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Original Article

Study of the Heart Rate and Accuracy Performance of Archers

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Abstract
On archery performance, heart rate variability is associated to higher parasympathetic activity and a better balance of parasympathetic and sympathetic are beneficial to performance within the sport (Lo, Huang & Hung, 2008). The purpose of this study was to compare heart rate and archery accuracy in experienced and inexperienced archers as to determine if experience contributes to increased accuracy and decreased heart rate. Eighteen male individuals (23.2 ± 5.3 years) participated. The task consisted in the realization of archery, aiming to achieve higher scores corresponding to greater accuracy in target. Twelve trials were performed at two blocks (i.e., total of twenty-four trials) by each participant. At each archery attempt, we collected the heart rate immediately before the trial and the respectively accuracy of archery performance. The t-independent test showed significant statistical differences on heart rate ($t_{(430)}$ = - 4.135, p-value = 0.001) and score of archery performance ($t_{(430)}$ = 2.745, p-value = 0.006), between experienced and inexperienced archers. Experienced archers exhibit a better accuracy and at same time a less heart rate comparing to inexperienced archers. It is possible that the experience of the archers help to improve the arousal control and, consequently, balance between sympathetic and parasympathetic systems.
Key words: sports performance, sympathetic nervous system, parasympathetic nervous system, arousal, archery.

Introduction

Neural influences are superimposed on the intrinsic rhythm of the myocardium (McArdle, Katch & Katch, 1996). The central nervous system controls heart rate by varying the impulse traffic in sympathetic and parasympathetic nerve fibers terminating in the sinoatrial node (Robinson, Epstein, Beiser & Braunwald, 1966). Heart rate and rhythm are the result of the intrinsic automaticity of the sinoatrial node and the modulating influence of the autonomic nervous system (Lo, Huang & Hung, 2008).

In essence, on physical exercise, the primary role is taken by the sympathetic nervous system although the withdrawal of parasympathetic activity is also important (Birch, McLaren & George, 2005). In most physiological conditions the efferent sympathetic and parasympathetic branches have opposing actions: the sympathetic system enhances automaticity, whereas the parasympathetic system inhibits it (Sztajzel, 2004). The sympathetic is responsible for speeding up the body systems and is sometimes designated the 'fight or flight' response. The parasympathetic is responsible for returning the body to normal functioning and can be thought of as the 'rest and digest' response (Draper & Hodgson, 2008).

The sympathetic nervous system is the key driver of the physiological changes within the body at the start of exercise (Draper & Hodgson, 2008). It is generally agreed that sympathetic blockade lowers the heart rate during exercise, a finding which suggests that sympathetic stimulation contributes to cardiac acceleration (Robinson, Epstein, Beiser & Braunwald, 1966). Sympathetic stimulation causes a relaxation of the airway in the lungs, an increase in heart rate, breathing rate and depth, an inhibition of digestion, stimulation of endocrine function, release of exercise-related hormones and vasoconstriction of blood vessels supplying the organs of the abdomen, such as the stomach, kidneys and intestine (Draper & Hodgson, 2008). Stimulation of the sympathetic cardioaccelerator nerves releases the catecholamines epinephrine and norepinephrine. These neural hormones act to accelerate the depolarization of the S-A node and cause the heart to beat faster (McArdle, Katch & Katch, 1996). The effects of the sympathetic nervous system and the release of the hormone adrenalin during exercise can increase SA node rhythm to an individual's heart rate maximum (Draper & Hodgson, 2008). It should be noted that sympathetic nervous system activity increases when humans are anxious or are in a stressful situation (Lo, Huang & Hung, 2008).

On the other hand, the cell bodies of the parasympathetic nervous system are located in the brain stem and sacral portion of the spinal cord. When stimulated, these neurons relase the neurohormone acetylcholine, with retards the rate of sinus discharge to slow the heart (McArdle, Katch & Katch, 1996). Nervous stimulation of the SA node via the parasympathetic division slows the natural rhythm of the SA node to around 70–75 bts min^{-1}

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(Draper & Hodgson, 2008). Parasympathetic nervous system activity increases when humans are carefree or at rest (Lo, Huang & Hung, 2008).Arousal is the component of several emotional responses, including anxiety and fear, and is characterized by feelings of apprehension, nervousness, and tension. The physiological manifestations of arousal include, among others, increased blood pressure, heart rate, hyperventilation, or musculoskeletal disturbances (Noteboom, Fleshner & Enoka, 2001). In sports that require accuracy, the high level of arousal can decrease the performance of the participants. On rifle shooters, Sade, Bar-Eli, Bresler and Tenenbaum (1990) found that highly skilled shooters were less anxious and performed better across all competitions than moderately skilled shooters.

On archery performance, heart rate variability is associated with higher parasympathetic activity. A balance between parasympathetic and sympathetic activity is beneficial to performance within the sport (Lo, Huang & Hung, 2008). Adaptations in the ANS are tricky to assess but changes in target tissue responses such as resting heart rate, due to greater parasympathetic tone and lowered exercise heart rates at the same external work rate suggest training influences on neural activation (Birch, McLaren & George, 2005). Therefore, it is possible for experienced practitioners to maintain a lower heart rate compared to the novice participants.

The purpose of this study was to analyze the heart rate and accuracy performance of experienced and inexperienced archers, trying to verify if the experience contributes to a reduction in heart rate and increase the accuracy of archery performance.

Methods

Participants

Eighteen male individuals (23,2 ± 5,3 years old) participated voluntarily in this study. Of the total participants, nine had experience at the archery and nine had not. All individuals signed the Free and Clarified Consent Form respecting the Declaration of Helsinki.

