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Anxiety sensitivity, stress, and postural control: their implications on archery performance in 11–14-year-olds

original paper
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ABSTRACT

Purpose. Archery, a sport based on individual performance, requires postural stability, concentration and the ability to cope with stress. The effect of stress on success, however, is not clear in the adolescent age group. The present study investigates the association between stress and trait anxiety levels and postural control and shooting performance in young adolescent archers.

Methods. Included in the study were a total of 22 licensed archers (6 female; 16 male) aged between 11 and 14 who were evaluated using the 'Anxiety Sensitivity Index-3' and 'Trier Social Stress Test' (child version, arithmetic component) to measure their trait anxiety status and susceptibility to stress, respectively. Stress was measured based on the number of heartbeats per minute. An evaluation of static postural control was made using a pedobarography device before arrow release, with and without subjecting the archer to stress. To assess performance, 10 arrows were shot at a target 18 metres away, twice – before and after subjecting the participant to stress..

Results. Postural control showed no significant change under stress. However, the participants' trait anxiety status inversely correlated with shooting success. Post-stress shooting scores correlated with total ASI-3 score (r = –0.513; p = 0.021) and its social sub-group (r = –0.634; p = 0.003).

Conclusions. A moderately inverse correlation can be noted between the trait anxiety state and shooting success in young adolescent archers subjected to stress. Furthermore, stress was observed to have a detrimental effect on the shooting success of people with a high level of trait anxiety.

Key words: adolescent, Trier's Social Stress Test for Children, trait anxiety

Introduction

It is a known fact that exercise and sports have numerous benefits for both physical and mental health, and when it comes to success in sports, the mental preparedness of athletes is equally as important as physical preparedness. In order to improve athletes' performance, it is important to support their efforts to increase their motivation, strengthen their mental resilience and improve their ability to cope effectively with stress. However, at the same time, increasing their ability to recognise the causes of stress can have a positive impact on them achieving superior sport performance. These strategies are among the important topics frequently discussed in the sport psychology and performance enhancement literature [1, 2].

In daily life, the adolescent age group encounters many stress factors, including physiological factors caused by hormonal and physical changes, and environmental factors such as family, school and their peers [3]. Adolescence is considered an important age in the development of stress reactions. Adolescents may associate the stress factors experienced in this period with negative affection, anxiety or depression [4].

Stress is an outcome of any event or situation that evokes negative emotions or thoughts in a person. A particular stress factor may not trigger stress in all individuals, and similarly, people encountering a stress factor cannot be expected to develop similar negative thoughts and emotions [5]. Stress initiates various physiological responses in the body, with the most easily observable ones being those related to circulation and

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respiration. Heart rate is a reliable parameter as an indicator of sympathovagal activation [6]. A study of athletes and non-athletes reported stress and depression to be less common among athletes, while no difference was observed in anxiety [5], suggesting a need to distinguish between stress and anxiety. The Trier Social Stress Test (TSST) is a method designed to understand acute stress responses in humans and is frequently used in studies in this field. The TSST aims to induce stress by forcing participants to give a high-pressure speech and solve a mental arithmetic test involving elements of social evaluation and uncertainty[7]. The strength of the TSST is that it can consistently trigger activation of the hypothalamus-hypophysis-adrenal axis in humans. This test has become an important tool in understanding the neurobiological basis of stress, especially in exploring how various factors, such as sex, age and genetics, influence the stress response. With these features, the TSST is considered the 'gold standard' in research on the neurobiology of acute stress [8]. People suffering from stress-related disorders (depression, panic, anxiety) have been observed to respond differently to the TSST than healthy individuals. The adaptive nature of the TSST has allowed it to be used with groups (TSST-G) [9], with children (TSST-C) [10] and in virtual situations (VR-TSST) [11]. These adaptations have broadened the applicability of the test and made it responsive to different research needs [12, 13]. The TSST adapted for children and adolescents (TSST-C) is the only recommended adaptation of the standardised TSST protocol for use with children and adolescents aged 7–16 years [14]. This adaptation includes a public speaking task and a mental arithmetic task. The core component of the TSST-C is the threat of social evaluation, and this was noted as an aspect of particular relevance in child and adolescent participants. An increase in the stress response to social evaluation has been observed during childhood and adolescence. The TSST-C is an important tool for understanding children and adolescents' stress responses to the threat of social evaluation and can be used to explain differences in the magnitude and duration of stress responses of individuals in these age groups [10, 14].

Negative emotional states, including nervousness, worry and doubt, which are associated with the activity or stimulation of the body, are called anxiety. Anxiety is basically divided into two subgroups: state anxiety and trait anxiety; state anxiety is defined as a temporary psychological state that an individual experiences within a certain period of time and especially under stress, while trait anxiety reflects the general tendencies of the individual and the levels of anxiety he/she shows during different situations and times. Trait anxiety is considered to be more of a persistent personality trait and usually manifests as a more prolonged and constant state of anxiety [15]. It has been suggested that individuals with high levels of trait anxiety show impaired ability to block distracting information, even under non-stressful conditions [16]. Even though anxiety is usually perceived as a negative and undesirable situation, it does not always have a negative impact on performance. Anxiety in sports refers to 'an unpleasant psychological response to stress resulting from the performance of a task under pressure' [17].

