology). Score of each shot was monitored. Comparison of HRV parameters between the two groups and correlation of scores with HRV parameters was obtained using SPSS17.

Results: **S**ignificant difference in LF/HF ratio was obtained between novice and experienced archers. Significant correlations of scores were obtained with heart rate during shooting (r = -0.607**), pNN50 (r = 0.257**), SDNN (r = 0.363**) and LF/HF (r=-0.501*).

Conclusion: Higher HRV is beneficial to the performance of the sport. Archery is a game of focus and control, thus players who exhibit balance of the autonomic system are able to perform with greater accuracy. With training archers develop ability to stay relaxed which is evident from their greater parasympathetic drive.

Keywords: heart rate variability, sympathetic system, parasympathetic system.

1. Introduction

The heart is considered the source of emotion, courage and wisdom. The heart and the brain communicate with each other and the activity of heart influences our perceptions, emotions, intuition and health. Heart coherence is an optimal physiological state which is associated with increased cognitive function, self regulatory capacity, emotional stability and resilience [1].

Heart rate variability (HRV) is a well-established non-invasive tool which can be used to study the effect of mental stress on autonomic control of the heart rate (HR) [2-4]. Heart rate variability is considered the most dynamic and reflective indicator of one's emotional states, and thus current stress and cognitive processes. Stressful or depleting emotions such as frustration and overwhelm lead to increased disorder in the higher-level brain centers and autonomic nervous system which are reflected in the heart rhythms and adversely affects the functioning of virtually all body systems [1].

There is clinical evidence about the specificity and sensitivity of the HRV parameters to assess the reduction in

parasympathetic activity related to several anxiety forms [5]. Although in the sport competitive field the relationship between HRV and emotions have been less studied, the reduction in parasympathetic cardiac control has been found in chess players in real situation [6]. As a dynamic marker of loads, HRV appears to be sensitive and responsive to acute stress. Experimentally, it has been shown that mental load (i.e., making complex decisions, public speaking tasks) decrease HRV [7].

The central nervous system controls the heart rate by varying the impulse traffic in sympathetic and parasympathetic nerve fibres terminating in the sinoatrial node [8]. Sympathetic nervous system activity increases when humans are anxious or are in a stressful situation. Parasympathetic nervous system activity increases when humans are carefree or at rest [9]. On archery performance, heart rate variability is associated with higher parasympathetic activity. It has been stated earlier that a balance between parasympathetic and sympathetic activity is beneficial for good performance in this sport.

In a study conducted on novice and experienced archers it was seen that experienced archers showed a higher LF band, RMSSD and pNN50. They demonstrated an increase in parasympathetic nervous system activity compared with pre-competition values. These characteristics were proposed to be appropriate for the optimal performance of an archer [10]. The experience of the archer results in better accuracy and lesser heart rate [11].

It has been suggested that the experience of the archer may help improve the arousal control and better balance between the sympathetic and the parasympathetic autonomic nervous system. Deceleration in heart rate in experienced athletes in the few seconds prior to execution has been observed in shooting [12] and archery [13] and is associated with good performance.

The present study aims at studying the differences in the autonomic profile of experienced archers as compared with novice archers, as a result of sport specific training. Another goal of the study is to analyze the effects of autonomic control on the performance of archers which is studied by the time domain and frequency domain parameters of the HRV.

2. Methodology

2.1 Subjects

A total of 30 archers were contacted for the study, out of which, 26 cleared the inclusion and exclusion criteria. Before the conduct of the assessment informed consent was taken from them.

The archers were divided into two groups, novice and experienced depending on number of years they have spent in training. Both the groups had equal number of participants (13 in both groups) and ratio of male and female participants (10 male and 3 female participants in both groups). The study was conducted on archers from Come & Play scheme of Sports Authority of India at Jawahar Lal Nehru Stadium, Delhi and National Campers training at Rajiv Gandhi Sports Complex, Rohtak.