Materials

For this study, we used two portable heart monitors (Polar FT4), four right-handed and one left-handed recurve initiation bows (68º). Also used twenty-five arrows, one protection net and two official's archery targets.

Task and Procedures

The task consisted in the realization of archery, aiming to achieve higher scores corresponding to greater accuracy in target.

Figure 1. Experimental Procedure

Before the study began, participants were informed of the aim of the study, providing information on all the procedures and purposes. After signing the informed consent, the participant was equipped with a heart monitor.

After the heart rate monitor was calibrated, we provide three attempts not accounted to adapt the participant with the task. Later gave up early to experimental study where the investigators collecting values of accuracy through the target points (zero - the less score and ten - top score), as well as the values of heart rate, immediately before at archery performance, which was provided online at the computer monitor.Twelve trials were performed at two blocks (i.e., total of twenty-four trials) by each participant. Between each attempt, participants passively recovered.

Statistical procedures

We used the t-independent test to establish the statistically significant differences between experienced and inexperienced archers. The assumption of normality distribution of t-independent was investigated using the Kolmogorov-Smirnov test with correction Lillefors. It was found that the distributions are not normal in the dependent variable. Although it was not normal, since n ≥ 30, using the Central Limit Theorem (Maroco & Bispo, 2003; Pedrosa & Gama, 2004) we assumed the assumption of normality (Akritas & Papadatos, 2004). The analysis of homogeneity was carried out using the Levene test. It was found uniformity score but there is no uniformity under the heart rate variable. However, despite the lack of homogeneity, the parametric test is robust to homogeneity violations when the number of observations in each group is equal or approximately equal (Vicent, 1999; Gageiro & Pestana, 2008; Maroco, 2010), which is our case. This analysis was performed using the IBM SPSS program (version 19) for a significance level of 5%.For the correlation analysis, we used the parametric Pearson's r test. Given that the statistical sample constituted as n ≥ 30, then the Central Limit Theorem will be able to assume normality (Pedrosa & Gama, 2004; Maroco & Bispo, 2003). Tests for linear correlation of Pearson apply when intended to test whether the relationship between two variables exists. The measure to use depends on the measurement scale of two variables: Pearson when have two quantitative variables and assumed normality of the data (Laureano, 2011).

Results

Experienced archers had a lower heart rate (87.20 bts min) in comparison to inexperienced archers (93.96 bts min). In addition experienced archers displayed higher accuracy, obtaining higher score (6.20 pts) compared to inexperienced archers (5.48 pts).

Table 1. Descriptive statistics of the experienced and inexperienced archers

		N	Mean	Std. Deviation
Heart Rate	Experienced	216	87.20	14.22
	Inexperienced	216	93.96	19.36
	Total	432	90.58	17.30
Score	Experienced	216	6.20	2.68
	Inexperienced	216	5.48	2.72
	Total	432	5.84	2.72

The t-independent test showed significant differences in heart rate, between experienced and inexperienced archers ($t_{(430)}$ = - 4.135, p-value = 0.001).

Table 2. Significance values of the experienced and inexperienced archers

	t	Sig.	Mean Difference
Heart Rate	-4.135	0.001	-6.76
Score	2.745	0.006	0.71

In the case of the score, t-independent test showed significant statistical differences between experienced and inexperienced archers ($t_{(430)}$ = 2.745, p-value = 0.006). In addition, it appears that experienced archers have a more and, consequently, better score in relation to inexperienced archers.

Table 3. Correlation values between heart rate and score of archery performance

		Score
Heart Rate	Pearson Correlation	- 0.026
	p-value	0.594
	n	432

There is statistical evidence to assert that the pairs are negatively intimacy related (p = 0.594). In fact it appears that there is an negative intimacy and inverse relationship between pairs (since the linear correlation coefficient $r_{(432)}$ = - 0.026), i.e., when the heart rate increases, the score decreases as well as the reverse.

Discussion

The aim of this study was to verify differences between experienced and inexperienced archers on parameters of heart rate and scores to determine a relation between heart rate and archery performance and if this relation is stronger in experienced archers.Data shows an inverse relationship between heart rate and score although the correlation values are low. However, this relation can be justified through the type of sport selected. In reality, sports accuracy need's a low arousal levels and a balance between sympathetic and parasympathetic stimulation.

Experienced archers evidence a better accuracy and at same time a less heart rate comparing to inexperienced archers. It is possible that the experience of the archers helped to improve the arousal control and, consequently, balance between sympathetic and parasympathetic systems. This argument can be supported on less heart rate of experienced archers. In fact differences between experienced and inexperienced archers on heart rate are statistical significant. The over-aroused archers are related to more sympathetic activity, which could be detrimental to a sport that requires relatively low stimulation (Lo, Huang & Hung, 2008). Indeed the inexperienced archers present a less score and high levels of heart rate, but isn't possible to concluded it was an over-arousal that decrease the accuracy archery or just the inexperience of archers.

However its possible suggest that the higher parasympathetic activity and a better balance of parasympathetic and sympathetic activity are beneficial to performance within the sport accuracy (Lo, Huang &

Hung, 2008), specifically in archery. Given the considerations mentioned above its possible verify that experience of archers can improve the accuracy and, at same time, decrease the heart rate, suggesting that the experienced archers can balance the sympathetic and parasympathetic systems and control yours arousal.

Conclusions

The experience of archers results on better accuracy archery and less heart rate, verifying that experienced archers statistical differs to inexperienced archers. In next studies we recommend an analysis of variability heart rate between experienced archers, trying to verify if the best performance correlate to less heart rate and best balance between sympathetic and parasympathetic systems.

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