Various psychometric scales are used to assess anxiety and its subcomponents. In particular, the ASI-3 is known as a tool that measures the way individuals interpret anxiety symptoms and the intensity of their response to them. This scale examines anxiety sensitivity under three separate components; physical, cognitive and social anxieties. The physical concerns subcomponent measures bodily reactions to anxiety, while the cognitive concerns focus on the effects of anxiety on thinking processes. Social concerns assess the effects of anxiety on social interactions and perceived social threats. The ASI-3 is a psychometric scale used to determine an individual's general predisposition to anxiety (trait anxiety) [18, 19].

Balance is achieved when the vertical projection of the body's centre of gravity is within the base area of support, and it is achieved and maintained based on feedback from the visual, vestibular and proprioceptive systems, which are constantly evaluated by the central nervous system. This, as a result, produces coordinated movements. It is important to maintain balance and an upright posture in daily life, and this is particularly important when it comes to sports [20]. In a study conducted by Cumberworth et al. in healthy children aged 5–17 years, it was reported that postural control starts to develop in early childhood and this development shows a linear relationship with age [21]. Recall that Steindl et al. [22] have shown that proprioceptive function seemed to be mature at 3–4 years of age, while visual and vestibular afferents only reached an adult level at 15–16 years.

Today, archery is recognised and studied as a discipline that challenges not only the perfection of physical strength and skill of athletes [23] but also the limits of mental resilience and concentration. This sport, which requires a high level of mental discipline, creates increased levels of mental stress in athletes, which is closely related to state anxiety as an important determinant of the athlete's performance [24]. Archery is a static sport in which success requires postural stability, coordination of body segments, attention and concentration [25], as well as the ability to cope with mental stress, being a further important criterion [26]. Like all other forms of stress, mental stress brings about a sympathetic activation in the body [27]. Among the physiological changes that occur, the effects on respiration and circulation disturb postural stability [28].

The aim of this study was to investigate the relationship between trait anxiety levels and shooting performance under stress in archers aged between 11 and 14 years. For this purpose, the participants' trait anxiety levels determined by ASI-3 and the effects of mental stress applied through the Trier Social Stress Test child version on shooting success were compared. The research aims to understand the psychological factors affecting the performance of young archers and to contribute to the development of training methods to improve their mental toughness by using this information. At the same time, it was aimed to reveal the effect of the level of trait anxiety on success in an individual sport such as archery when stress is encountered.

Material and methods

Participants

All licensed archers aged 11–14 years (6 female; 16 male) in our region who met the inclusion criteria were included in the study. The demographic data of the participants as the lowest, highest, mean (± *SD*) were as follows; age 11–14 years (11.90 ± 1.90), height 136–186 cm (156.50 ± 14.35), weight 28–90 kg (51.18 ± 15.94), body mass index 14.29–28.04 kg/m^2 (20.54 ± 4.36) and duration of practicing the sport 2–36 months (13.50 ± 10.51).

Inclusion criteria:

1 – Approval by the participant and their family

2 – Being a licensed archer at the national level

3 – Not having experienced a trauma requiring treatment in the last 6 months

4 – Not having a known neurological or endocrine problem

5 – No cognitive disability that may bring about problems in communication or simple calculations

Measures

Heart rate measurement

Heart rate was measured as an indicator of autonomic system activity. Accordingly, the average, maximum and minimum heart rates of the participants were recorded using a Polar RS400 (Polar, Electro OY, Kempele, Finland) chest-strap device and a data logger watch.

Evaluation of balance

Balance was measured using the oscillation analysis program of the Tekscan HR MatScan (Tekscan, Boston, USA) plantar pressure measuring device, which calculates the force midpoint from data received simultaneously from the sensors. The oscillation analysis program provides five different data:

– Area: The elliptical area containing the 95% confidence interval of the pressure midpoints of the received data (cm2).

– Distance: The sum of the distance between the pressure midpoints when they lie sequentially (cm).

– Variance: The variability of the distance in millimetres when the pressure midpoints are positioned sequentially.

– Anterior-posterior (A-P) Excursion: Considering the initial position, this is the vertical distance between the frontmost and rearmost pressure midpoints (cm).

– Left-Right (L-R) Excursion: Considering the initial position, this is the vertical distance between the rightmost and leftmost force midpoints (cm).

Evaluation of stress and anxiety status

The Trier Social Stress Test for children was used to put pressure on the participants [29]. Only the mental arithmetic component of this test was applied, in which the subject was asked to count backwards from 1000 (in 7s, 9s, 11s or 13s) before the second shooting. In order to ensure randomness during the countdown, different numbers were assigned to each participant and before each shot, and they were asked to count backwards from 1000, and if they made a mistake, they were asked to count from the beginning again. The participants were asked to continue counting for at least 60 seconds, and stress was attempted to be created at times by questioning the number they had reported.