2.2 Methodology

Heart Rate Variability Test which measures the inter-beat intervals was conducted for every archer using the biofeedback equipment (Biograph Infiniti, Thought Technology). The test was first done during resting before starting with the shooting and then during shooting. Prior to shooting, resting measurements of heart rate variability were taken for 10 minutes in sitting position, following 5 minutes of resting period. The electrode was applied to the palmar aspect of the proximal phalanx of the index finger of left hand. Both time domain and frequency domain parameters were assessed including, heart rate, SDNN, pNN50, VLF, LF, HF, LF/HF ratio. For every player the measurements were done during the same time of the day to avoid any bias due to the circadian rhythm variation.

During shooting, the measurements of heart rate variability were taken using the same protocol, but for 30 sec duration just before every shooting round. Heart rate was also monitored for every shot. The archers were allowed to shoot at the distance they were confident in. The time allowed for shooting of arrows was similar to that allowed during competitions. Record of score of each and every arrow shot was taken to compare the heart rate variability measurements with the score.

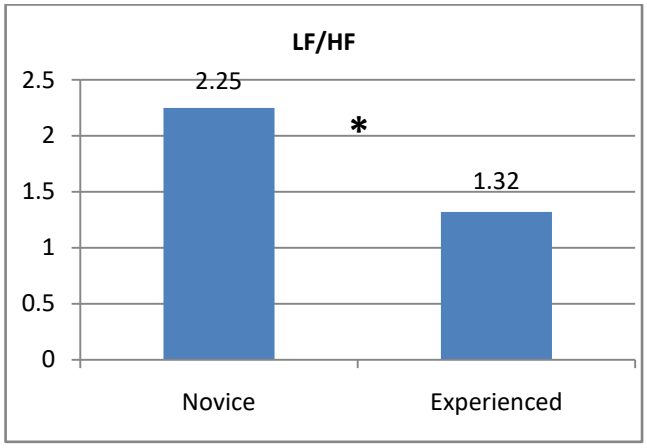
2.3 Statistical Analysis

Comparison of heart rate variability between novice and expert archers was done using the independent samples t-test. For the analysis of the correlation of scoring with heart rate and the various parameters of heart rate variability (LF/HF, HF, LF, pNN50, SDNN) Pearson's correlation coefficient was used. The software used for these tests was SPSS17.

3. Results

Comparison of the heart rate variability parameters between the novice and the experienced archers showed a significant difference in the LF/HF parameter (Figure 1). Although, the other parameters did not show any significant differences but their trend is indicative of greater parasympathetic drive in experienced archers as compared to novice archers, as shown in Figure 2.

The high frequency (HF) and pNN50 parameters of HRV which are indicative of parasympathetic control are higher in experienced archers.



* - Significant (p<0.05)

Figure 1: Comparison of LF/HF in novice and experienced archers

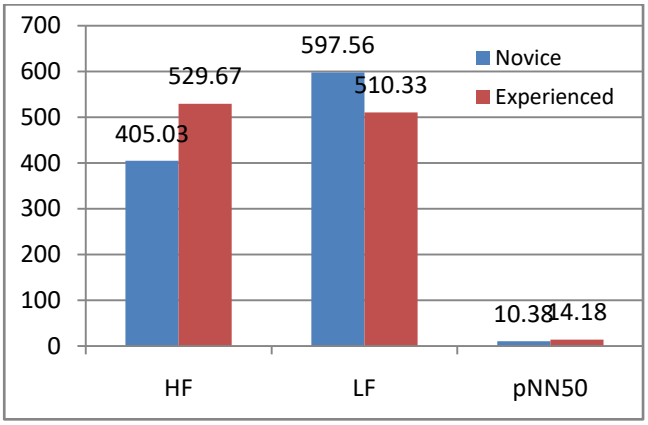


Figure 2: Various parameters of HRV in novice and experienced archers

Measurement of HRV during shooting brought forward interesting findings that state that better autonomic control is beneficial to the performance of archery. The correlations of scores with heart rate prior to shooting and HRV are shown in figure 3(a-d).

