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THE IMPACT OF FENCING-FOCUSED MINDFULNESS TRAINING ON LOCUS OF CONTROL IN SPORT, SPORT-CONFIDENCE AND CHOICE REACTION TIME

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Studies suggest that mindfulness meditation may shorten the reaction time in cognitive tests. Mindfulness-based interventions are considered to influence positively both performance and psychological state of athletes. Since reaction time and psychological factors are crucial for winning bouts in fencing, the purpose of this study was to investigate whether fencing-focused mindfulness training increases internal locus of control and sport confidence, and shorten choice reaction time in fencers. The study also examined the relationship between choice reaction time and the aforementioned psychological variables. Twenty-one fencers (age $M = 15.67$, $SD = 1.91$) from three Polish fencing clubs took part in the study. Participants completed pre- and two post-intervention measures of locus of control (LOC) in sport, sport-confidence, and choice reaction time (Blaze Pod device). Fencers were randomly assigned to three groups. The experimental group ($N = 7$) took part in 8 fencing-focused mindfulness trainings, while the active control group ($N = 7$) participated in 8 lectures on dietary habits and post-workout regeneration. The control group ($N = 7$) was passive. Results revealed a post-intervention increase in internal LOC on the competition scale in the experimental group and its decrease in both control groups. Results showed that the increase in confidence was associated with a decrease of the reaction time in the experimental group post-intervention. From an applied perspective, mindfulness training may influence increased effectiveness of fencing training and faster execution of fencing actions.

Keywords: fencing; mental training; mindfulness; self-confidence; locus of control

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Contemporary fencing as a sport requires competitors to focus on two equally important tactical tasks: to hit the opponent and at the same time not to be hit by them. A fencer faces numerous challenges both physically and mentally due to the intensity of the fencing fight (rapid changes in a heart rate, a need for quick and appropriate reactions). Additionally, its technical complexity (choosing numerous offensive and defensive actions and the right moment to perform it) and tactical complexity (hiding one's intentions, recognizing the opponent) also impact performance difficulty (Czajkowski, 1988; Patócs et al., 2016).

Fencing Characteristics

Despite the differences in actions used to hit the opponent and combat speed with three weapons in fencing (foil, saber, épée), their common characteristic is the presence of many open movement habits and the fact that psychological and tactical skills are equivalent to the fencing technique. This raises a particular need for fencers to develop various properties of attention, perception, operational and tactical thinking, analysis of motivational and emotional processes (Czajkowski, 1988; Poliszczuk et al., 2013).

In addition, fast reaction time is crucial for a fencer to win a bout. To strike without being hit by the opponent, the fencer must be faster than their opponent by at least: 0.17sec +/−0.01 in saber, 0.04sec +/−0.01 in épée, or 0.30sec +/−0.025 in foil (International Fencing Federation, 2021).

During the bout, a fencer reacts to stimuli with a simple response or a choice response. Stimuli can be visual (noticing the opponent's movement), tactile (e.g., pressure on the blade), or mixed (simultaneous use of sight and touch).

Fencers have the fastest reaction to a mixed stimulus and the slowest to a visual stimulus. Czajkowski (2004) mentions that fencers with shorter times of sensory-motor responses show more accurate tactical and technical analyzes of the performance of the opponent. Shorter execution times also correlate with better results during the competition. The times of sensori-motor responses and especially latent response times are therefore a very strong indicator of the athlete's training and sports form level (Czajkowski, 1988).