The Turkish version of the Anxiety Sensitivity Index-3 (ASI-3) was used to determine the trait anxiety status of the participants before the study [18].

Based on a five-point Likert-type measurement approach, the ASI-3 comprises a total of 18 items divided into three sub-dimensions (physical, cognitive and social), each containing six items. Potential scores range between 0 and 72, with higher scores indicating greater anxiety sensitivity.

Design and procedures

This cross-sectional study was conducted to determine the extent to which trait anxiety affects shooting success in the face of a stress stimulus in adolescent licensed archers.

The participants were asked to use the bow they would normally use in competition. The target was a board similar to those used in international competitions, with a diameter of 60 cm, which was commonly used in indoor competitions and training sessions for various skill levels. The target features 10 concentric rings, each assigned a specific point value. The outermost ring was worth 1 point, and the value increases by 1 point for each ring closer to the centre, with the innermost ring scoring 10 points. The arrows were standard competition arrows. The participants were asked to shoot at the target from a distance of 18 metres. For each stage of the experiment, the participants were given 10 arrows to shoot at the target, and the most successful and the most unsuccessful shots were disregarded, while the total score of the remaining shots was recorded as the success of the shooting.

The data were collected during the off times of the athletes, during which the researcher spent time with the athletes one-on-one, when they were first asked to fill out the ASI-3. The archers were asked to warm up by shooting 5 arrows. A Polar RS400 sensor was attached to their chests to record their heart rates, and their static balance was measured before the shootings using an HR MatScan plantar pressure measuring device, through which balance was recorded at a 50 Hz frequency for 40 seconds. The participants were then asked to shoot 10 arrows at a target 18 metres away, during which their scores and heart rates were recorded. After the shootings, the participants were given a 1-hour break, after which they were asked to return to their shooting places, and to count down from 1,000 (in 7s, 9s, 11s or 13s). After 1 minute of counting down, their balance was measured again for 40 seconds, and after the completion of the measurement, they were asked to shoot 10 arrows at a target 18 metres away, and their heart rates were again recorded during the shootings.

Statistical analysis

The SPSS for Windows (Version 15.0. Chicago, SPSS Inc.) statistical software was used for the analysis of the data. The data were entered into the program, and the Shapiro–Wilks test was performed to examine the normality of distribution. Data with an abnormal distribution (only heart rate values) were analysed with non-parametric tests, including a Wilcoxon signed-rank test, while data with a normal distribution were investigated with a dependent sample *t*-test and a Pearson's correlation analysis. Simple linear regression analyses were performed to estimate shooting success. In all analyses, $p < 0.05$ was accepted as statistically significant.

Ethical approval

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the Manisa Celal Bayar University, Faculty of Medicine Local Ethics Committee (approval number: 2017-36294).

Informed consent

Those taking part in the study were informed verbally about the study objectives and the measurements that would be made, and a signed voluntary consent form was obtained from all the participants and their parents. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Results

The ASI-3 test was applied at the beginning of the experimental protocol to measure the participants' trait anxiety status, and the relationship between their pre- and post-stress shooting success and trait anxiety score was investigated. A statistically significant, negative correlation was observed between post-stress shooting success and trait anxiety status, and a statistically significant inverse correlation was detected between the social sub-group result of the ASI-3 test and both pre- ($r = -0.454$, $p = 0.044$) and post-stress ($r = -0.634$, $p = 0.003$) shooting success (Table 1).

No statistically significant difference was observed between the pre- and post-stress minimum, maximum and mean heart rates (Table 2).

A comparison of the static balance parameters of the participants revealed no statistically significant difference between the pre- and post-stress static balance measurement results ($p > 0.05$) (Table 3).

A simple regression analysis was performed to create a model to reflect the relationship between shooting success and trait anxiety status. According to this regression analysis, a statistically significant relationship exists between the total ASI-3 score and post-stress shooting success ($F(1.21) = 6.417$, $p = 0.021$). Based on the results of the application of this model, it can be argued that the ASI-3 score calculated from

Table 1. Association between ASI-3 results and shooting success

		ASI-3			
		Physical	Cognitive	Social	Total
Pre-stress shooting score	*r*	–0.263	–0.267	–0.454	–0.370
	p	0.263	0.255	**0.044**	0.108
Post-stress shooting score	*r*	–0.330	–0.398	–0.634	–0.513
	p	0.155	0.083	**0.003**	**0.021**

The bolded values were significant at $p < 0.05$.