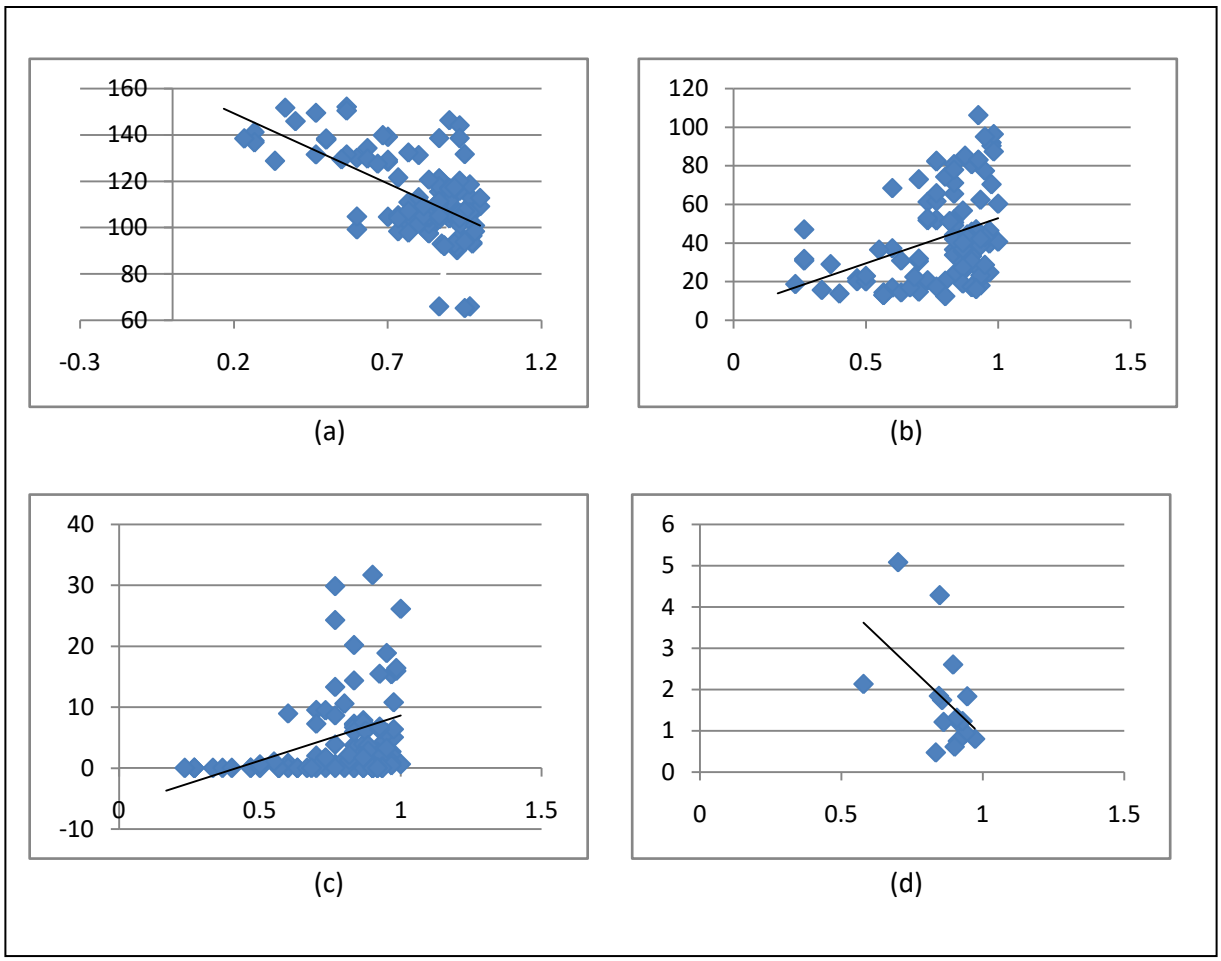


Figure 3(a): Correlation of scores with heart rate (-0.607), (b) Correlations of scores with SDNN (0.363**), (c): Correlations of scores with pNN50 (0.262**), (d): Correlations of scores with LF/HF (-0.501*)**