There are various psychological skills necessary for an optimal level of fencing performance, i.e., adaptability, coping with stress, anxiety control, self-control, attention (Czajkowski, 2007; Obmiński et al., 2014). As a result

of a direct confrontation with the opponent, fencers are also characterized by a rather high level of self-confidence (Ali & Abbas, 2021) with its highest level among medallists (Hagag & Ali, 2014). Fencing requires also both long-term, narrow external attention (observing and anticipating opponents' movements, quick changes of action depending on the situation), and broad internal attention (awareness of one's own technical and tactical skills as well as thoughts and feelings while performing) (Nideffer, 1976, as cited in Czajkowski, 2007). In addition, it is important to synthesize information received from both of these sources in order to create an appropriate situation to win the fight. The need to develop both types of attention—narrow external and broad internal—was pointed out by Hijazi (2013) in her research. She states that attention as a psychological factor is one of the most important advantages a fencer can have. Numerous studies (i.e., Predoiu et al., 2020; Thelwell & Greenleese, 2003) proved that fencers require a high level of self-confidence and persistence.

In a study focusing on the French women's national saber team it was shown that perceived control during a fight was a mediator of the outcome through direct and indirect influence on negative emotions and of the use of a problem-focused coping style (Doron & Martinent, 2021). Another study conducted on a group of fencers by Doron and Gaudreau (2014) showed that scoring a hit was correlated with the subsequent sense of perceived control and the use of a task-oriented coping style. Other studies have been conducted on epeeists by Mahmoud et al. (2022). They were aimed at verifying whether mental toughness training would affect such psychological determinants as confidence, control and stability of mental toughness. The research was conducted without a control group, however; it showed that among the subjects there was a statistically significant strengthening of mental toughness. It also turns out that winning medals was correlated with higher self-confidence and the ability to control emotions among Egyptian fencers participating in the African Games (Hagag & Ali, 2014). The discrepancy in studies of LOC and perceived control conducted on athletes from different disciplines leaves many questions and research opportunities.

Mindfulness Practice in Sport Context

For several years, the growing popularity of mental training based on the practice of mindfulness has been observed in sports (i.e., Ajilchi et al., 2021;

Myall et al., 2022). Neuro-imagining studies of the brain show the positive impact of mindfulness practice on its neuroplasticity, which in turn translates into greater self-regulation, body awareness, and better results in attention tests (Hölzel et al., 2011).

Currently, evidence is still being sought for the impact of mindfulness practice on strengthening the psychological qualities needed in sport, such as self-regulation skills, processes attention, flexibility, state of flow, etc. (Birrer et al., 2012; Doron, 2020). The results of the meta-analysis conducted by Bühlmayer et al. (2017) prove that shooters and dart players practicing mindfulness achieved better sport results and had more favorable results of such psychological parameters as: higher flow level, concentration on the task and lower level of fear. The positive effect of mindfulness training on self-confidence was also observed in the martial art of Sanda Wushu. After participating in an eight-week mindfulness practice program, they showed higher level of confidence during the competition (Mehrsafar, 2019). The impact of mindfulness training can be seen not only in terms of psychological characteristics but also within executive functions. Studies have shown that people who regularly practice mindfulness make fewer errors in cognitive tests than people in the control group. However, the groups did not differ in terms of average reaction time (van den Hurk et al., 2010).

Research Problems

Analyzing the specificity of fencing and the challenges it poses to the competitor from the physical and psychological side, it was decided to examine whether mindfulness training can affect the key mental aspects of the fencers as well as their reaction time. Bearing in mind the definitions presented above and previous scientific research on those notions, the following hypotheses were formulated: (H1) Participation in fencing-focused mindfulness training will strengthen the internal locus of control in the sport; (H2) Participation in fencing-focused mindfulness training will increase sport-confidence; (H3) Participants of fencing-focused mindfulness training will have faster reaction times in reaction time test.

The hypotheses were tested for effect at two time points: T2, immediately after the intervention, and T3, 5 weeks after the intervention.

METHOD

Participants

Fencing is not a popular sport in Poland. The official classification list of the Polish Fencing Federation in the category under 17 years old includes 173 épéeists (90 women and 83 men) and 142 sabreurs (74 men and 68 women).