Table 2. Results of a paired sample *t*-test based on heart rates recorded during the first shootings and during the second shootings during which a stress factor was applied

	Pre-stress				Post-stress				*p*
	Min	Max	Mean	*SD*	Min	Max	Mean	*SD*	
Heart-min.	62	108	86.18	16.11	65	105	82.68	28.75	0.795
Heart-max.	77	138	117.59	12.82	94	142	119.36	13.66	0.505
Heart-mean	64	119	104.64	12.94	68	129	105.64	14.41	0.680

Table 3. Results of a paired sample *t*-test based on static balance parameter values obtained using the pedobarography device before and after the application of a stress factor

	Pre-stress				Post-stress				*p*
	Max	Min	Mean	*SD*	Max	Min	Mean	*SD*	
Area	12.91	0.26	3.66	3.29	22.73	0.29	3.78	4.80	0.908
Distance	844.30	134.40	377.17	185.14	593.55	151.15	346.13	131.92	0.131
Variance	0.39	0.06	0.17	0.08	0.27	0.07	0.16	0.06	0.365
Anterior-posterior excursion	7.05	0.33	3.01	1.46	5.99	0.59	2.72	1.30	0.313
Left-right excursion	6.63	1.22	2.77	1.24	7.28	1.22	2.81	1.37	0.855

Table 4. Simple linear regression analysis of total ASI-3 score and shooting success.

Variables	Estimated variable: post-stress shooting score						
	B	SHB	β	*t*	*p*	Pearson correlation	Partial correlation
Constant	9.215	0.718		12.840	0.000		
Total ASI-3	–0.113	0.045	–0.513	–2.533	**0.021**	–0.513	–0.513

The bolded values were significant at $p < 0.05$.

Table 5. A stepwise regression analysis of post-stress shooting success based on ASI-3 sub-dimensions

Variables	Estimated variable: post-stress shooting score						
	B	SHB	β	*t*	*p*	Pearson correlation	Partial correlation
Constant	9.215	0.718		12.840	0.000		
Social ASI	–0.462	0.133	–0.634	–3.478	**0.003**	–0.634	–0.634

The bolded values were significant at $p < 0.05$.

the participant data explains 26.3% of the variance in post-stress shooting success (β = –0.513; R^2 = 0.263) (Table 4).

A stepwise regression analysis was performed to detect which ASI-3 sub-group(s) best explained the post-stress shooting success. A model was created based on the obtained results, and after the application of the model, post-stress shooting success was found to be explained solely by the social dimension of the ASI-3 (F(1.21) = 12.098, p = 0.03). According to this model, the social dimension of the ASI-3 explains 40.2% of post-stress shooting success (β = –0.634; R^2 = 0.402) (Table 5).

Discussion

In this study of 22 individuals aged 11–14, it was determined that the arithmetic component of the TSST-C, which was used to create stress, led to no statistically significant difference in either heart rate or postural stability. Furthermore, when the shooting success was analysed based on a comparison of the pre- and post-stress scores, no statistically significant difference was observed.

The association between post-stress shooting scores and the ASI-3 test results – especially the social component – which was applied before the test to determine the trait anxiety status of the participants, was investigated, revealing a statistically significant inverse correlation, meaning that the higher the trait anxiety of the respondent, the lower the shooting score (ASI-3 social: r = –0.634, p = 0.003; ASI-3 total: r = –0.513, p = 0.021).

Psychologically speaking, stress is a term that is often used in daily life to describe a difficult situation to manage. Acute stress arises from environmental or bodily threats leading to a number of physiological reactions in the body, including the hypothalamic-pituitary axis, sympathetic autonomic system activation, etc. Furthermore, the higher cognitive areas of the brain, as well as lower centres such as the brainstem and hypothalamus, which play a role in the development of autonomic and neuroendocrine responses, make assessments with regard to the concerned anxiety, make decisions and assess the threat level of the experience, therefore playing a role in the stress process. These regions of the brain are also the target of stress and stress hormones [30]. Developed by Kirschbaum et al., the Trier Social Stress Test [7] for children (TSST-C) was used in the present study to create a psychobiological stress response. Accordingly, the arithmetic component of the test was used to create stress, after which shooting success was evaluated. The objective was to have the respondents perform their shots when their stress level was at its highest. This test has been proven to activate the hypothalamic-pituitary axis, to affect the immune system, to activate the sympathetic system, and to generate a cardiovascular response [27, 31, 32]. In the present study, the heart rate parameter was calculated to estimate the autonomic response to stress, although no statistically significant difference was observed between the pre- and post-stress heart rates (p = 0.680). This can be attributed to different causes. First of all, those who engage in sports may have a lower stress response [5]. Furthermore, the test was applied individually rather than in groups, which may explain the lack of an adequate autonomic response in the volunteer group [32]. Furthermore, the children may have already been exposed to constant stress, brought on by their success-oriented lifestyle, and especially under pressure from their families, and so the stress response may have developed even before starting the test. There have been previous studies reporting differences in the stress responses of males and females in neuroendocrine and behavioural terms [33, 34], however, no statistically significant difference was observed in the average heart rates (considered a stress response) of the female and male respondents. Having said that, it is obvious that the desired stress response could not be obtained with the TSST-C, of which only the arithmetic component was used, which may be attributed to numerous miscellaneous and unknown reasons, and can be considered a weakness of our study. Some researchers argue, however, that stress responses triggered by TSST, especially in humans, may lead to cortisol levels that do not exceed normal limits, and therefore an adequate stress response may not develop [35]. The social component of the TSST in particular is reported to be effective in creating an adequate stress response [35, 36], although in the present study, we failed to expose the archers to stress using the arithmetic component of the TSST-C. In other words, considering the lack of cardiovascular response and based on the fact that the participants were able to maintain their balance, it can be argued that we failed to produce the desired stress levels, and therefore no change was observed in shooting success.

