Original Article

The influence of the auto-training technique on the excretion of catecholamine in archers under different psychological states

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ABSTRACT

The aim of this study is to analyse the improvement of the archer's readiness based on a specialized psycho-regulatory training technique using biochemical methods of controlling the excretion of catecholamines. The sample consisted of fifteen archers (KMS and MS) aged between 18 and 20 (mean 19.3 ± 0.28), divided into two groups (experimental and control). Before each training, the archers of the experimental group used the proposed technique of increasing the level of psychological readiness. The biochemical examination of the archers was carried out in two stages: during training and during competitions. Before physical activity, urine samples of the archers were taken, in which the content of the catecholamines was determined by the liquid chromatography in the columns. The application of the auto-training technique during the archer's meeting sessions did not change the excretion of catecholamine hormones. Whereas the systematic application of psycho-regulatory techniques during active competitions led to a decrease in the A concentration and an increase in the NA concentration in the experimental group archers ($p < .001$). The variance analysis established a significant contribution of the auto-training technique to changes in the excretion of Adrenalin (56.1% ($p < .01$)) and Noradrenaline (72.7% ($p < .001$)). The contribution of unaccounted factors to the performance of the archers remained significant but was unreliable. The systematic application of the method of increasing the level of psychological readiness allows you to adjust the level of catecholamines and, accordingly, positively influence the athlete's performance during active competitions.

Keywords: Archer, Catecholamine, Competition, Variance analysis, Auto-training technique, Sports performance.

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INTRODUCTION

Archery is a sport that is characterized by a significant and intense psychological load; it is accessible to a wide range of people, no matter their age, gender, or ability, it can be practiced by both physically healthy athletes and athletes with certain health disabilities on equal terms (Vendrame et al., 2022).

To attain mastery in archery sport requires the archer to have high movement coordination and clear balanced actions, and for this, a significant level of physical fitness of the athlete is required (Vynogradskyi, 2012; Muazu et al., 2016). Muazu et al. (2019) concluded that the combination of core body strength, upper body strength, handgrip, leg power (Martin et al., 1990; Ertan et al., 2003), body static balance, and its balance (Hrysomallis, 2011) are important to ensuring stability, which, in turn, affects the accuracy of the arrow hitting the target. Better stability of the archer will lead to a smaller angle of the arrow's parabolic trajectory. This will minimize any interference from extraneous factors that can change the arrow's course. Moreover, Spencer et al. (2004) documented that physical fitness components are essential for successful performance in the sport of archery.

Stress hormones, in particular, adrenaline (A or epinephrine) and norepinephrine (NA or norepinephrine), are responsible for adaptation processes both at rest and during exercise of various physical loads (Sybil, 1996; Sybil et al., 2017). The catecholamine importance as regulators of the body's adaptive reactions (Eiden, 2013) stems from their properties to accelerate the metabolism quickly and intensively in the body, stimulate glycogen and fats breakdown, cause the accumulation of glucose in the blood. Also, the catecholamines promote the fatty acids' oxidation, increase the O_2 absorption by tissues, cause a redistribution of blood in the tissues, as well as increase the performance of the heart and skeletal muscles, the excitement of the nervous system, and participate in the development of the emotional reaction. (Kvetnansky et al., 2013).

Among the factors that affect the sympatho-adrenal system of the body reaction (Sybil, 1996), it is necessary to name firstly emotional tension, which is particularly expressed in intellectual sports (Vynogradskyi, 2007). The emotional tension of the archer additionally changes the increase in the concentration of blood catecholamines during exercise. Other factors that increase the concentration of catecholamines during exercise are increased or decreased environmental temperature (Weiss et al., 1988; Brenner et al., 1998), even in invertebrates (Avramov et al., 2013), as well as hypoxia (Sybil et al., 2015; 2009).

Usually, under equal conditions, the athlete who knows how to control his psycho-physiological state and balance the processes of inhibition and excitement to the level that most favourably and effectively affects the technique of shooting and obtaining a high result, wins. Studies have shown that minor disturbances in the attention process can lead to dramatic changes in an athlete's performance in the final stages of competition (Lu et al., 2021; Druckman and Bjork, 1991). Therefore, the main task of the sportsman-archer training is the formation, development, and improvement of the athlete's psychological readiness before the start, his psycho-physiological state, concentration of attention, and self-analysis to obtain the maximum result (Vynogradskyi, 2007).