For logistical reasons, the study could only be carried out in the Silesian Voivodeship. Fourteen épée athletes (8.00 % of the total population) and seven sabre athletes (5 % of the total population) participated in the study (9 women and 12 men). They came from three Polish fencing clubs, and fencers in each group were a natural training group in their clubs. The age of the participants ranged from 12 to 19 years (M = 15.67, SD = 1.91), and the training period was from 4 to 11 years (M = 6.86, SD = 2.13).

The fencers' clubs were randomly assigned to three groups. (1) The experimental group (N = 7) consisted of 4 women and 3 men aged from 12 to 18 years (M = 15.29, SD = 2.14), with training experience from 4 to 9 years (M = 6.14, SD = 1.95); all of them are sabreurs.(2)The active control group (N = 7) consisted of 7 men aged from 13 to 18 years (M = 15.29, SD = 1.98), with training experience from 4 to 11 years (M = 6.57, SD = 2.37); all of them are épéeists. (3) The passive control group (N = 7) consisted of 5 women and 2 men aged from 15 to 19 years (M = 16.43, SD = 1.62),with training experience from 4 to 10 years (M = 7.86, SD = 1.95); all of them are épéeists.

Measures

Locus of Control

Locus of control was measured using the Polish version of the Questionnaire of the Locus of Control in Situations of Success/Failure in Sport (PKSPwS; Rutkowska, 2011). The questionnaire can be used in studies of children and adolescents. Participants answered statements on a 4-point Likert scale (1 = *definitely yes*, 4 = *definitely not*).The questionnaire is used to measure the locus of control (LOC), the total score from all 24 statements contributes to the global LOC dimension in sport (reliability of the overall LOC scaleα = .79). Individual statements make up the following scales: success (α = .69), i.e., how a person perceives their role in winning or achieving

a goal, for example: "Winning a competition is the result of your hard work"; failure (α = .61), i.e., how a person perceives their role when losing or not achieving goal, for example: "When you can't cope with an exercise during training, it's because it is too difficult"; training (α = .56), i.e., how a person assesses their impact in a training situation, for example: "When you succeed at everything at practice, it's because you're having a good day"; start (α = .68), i.e., whether the person perceives the outcome of their competition as one they could control, for example: "You usually influence the poor results of your starts and worse results during competitions"; the relationship with the coach/players (α = .56)—whether the person perceives the relationship with the coach or players as one over which he or she has influence, for example: "When other players laugh at you, it's because they don't like you."

The Training, Start and Relationship scales consist of a different number of questions. In order to be able to compare their results with each other, not raw results, but converted to the means, were used in the analyses. To maintain consistency, the other scales, i.e., General LOC, Success and Failure, have also been converted to the average and are presented as such in the article.

Sport-Confidence

Sport-confidence was assessed using Trait Self-Confidence Inventory – Polish Version (TSCI-PL; Gazdowska et al., 2017). The inventory consists of 13 statements in which the participants *compare their confidence in specific contexts to the most confident player they know* on a 1–9 scale. The higher the score of the person the higher the self-confidence in sport, the examined person is characterized by. TSCI-PL reliability is satisfactory α = .94; see a sample item: "Compare your confidence in using an effective strategy to the most confident athlete you know."