A normal stress response is needed in humans to cope with internal or external factors that threaten the body, although any response that is lower or higher than normal may be harmful to the health. A prolonged stress response, in particular, may cause anxiety [37]. In people with higher anxiety sensitivity, situations that cause mental stress can have a negative impact on success in the fulfilment of the tasks assigned to them [38]. In the present study, a close inverse association was recorded between anxiety sensitivity and shooting success ($r = -0.513$, $p = 0.021$), which can be attributed mostly to the social component of the anxiety sensitivity index ($r = -0.634$, $p = 0.003$). In the 11–14 years age group assessed in the present study, the higher the anxiety sensitivity, the lower the shooting success. In a meta-analysis by Kleine et al. investigating the association between anxiety and sports performance in different age groups, the strongest association was found in the 10–14 age group, and the same study found that the association between anxiety and performance was a lot closer in amateurs than in more qualified athletes [39].

In Weinberg and John's investigation of the relationship between different levels of anxiety and stress, as well as motor performance, it was observed that people with high state anxiety performed poorly under stressful conditions, which was associated with the fact that they paid attention to stimuli unrelated to the task given (i.e. internal self-evaluation). The authors reported these individuals to be more successful in focusing on their tasks when the conditions were less stressful, and so to perform better. On the other hand, they pointed out that people with low state anxiety performed better under highly stressful conditions, but that these people demonstrated poor motor performance under low-stress conditions, as they focused their attention on stimuli unrelated to the task [40]. This concept, called the Inverted-U theory, is a continuation of the 'positive linear theory' in which it is argued that stress is mostly a positive factor in terms of motor performance. Accordingly, at the peak of moderate stress, performance is also at a maximum, but when stress goes beyond this point, performance is adversely affected [41].

In a review of studies investigating the relationship between anxiety and sportive performance, it was found that anxiety had an impact on performance, especially in individual sports, but that the same did not apply to team sports. It was further pointed out that athletes with high state anxiety experience instantaneous anxiety reactions at greater frequencies and intensities, although the experience of the athlete was argued to be decisive in controlling such situations [42, 43]. Additionally, self-confidence-enhancing efforts in the event of instantaneous anxiety were proven to increase athletic performance in archers [44]. There are studies suggesting that anxiety may have both a facilitative and a negative role in sportive performance [45, 46]. A study showing that increased levels of anxiety during the Covid-19 pandemic caused inconsistent shooting performance in archers suggests that anxiety negatively affects performance in archery, an individual sport [47]. Martens et al. reported anxiety to have two components when it comes to sports, namely cognitive and somatic, in which the cognitive component involves negative expectations related to success (negative linear relationship), while the somatic component is a physiological and affective component that is directly related to an autonomic stimulus, with both low and high levels affecting sportive performance negatively. The same researcher presented a third factor – self-confidence – and stated it to be in a positive linear relationship with performance [48]. The present study is compatible mostly with sports performance and somatic sub-components of anxiety. Accordingly, rather than identifying a relationship between instantaneous anxiety and performance, a negative correlation is noted between state anxiety and performance. Whether the anxiety-performance relationship is closer to the positive linear, negative linear or inverted-U theories is still a matter of debate. Having said that, according to our study of archers aged 11–14 years, it is closer to the negative linear theory.

It is known that there are conceptual differences between stimulation and stress. Researchers argue that all demands can cause stimulation [49, 50], while there is a lack of consensus on the demands leading to stress, although it is argued that demands beyond one's abilities lead to stress [35]. In the present study, the attempts to induce stress failed to lead to autonomic responses that reflected stress indirectly, and no stressful environment was created since the tasks did not go beyond the individuals' abilities. As such, it would not be fair to talk about a stress situation that negatively affects performance.

Postural control and balance are important parameters for success in many branches of sports. The pre- and post-stress static balance parameters of the participants in the present study were measured, and no statistically significant difference was observed between them ($p > 0.05$). Furthermore, no association was found between balance parameters and shooting performance. As with the previous heart rate values, we observed that the targeted mental stress had no effect on static balance. In archery, postural control is defined as a significant factor for success [51]. In Mason and Pelgrim's study of junior and elite archers, they found postural stability to be more important for young archers than elites, especially when it comes to shooting success [52]. Similarly, Stuart and Atha reported postural stability not to be of primary importance for success in elite archers [53]. Another study showed that shooting success decreased as postural sway increased, especially in the preparation and aiming phases [54].