The relationship between the concentration of the hormones in the blood and heart rate and oxygen consumption has been confirmed in untrained and trained individuals, in particular, in rowers (Premel-Cabic et al., 1984), cyclists (Lehmann et al., 1981), sprinters and runners on endurance (Zouhal et al., 2001). There is a direct relationship between the level of catecholamines and lactate; however, this relationship becomes less precise during higher exercise intensities. In addition, it was confirmed that higher physical fitness in wrestlers of national rank significantly reduced the response of NA and angiotensin in blood plasma to

maximal physical loads, which required special skills in performing tasks that were not included in their training program (Vigas et al., 1998). The wrestlers' training did not cause an increasing A response in the blood plasma to the physical exertion. However, data on the dynamics of the catecholamine changes in the urine of the archers during training and active competitions, especially after the use of a specialized auto-training technique (increasing the level of psychological readiness), are scarce.

This study therefore sought to quantitatively assess (on the dispersion analysis) the contribution of the specialized auto-training technique in the improvement of the psychological readiness of the highly qualified archers based on using biochemical methods of controlling the catecholamine excretion.

MATERIAL AND METHODS

Participants

Five archery masters and 10 KMS athletes (young men, age of participants – 18-21 (mean 19.3 ± 0.28)) took part in the experiment. Written approval was obtained, and all the archers signed consent forms. To determine the effectiveness of the auto-training technique, the athletes were divided into two groups (experimental and control), each consisting of five people. Before each workout, the athletes of the experimental group used the proposed auto-training technique. The research lasted from September to March and took place in two stages. The archers also had to present a clean bill of health, with no injuries, aches, or ongoing medication.

Procedures

The research was conducted based on the Department of Shooting and Technical Sports and the Department of Biochemistry and Hygiene (Ivan Bobersky Lviv State University of Physical Culture). The psychological-pedagogical experiment consisted of the introduction of an auto-training specialized method of regulating the psychological states of the archers (Vynogradskyi, 2012); it was carried out for 2 months.

The specialized method of increasing the level of psychological readiness of archers (auto-training method) includes the concentration of attention on each element of the technique and the nature of the athlete's emotional feeling during the execution of a bow shot (Vynogradskyi, 2012).

The application of the auto-training technique consisted in the fact that before each training, the archer athletes first perform the calming part (in one of the positions: lying on the back, semi-lying in a soft chair or in the coachman's position). After the first part of the auto-training, archers go to execution the immobilizing part of the psycho-regulatory training.

Then the athletes started shooting and before the real shot (in a standing position) applied the 3rd part of the ideomotor training. The athlete closes his eyes and clearly imagines the scheme of the correct shot. And only after ideomotor training and scrolling through the elements of the shot, a combat shot is fired.

The biochemical examination of the athletes also was carried out in two stages: during training meeting (Rest) and active competitions (Start). The content of catecholamine in the urine of archers was determined by liquid chromatography in columns (Kamyshnykov, 2003).

Data analysis

The statistical analysis of the data (difference probability of the determined indicators (Student's t-test) and normality of the distribution) was carried out using the SPSS Statistics Base program

(https://www.ibm.com/products/spss-statistics), one-way ANOVA tests was conducted to compare the share of the contribution of the applied auto-training technique to the performance athletes (Glantz, 1997). The mean (M) and standard deviation (SD) were used to describe the data. *p*-values of < .05 or lower were set as statistically significant.

RESULTS

As a result of a biochemical study of the catecholamine excretion in the urine of the archers, the following data were obtained. Excretion of A at the Rest state (during training meeting) of the shooters before and after training in both the control and experimental groups was approximately the same and did not differ significantly. Before training, A excretion was on average 2.63 ÷ 0.29 ng/min, and after training – 2.8 ÷ 0.39 ng/min (Figure 1). Therefore, the auto-training technique application during archery regular meetings had not a significant effect on the release of the hormone A.