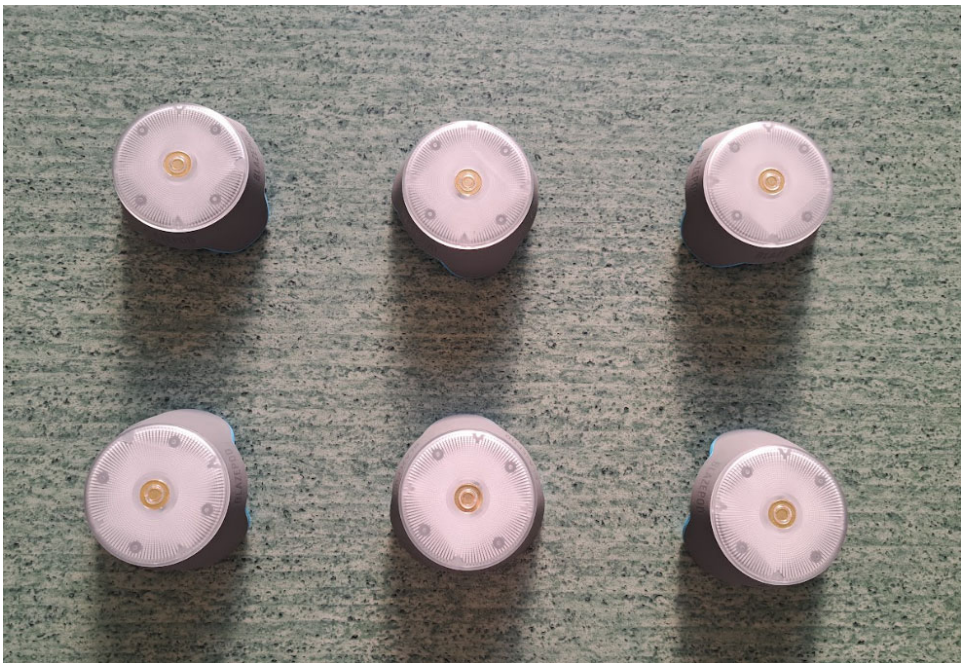
Reaction Time With Blaze Pod Random Mode

The Blaze Pod consists of six separate pods and is used to measure response time (see Figure 1). In the Random mode used, the device randomly lights one pod at a time and the task of the tested person is to hit it as quickly as possible. The next button lights up 2 seconds after hitting the previous one. Participant must hit as many pods as possible within 30 second duration of the test. The Blaze Pod shows average response times down to a thousandth of a second. Due to the fact that thousandths of a second decide about blocking the

signaling unit in fencing, it was decided to use the results with an accuracy of exactly one thousandth of a second. The shorter the reaction time, the higher the skill level.

Figure 1

Blazepod Placement



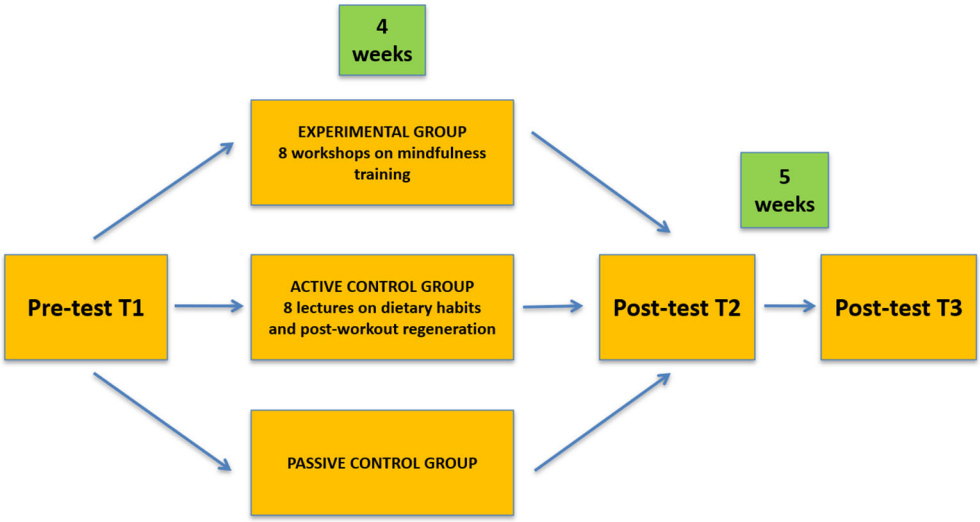
Procedure

After signing the informed consent form, all participants completed the pre-test T1: Questionnaire of the Sense of Control in Situations of Success/ Failure in Sport (PKSPwS), TraitSelf-Confidence Inventory (TSCI-PL), and a 5-minute general warm-up followed by Blaze Pod Random test. Then, the experimental group participated in mindfulness classes, while the active control group participated in educational classes related to diet and regeneration. The sessions were organized twice a week for a period of one month. Each class lasted about 15 minutes, and after the class the participants received a short homework related to the topic of the given class. No intervention was introduced in the passive control group. After the end of the classes, all

participants completed the post-test T2, and T3, a deferred measurement five weeks later. The full procedure of the study is presented in Figure 2.