An analysis of physiological, psychological and performance data obtained from licensed archers in puberty and with different levels of experience revealed that the mental stress aimed to be created with the TSST-C could not be created in this age group. Moreover, no statistically significant difference was found between the pre- and post-stress balance data. It was determined that shooting success was inversely correlated only with the trait anxiety state, revealing anxiety sensitivity as an important factor affecting success in archery. Unlike instantaneous anxiety, it is apparent that anxiety sensitivity is a problem that is difficult to overcome, even with experience and intense exercise, and so anxiety sensitivity can be used as an objective criterion in the selection of athletes at an early age.

The present study showed the arrow shooting performances of participants with high levels of trait anxiety to be negatively affected by stress. Even though the desired autonomic response could not be induced through the experimental stress model, the correlation analyses revealed the existence of a strong inverse correlation in arrow shooting success after the application of a stress stimulus (ASI-3 social: $r = -0.634$, $p = 0.003$; ASI-3 total: $r = -0.513$, $p = 0.021$). Furthermore, the trait anxiety level can be used as a model to predict 40.2% of shooting success, which reveals the trait anxiety state to be an important factor in shooting success. However, considering the use of only the arithmetic component in studies using the TSST-C, it is suggested that it would be more appropriate to ensure familiarisation between the volunteers and the research group so that the social component of the test does not cause a pre-stress physiological response in repeated measurements.

Conclusions

Based on the study results, it can be argued that assessments of the trait anxiety state may be highly beneficial in the selection of athletes at an early age and in predicting how an athlete will perform under stress. It can further be argued that trait anxiety status plays a more important role in shooting success than the stress factor. We thus conclude that determining the trait anxiety states of athletes, especially those engaged in individual sports such as archery, can be significant when it comes to athlete selection and training.

Disclosure statement

No author has any financial interest or received any financial benefit from this research.

Conflict of interest

The authors state no conflict of interest.

References

1. Olmedilla A, Moreno-Fernández IM, Gómez-Espejo V, Robles-Palazón FJ, Verdú I, Ortega E. Psychological intervention program to control stress in youth soccer players. Front Psychol. 2019;10:2260; doi: 10.3389/fpsyg.2019.02260.
2. Gross M, Moore ZE, Gardner FL, Wolanin AT, Pess R, Marks DR. An empirical examination comparing the mindfulness-acceptance-commitment approach and psychological skills training for the mental health and sport performance of female student athletes. IJSEP. 2018;16(4):431–451;doi:10.1080/1612197X.2016.1250802.
3. van Rens FECA, Borkoles E, Farrow D, Curran T, Polman RCJ. Development and initial validation of the role strain questionnaire for junior athletes (RSQ-JA). Psychol Sport Exerc. 2016;24:168–178; doi: 10.1016/j.psychsport.2016.02.004.
4. Romeo RD. Adolescence: a central event in shaping stress reactivity. Dev Psychobiol. 2010;52(3):244–253; doi: 10.1002/dev.20437.
5. Mishra M, Tiwari S, Shah MM. Comparison of depression, stress and anxiety, between sports person and non-sport persons. Int J Appl Res. 2016;2(6):210–212.
6. Pereira T, Almeida PR, Cunha JPS, Aguiar A. Heart rate variability metrics for fine-grained stress level assessment. Comput Methods Programs Biomed. 2017;148: 71–80; doi: 10.1016/j.cmpb.2017.06.018.
7. Kirschbaum C, Pirke KM, Hellhammer DH. The 'Trier Social Stress Test' – a tool for investigating psychobiological stress responses in a laboratory setting. Neuropsychobiology. 1993;28(1–2):76–81; doi: 10.1159/000119004.
8. Allen AP, Kennedy PJ, Dockray S, Cryan JF, Dinan TG, Clarke G. The trier social stress test: principles and practice. Neurobiol Stress. 2017;6:113–126; doi: 10.1016/j.ynstr.2016.11.001.
9. von Dawans B, Kirschbaum C, Heinrichs M. The Trier Social Stress Test for Groups (TSST-G): A new research tool for controlled simultaneous social stress exposure in a group format. Psychoneuroendocrinology. 2011;36(4): 514–522; doi: 10.1016/j.psyneuen.2010.08.004.
10. Thomassin K, Raftery-Helmer J, Hersh J. A review of behavioral observation coding approaches for the Trier Social Stress Test for children. Front Psychol. 2018;9: 2610; doi: 10.3389/fpsyg.2018.02610.
11. Jönsson P, Wallergård M, Osterberg K, Hansen AM, Johansson G, Karlson B. Cardiovascular and cortisol reactivity and habituation to a virtual reality version of the Trier Social Stress Test: a pilot study. Psychoneu-