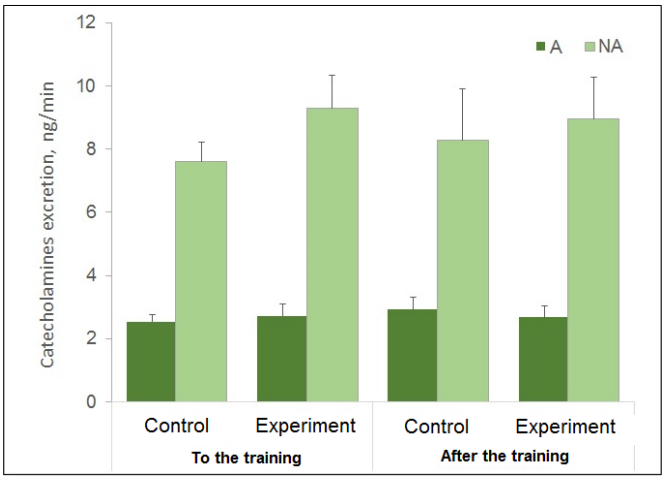
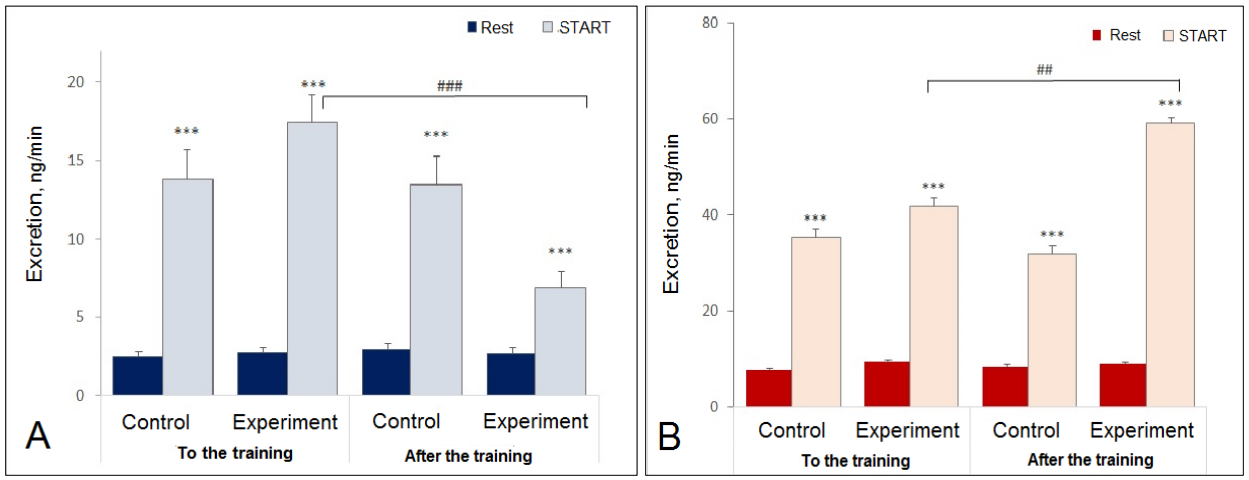


Figure 1. Excretion of the adrenaline (A) and noradrenaline (NA) in the archers at the Rest state (during training meeting; n = 15).



*Note. *** – p < .001 – significant changes compared to the Rest state; ## - p < .01; ### – p < .001 – significant changes compared before training.*