Figure 2

Time Flowchart of the Experiment Procedure



Mindfulness workshops (based on Teasdale et al., 2016; Williams & Penman, 2014) included discussion and exercises related to meditation and concentration—body scan, mindful eating, mindful breathing. Additionally, participants tried to observe their emotions and thoughts during performance and practice mindful movement in fencing position and actions. The active control group's educational classes on dietary habits, post-workout regeneration and wellness were based on Ciechanowska et al. (2014), Dalleck (2022), and Reguła (2013).

RESULTS

The aim of the study was to verify if the changes in the scores obtained on individual T1, T2 and T3 measurements differed between groups. The descriptive statistics of each variable are shown in Table 1 for T2 and T3, but for T1 due to the baseline comparisons in Table 2.

Table 1

Descriptive Statistics for Each Study Variable

	Experimental (*N* = 7)		Active control (*N* = 7)		Passive control (*N* = 7)	
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*
			T2			
General LOC	3.37	0.22	3.16	0.23	3.26	0.26
Success LOC	3.48	0.28	3.17	0.23	3.31	0.31
Failure LOC	3.26	0.25	3.14	0.30	3.20	0.27
Competition LOC	3.43	0.18	3.18	0.39	3.40	0.23
Training LOC	3.47	0.31	3.23	0.43	3.23	0.33
Relationship LOC	3.18	0.45	3.04	0.37	3.23	0.14
TSCI-PL	6.37	0.73	5.76	1.20	5.65	0.52
Reaction time	0.38	0.05	0.36	0.04	0.36	0.03
			T3			
General LOC	3.39	0.35	3.17	.16	3.29	0.13
Success LOC	3.46	0.15	3.18	.16	3.39	0.17
Failure LOC	3.31	0.28	3.17	.20	3.19	0.20
Competition LOC	3.37	0.22	3.27	.16	3.41	0.27
Training LOC	3.41	0.25	3.16	.16	3.21	0.17
Relationship LOC	3.39	0.35	3.06	.39	3.23	0.14
TSCI-PL	6.39	0.50	5.93	.93	5.43	0.89
Reactiontime	0.40	0.05	0.36	0.03	.37	0.05

Note. LOC = Locus of Control, TSCI-PL = sport-confidence, T1, T2 and T3 = time point of measurement.

As a preliminary step, a Kruskal–Wallis *H* test was conducted to examine whether there were any initial differences between the groups at baseline (T1) across all variables measured in the study. Results of this comparison are shown in Table 2. The results of the test confirmed that the random selection into groups was effective and the results of each variable did not differ according to the study group.

Table 2

Randomization Check in First Measurement Point (T1)

	Experimental (*N* = 7)		Active control (*N* = 7)		Passive control (*N* = 7)		Comparison	
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*	*H*	*p*
General LOC	3.40	0.22	3.20	0.25	3.84	0.45	2.12	.346
Success LOC	3.44	0.14	3.17	0.30	3.33	0.23	3.50	.174
Failure LOC	3.37	0.31	3.23	0.28	3.35	0.18	0.41	.814
Competition LOC	3.32	0.24	3.33	0.33	3.43	0.12	0.70	.706
Training LOC	3.41	0.30	3.13	0.37	3.25	0.25	2.37	.306
Relationship LOC	3.51	0.30	3.10	0.33	3.37	0.39	4.49	.106
TSCI-PL	5.97	0.77	5.37	1.11	5.84	0.45	1.15	.563
Reactiontime	0.41	0.05	0.38	0.05	0.37	0.04	2.12	.347

Note. LOC = Locus of Control, TSCI-PL = sport-confidence.