roendocrinology. 2010;35(9):1397–1403; doi: 10.1016/j.psyneuen.2010.04.003.
12. Seddon JA, Rodriguez VJ, Provencher Y, Raftery-Helmer J, Hersh J, Labelle PR et al. Meta-analysis of the effectiveness of the Trier Social Stress Test in eliciting physiological stress responses in children and adolescents. Psychoneuroendocrinology. 2020;116:104582; doi: 10.1016/j.psyneuen.2020.104582.
13. Narvaez Linares NF, Charron V, Ouimet AJ, Labelle PR, Plamondon H. A systematic review of the Trier Social Stress Test methodology: issues in promoting study comparison and replicable research. Neurobiol Stress. 2020; 13:100235; doi: 10.1016/j.ynstr.2020.100235.
14. Gunnar MR, Reid BM, Donzella B, Miller ZR, Gardow S, Tsakonas NC. Validation of an online version of the Trier Social Stress Test in a study of adolescents. Psychoneuroendocrinology. 2021;125:105111; doi: 10.1016/j.psyneuen.2020.105111.
15. Knowles KA, Olatunji BO. Specificity of trait anxiety in anxiety and depression: Meta-analysis of the State-Trait Anxiety Inventory. Clin Psychol Rev. 2020;82: 101928; doi: 10.1016/j.cpr.2020.101928.
16. Pacheco-Unguetti AP, Acosta A, Marqués E, Lupiáñez J. Alterations of the attentional networks in patients with anxiety disorders. J Anxiety Disord. 2011;25(7):888–895; doi: 10.1016/j.janxdis.2011.04.010.
17. Mellalieu, S.D., Hanton S,, and Fletcher D, A Competitive anxiety review: recent directions in sport psychology research. In: Hanton S, Mellalieu SD (eds.), Literature Reviews in Sport Psychology. New York: Nova Science; 2009.
18. Mantar A. Validity and reliability study of the Turkish form of Anxiety Sensitivity Index-3 [in Turkish]. Dokuz Eylül University Faculty of Medicine; 2008. Available from: URL: http://acikerisim.deu.edu.tr:8080/xmlui/handle/20.500.12397/5745
19. Yılmaz Koğar E. Examining the Factor Structure of the Anxiety Sensitivity Index-3 in a Turkish Sample: the Factor Structure of the Anxiety Sensitivity Index-3. Psychol Rep. 2022;125(6):3289–3312; doi: 10.1177/00332941211040427.
20. Hrysomallis C. Balance ability and athletic performance. Sports Med. 2011;41(3):221–232; doi: 10.2165/11538560-000000000-00000.
21. Cumberworth VL, Patel NN, Rogers W, Kenyon GS. The maturation of balance in children. J Laryngol Otol. 2007;121(5):449–454;doi:10.1017/S0022215106004051.
22. Steindl R, Kunz K, Schrott-Fischer A, Scholtz AW. Effect of age and sex on maturation of sensory systems and balance control. Dev Med Child Neurol. 2006; 48(6): 477–482; doi: 10.1017/S0012162206001022.
23. Vendrame E, Belluscio V, Truppa L, Rum L, Lazich A, Bergamini E. Performance assessment in archery: a systematic review. Sports Biomech. 2022:1–23; doi: 10.1080/14763141.2022.2049357.
24. Muazu Musa R, Taha Z, Anwar PP, Majeed A, Abdullah MR. Psychological variables in ascertaining potential archers. In: Machine Learning in Sports: Identifying Potential Archers. Springer; 2019:21–27.
25. Stambolievaa L, Otzetovb M, Petrovac D, Ikonomovd R, Gatev P. Postural stability during static upright stance in archers. In: Posture, Balance and the Brain, International Workshop Proceedings. Sofia: Procon; 2015; doi: 10.11610/posture.05.
26. Martens R. Coaches guide to sport psychology. A publication for the American Coaching Effectiveness Program: Level 2 sport science curriculum. Washington: Human Kinetics Books; 1987.
27. Taelman J, Vandeput S, Spaepen A, Van Huffel S. Influence of mental stress on heart rate and heart rate variability. In: 4th European Conference of the International Federation for Medical and Biological Engineering: ECIFMBE 2008 23–27 November 2008 Antwerp, Belgium. Springer; 2009.
28. Sahebjamee N, Nagy E. The effect of a short breathing intervention on postural control and heart rate variability. Dev Health Sci. 2022;5(1):25–30; doi: 10.1556/2066.2023.00045.
29. Buske-Kirschbaum A, Jobst S, Wustmans A, Kirschbaum C, Rauh W, Hellhammer D. Attenuated free cortisol response to psychosocial stress in children with atopic dermatitis. Psychosom Med. 1997;59(4):419–426; doi: 10.1097/00006842-199707000-00012.
30. Juruena MF, Eror F, Cleare AJ, Young AH. The role of early life stress in HPA axis and anxiety. In: Kim Y-K (ed.), Anxiety disorders: rethinking and understanding recent discoveries. Springer; 2020;141–153.
31. Campisi J, Bravo Y, Cole J, Gobeil K. Acute psychosocial stress differentially influences salivary endocrine and immune measures in undergraduate students. Physiol Behav. 2012;107(3):317–321; doi: 10.1016/j.physbeh.2012.09.003.
32. Childs E, Vicini LM, De Wit H. Responses to the Trier Social Stress Test (TSST) in single versus grouped participants. Psychophysiology. 2006;43(4):366–371; doi: 10.1111/j.1469-8986.2006.00414.x.
33. Bangasser DA, Valentino RJ. Sex differences in molecular and cellular substrates of stress. Cell Mol Neurobiol. 2012;32(5):709–723; doi: 10.1007/s10571-012-9824-4.
34. Moisan M-P. Sexual dimorphism in glucocorticoid stress response. Int J Mol Sci. 2021;22(6):3139; doi: 10.3390/ijms22063139.
35. Boyle NB, Lawton C, Arkbage K, Thorell L, Dye L. Dreading the boards: stress response to a competitive audition characterized by social-evaluative threat. Anxiety Stress Coping. 2013;26(6):690–699; doi: 10.1080/10615806.2013.766327.
36. Gruenewald TL, Kemeny ME, Aziz N, Fahey JL. Acute threat to the social self: shame, social self-esteem, and cortisol activity. Psychosom Med. 2004;66(6):915–924; doi: 10.1097/01.psy.0000143639.61693.ef.
37. Lupien SJ, McEwen BS, Gunnar MR, Heim C. Effects of stress throughout the lifespan on the brain, behaviour