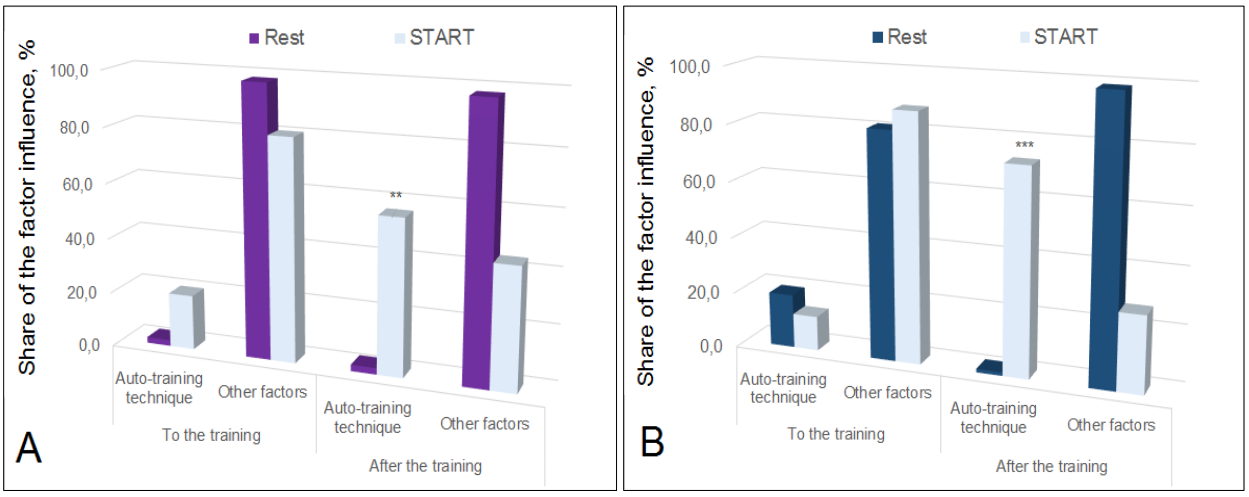
Figure. 2. Catecholamines excretion (A – adrenaline, B – noradrenaline) in the archers on the Start state (during active competitions) compared to the Rest state (during training sessions; n = 15).

NA excretion by the adrenal glands, as well as A, in the Rest state in the archers of both research groups also did not differ. In the control group before training, NA excretion was 7.62 ÷ 0.61 ng/min, after training – 8.28 ÷ 1.64 ng/min; in the experimental group using psycho-regulatory training before training – 9.3 ÷ 1.05 ng/min, after training – 8.96 ÷ 1.32 ng/min. It should be noted that pronounced changes in NA during training sessions of athletes testify to the emotional component of the psychological state of athletes (Zouhal et al., 2008). Therefore, the auto-training technique method application during the meeting sessions of the archers did not change the hormone of catecholamine excretions by the adrenal glands.

During the sports competitions (the Start state), significant changes in the A excretion in the archers' urine of the experimental group were found. A significant increase in the A concentration in the urine during active competitions (Figure 2, A) compared to this hormone excretion at the Rest state (during training meeting) was established. The use of psycho-regulatory technique over a long period (at least two months) led by three times to a decrease in the A concentration ($p < .001$) of the archers of the experimental group after training in relation to the A excretion before training. It is interesting that after training, the A excretion in the experimental group by 2 times compared to the control group during active competitions. In the control group, significant reliable changes in the A excretion were not detected (Figure 2, A).

Similar changes in the catecholamine excretions after the use of auto-training technique were also found for NA at the Start state in the archers of the experimental group. After physical training, NA excretion in the experimental group by 2 times increased compared to the control group (Figure 2, B). Evidence suggests that through psycho-regulatory technique, we can reduce A excretion and increase NA excretion, which is a favourable factor during competitive performance. Thanks to this, the results of the athletes of the experimental group in exercise M-3 increased by 11 points on average, while in the control group only by 2 points.

To find out the dependence of changes in the catecholamine excretions in the archers under different states (performing physical exercises or the use of specialized methods of increasing the level of psychological readiness), it was considered appropriate to quantitatively assess, compare, and confirm the presence or absence effect of a psycho-regulatory technique on the body of the archers.



*Note. ** – p < .01; *** – p < .001.*

Figure. 3. One-way ANOVA analysis of the auto-training technique on the catecholamine excretions (A - adrenaline, B - noradrenaline) in the archers on the Start and Rest states.

One of the adequate methods of assessing the influence of the factors (by relative shares of the influence on the variability of the values of the studied indicator), as well as statistically confirming such influence on the functioning of the organism, is the one-way ANOVA analysis (Glantz, 1997). This powerful statistical method makes it possible to conduct an adequate examination of the variability of the experimental dates.

The results of the one-way ANOVA analysis are shown in Figure 3. At the Rest stage was revealed an unreliable contribution of the influence of the auto-training technique of the archers on the performance and excretion of the hormones of the adrenal glands (for A - 2.2% and for NA 19.2%). The influence share of other unaccounted factors exceeded 95%. So, at the first stages of the application of the auto-training technique, the main factors that determine the archers' performance during training are the athlete's physical preparation and emotional state.

The long-term systematic use of the auto-training technique of the archers' readiness (at least two months) changed the contribution of the share of the effect of the method using to changes in the excretion of the adrenal glands' hormones.