* Significant (p<0.05)
** Significant (p<0.01)

4. Discussion

Archery is a game of skill and focus. Anxiousness and stress is detrimental to every sporting activity, but it can have significant effect on archery performance due to the immense focus that is required in the game. To improve accuracy in shooting and archery events, it is important to have a lower heart rate and reduced anxiety to provide a calmer environment. Strong negative correlation ($r=-0.607$, $p<0.01$) was obtained when a correlation of scores and measure of heart rate just prior to the shot was done. Beta-blockers are drugs that control heart rate, hand tremor and anxiety, which is an advantage for sports like archery where a steady hand is important. They are banned in archery and shooting since 1986 [14], both during competitions and out of competitions [15].

With training and experience archers improve their arousal control and consequently, balance between the sympathetic and parasympathetic systems [11]. Comparison of LF/HF ratio between novice and experienced archers presented similar findings. The experienced archers showed a better balance between the sympathetic and parasympathetic control whereas in novice archers sympathetic system was found to be dominant. A higher parasympathetic activity has been reported to be beneficial to the performance of this sport [9]. The physiological symptoms of fight/flight response associated with performance anxiety and panic (pounding heart, cold/clammy hands, increased respiration, sweating, etc.) are significantly reduced, thus allowing anxious individuals to concentrate on the task at hand [16]. Higher heart rate variability in experienced archers in our study signifies this.

Study of time domain and frequency domain parameters of heart rate variability during shooting shows that higher heart rate variability is associated with higher scoring. SDNN, which is considered the global HRV measure, is significantly positively associated with scores ($r=0.363^{**}$). Time domain measures of SDNN, RMSSD and pNN50 are measures of high frequency variations in heart rate [4] and they also show positive correlation with scoring. Earlier studies have reported increased attention as well as relaxation in elite archers when an analysis of EEG was done, while mid-level archers showed increased attention but decreased relaxation [17]. It is known that higher LF/HF values reflect domination of the sympathetic system whereas lower values reflect domination of parasympathetic system. Negative correlation with LF/HF states that greater parasympathetic drive is associated with better scoring and vice versa. All the observations made in the study reflect a better control of autonomic system is beneficial to the performance of an archer and this must be used to provide scientific support to archers to train them to control their stress and anxiety.

Based on the study it would be meaningful to conclude that heart rate variability biofeedback training can prove beneficial to archers. Efficacy of HRV biofeedback treatment to decrease anxiety has been reported in the past. Stress and anxiety share a number of symptoms associated with physiological arousal induced by fight or flight response. It seems that HRV biofeedback not only directly teaches clients to change those physiological reactions to anxiety and stress but also assists clients to enhance self-efficacy and a sense of mastery with direct feedback. Those advantages specific to HRV biofeedback treatment may implicate the potential benefit of utilizing HRV biofeedback treatment in stress management programs and anxiety reduction treatment [18].

5. Conclusion

Maintaining optimal levels of arousal and relaxation is essential to good performance of precision sports such as archery and shooting. In sports such as archery, even a small level of anxiousness would lead to greater deviations in accuracy of the arrow due to the physiological effects anxiety has on the player. Thus it is important for the archer to maintain correct balance of sympathetic and parasympathetic balance. This can be achieved by providing biofeedback training in heart rate variability to the archers.

The current study was conducted in a simulated environment. Thus, all the factors that affect an archer's physiological system during a competitive event could not be studied. The author suggests a similar study to be conducted during a competitive event so that all the factors that affect the physiological status of the archers during that time can be studied.

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