and cognition. Nat Rev Neurosci. 2009;10(6):434–445; doi: 10.1038/nrn2639.
38. Edwards EJ, Edwards MS, Lyvers M. Cognitive trait anxiety, situational stress, and mental effort predict shifting efficiency: implications for attentional control theory. Emotion. 2015;15(3):350–359; doi: 10.1037/emo0000051.
39. Kleine D. Anxiety and sport performance: a meta-analysis. Anxiety Res. 1990;2(2):113–131; doi: 10.1080/08917779008249330.
40. Weinberg RS, Ragan J. Motor performance under three levels of trait anxiety and stress. J Mot Behav. 1978; 10(3):169–176; doi: 10.1080/00222895.1978.10735150.
41. Muse LA, Harris SG, Feild HS. Has the inverted-U theory of stress and job performance had a fair test? Hum Perform. 2003;16(4):349–364; doi: 10.1207/S15327043HUP1604_2.
42. Raglin JS. Anxiety and sport performance. Exerc Sport Sci Rev. 1992;20:243–74.
43. Van de Pol PK, Kavussanu M. Achievement motivation across training and competition in individual and team sports. Sport Exerc Perform Psychol. 2012;1(2):91–105; doi: 10.1037/a0025967.
44. Prapavessis H, Grove JR, McNair PJ, Cable NT. Self-regulation training, state anxiety, and sport performance: a psychophysiological case study. Sport Psychologist. 1992;6(3):213–29; doi: 10.1123/tsp.6.3.213.
45. Besharat MA, Pourbohlool S. Moderating effects of self-confidence and sport self-efficacy on the relationship between competitive anxiety and sport performance. Psychology. 2011;2(7):760–765; doi: 10.4236/psych.2011.27116.
46. Correia ME, Rosado A. Fear of failure and anxiety in sport. Análise Psicológica. 2018;36(1):75–86; doi: 10.14417/ap.1193.
47. Ahmad WNW, Adib MAHBM, Nashir IM, Txi MRS, Salleh FNM, Tang JR. Anxiety status of junior archers in COVID-19 during training isolation period towards the shooting performance. Int J Public Health. 2023;12(1):361–370; doi: 10.11591/ijphs.v12i1.21982.
48. Martens R, Vealey RS, Burton D. Competitive Anxiety in Sport. Ilinois: Human Kinetics Books; 1990; 3–18.
49. Anderson KJ. Arousal and the inverted-U hypothesis: a critique of Neiss's "Reconceptualizing arousal". Psychol Bull. 1990;107(1):96–100; doi: 10.1037/0033-2909.107.1.96.
50. Dickman SJ. Impulsivity, arousal and attention. Pers Indiv Dif. 2000;28(3):563–581; doi: 10.1016/S0191-8869(99)00120-8.
51. Sarro KJ, Viana TDC, De Barros RML. Relationship between bow stability and postural control in recurve archery. Eur J Sport Sci. 2021;21(4):515–520; doi: 10.1080/17461391.2020.1754471.
52. Mason BR, Pelgrim PP. Body stability and performance in archery. Excel. 1986;3(2):17–20.
53. Stuart J, Atha J. Postural consistency in skilled archers. J Sports Sci. 1990;8(3):223–234; doi: 10.1080/02640419008732148.
54. Mohamed MN, Azhar AH. Postural sway and shooting accuracy of skilled recurve archers. Mov Health Exerc. 2012;1(1):49–60; doi: 10.15282/mohe.v1i0.5.