At the Start stage, the contribution of the specialized auto-training technique to changes in A excretion was 56.1% ($p < .01$), and to changes in NA – 72.7% ($p < .001$). It should be noted that the contribution of unaccounted factors to the performance of athletes remained substantive (43.9 and 27.2%, respectively), but was unreliable.

DISCUSSION AND CONCLUSIONS

The psychological factors significantly affect archer performance during archery games. Many experienced archers are unable to perform as well as they normally would because of the tension, anxiety, and stress caused by the game itself (Parnabas et al., 2014). Mostly, stress activates the hypothalamic-pituitary-adrenal (HPA) axis and the sympatho-adrenal brain system (SAM). HPA axis activity increases cortisol levels, while SAM system activity increases catecholamine levels (Ali & Pruessner, 2012). Stress levels are commonly measured by the concentrations of cortisol (Ali & Pruessner, 2012) and blood catecholamines (Kennedy et al., 2001). However, the salivary alpha-amylase, secreted into the saliva for starch digestion, is known to increase when sympathetic nerves are activated during situations of physical and mental stress (Robert-Mercier et al., 2015; Gords et al., 2006).

The mobilization of the energy and functional capabilities of archer depends on the state of the sympatho-adrenal system, and catecholamines are known to be an important indicator of the state of this system (Vyunytska et al., 2022). Determination of the level of these biogenic amines in the plasma and urine of the athletes is an important indicator of the state of the central and peripheral nervous system of athletes. Adaptation of the body to the action of stressors occurs primarily through changes in the work of the central nervous system, immune, and endocrine systems (De Kloet et al., 2005). In a state of stress, the medulla of the adrenal glands' releases adrenaline, a catabolic hormone that affects all types of metabolism and plays an important role in the body's adaptation to stress. The adrenaline activates the glucose release and fatty acids from adipocytes, which the body uses as energy to respond to stress. This hormone increases the mental mobilization and activity of the body, but the long-term effect of an adrenaline high concentration on the energy exchange system causes an increase in protein catabolism, which leads to general exhaustion of the body (Vyunytska et al., 2022).

The archers' special training is decided comprehensively by the athletes and includes (Vendrame et al., 2022): special orientation (raising, holding, and lowering the weapon places a load on the defined muscle groups that are strained when performing these actions); technical orientation (working out the technique elements: preparation, breathing, aiming, descent); tactical orientation (choice of the pace and rhythm of the firing; rest interval); the selection of release processing options depending on the meteorological conditions and psychological orientation (attuning to a good shot, concentration of the attention on the execution of the individual elements of the technique, coordination of the weapon stability, aiming, release, etc.).

As you know, regular archer training is aimed at developing strength, speed, dexterity, and general endurance, so these pieces of training do not trigger maximum psychological stress on the athlete's body during meeting sessions. While in the conditions of the official competitions (Start stage), psychological orientation plays almost the most significant influence on the athlete's performance.

Functionally, the catecholamines are responsible for the adaptive state at rest and during exercise. Jacob's studies (2004) have documented differences in catecholamine excretion in response to physical training in male and female subjects, both trained and untrained subjects. Increased epinephrine secretion has been observed in response to exercise and other stimuli, including hypoglycaemia and hypoxia (Jacob et al., 2004). According to some authors, this phenomenon can partially explain the higher physical performance observed in trained subjects compared to untrained ones.

Based on the results of the variance analysis, it can be stated that the level of catecholamine excretion in the urine during the training of the archers depends on the physical training and the emotional and psychological state of the athlete. The systematic application of the auto-training technique allows you to adjust the level of the adrenal gland hormones and, accordingly, positively influence the athlete's performance during active competitions.

So, it was established that the systematic application of the specialized method of increasing the level of psychological readiness of athletes-archers allows for the reduction of the excretion of adrenaline and increasing of the excretion of noradrenaline at official competitions. Such change of catecholamine excretion is a favourable factor for competitive activity and obtaining a high positive archer's result.

AUTHOR CONTRIBUTIONS

All authors collaborated in the design and regular review of the manuscript. BV was the main responsible for the writing and execution of the study. MB wrote the results and part of the statistical analysis. AH and IH contributed to the translation. MS and MR drafted the abstract and supervised the conclusions.

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DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

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