In order to compare the effects of the intervention between the groups, the difference between baseline and post-experiment results at T2 and T3 points was calculated (T2–T1, T3–T1). Those difference between results obtained in selected time points are presented in Table 3.

Table 3

Hypothesis Testing of Changes in Measured Variables from Pre- to Post-intervention

Variable	Experimental (N = 7)		Active control (N = 7)		Passive control (N = 7)		Comparison	
	M	*SD*	*M*	*SD*	*M*	*SD*	*H*	*p*
	Difference T2–T1							
General LOC	−0.04	0.13	−0.04	0.11	−0.08	0.20	0.21	.902
Success LOC	0.36	0.19	0.00	0.17	−0.02	0.23	0.33	.850
Failure LOC	−0.11	0.16	−0.08	0.20	−0.14	0.23	0.65	.724
Competition LOC	0.11	0.19	−0.16	0.17	−0.03	0.20	5.80	.055
Training LOC	0.05	0.19	0.11	0.15	−0.02	0.20	1.57	.456
Relationship LOC	−0.33	0.31	−0.06	0.20	−0.22	0.35	3.51	.173
TSCI-PL	0.41	0.86	0.38	0.98	−0.19	0.29	3.64	.162
Reaction time	−0.026	0.05	−0.02	0.05	−0.01	0.03	0.42	.812
	Difference T3–T1							
General LOC	−0.18	0.15	−0.02	0.21	−0.05	0.19	0.13	.939
Success LOC	0.02	0.15	0.01	0.27	0.06	0.30	0.55	.758
Failure LOC	−0.06	0.18	−0.06	0.22	−0.15	0.16	1.41	.494
Competition LOC	0.05	0.29	−0.06	0.21	−0.02	0.25	1.78	.412
Training LOC	0.00	0.24	0.04	0.27	−0.04	0.17	0.59	.745
Relationship LOC	−0.12	0.41	−0.04	0.27	−0.10	0.29	0.04	.980
TSCI-PL	0.42	0.85	0.56	1.01	−0.41	0.59	5.08	.079
Reaction time	−0.01	0.02	−0.02	0.043	0.01	0.03	1.92	.382

Note. LOC = Locus of Control, TSCI-PL = sport-confidence, T1, T2 and T3 = time point of measurement. Difference T2–T1 is between results obtained in the second and the first time point. Difference T3–T1 is between results obtained in the third and the first time point.

The Kruskal–Wallis test (a non-parametric equivalent of analysis of variance) was used to evaluate whether the differences in the results obtained in successive measurements, by each independent group, are statistically significant. This test was used due to the small number of participants, $N = 21$. Results are shown in Table 3 for each variable.

Analysis did now show statistically significant differences in any variable; however, the *p*-value was close to significant between T2 and T1 measurements, $H = 5.80$, $p = .055$, suggesting potential influence of mindfulness training in Locus of Control Competition scale. Bonferroni post hoc test analysis of T2–T1 differences, showed a statistically significant difference between the experimental group and the active control group. In the second measurement, the experimental group increased the results of the sense of LOC in the competition situation ($M = 0.11$, $SD = 0.19$), while the active control group obtained lower results on this scale than in the first measurement ($M = -0.16$, $SD = 0.17$), $p = .048$. This was a favorable change for the experimental group, as higher LOC scores imply a stronger internal sense of control and agency during competition situation.

Statistical tendency (*p*-value close to .05) was visible also in TSCI-PL variable, between T3 and T1 results, $H = 5.08$, $p = .079$, but post-hoc Bonferroni test showed no significant differences between groups ($p > .05$).

DISCUSSION

Fencing is a dynamic sport where reaction time is a key aspect to taking or losing a hit (International Fencing Federation, 2021). A large number of opponents encountered during one tournament as well as a large number of fencing activities and the possibilities of their use mean that the fencer must be able to quickly adapt to various, often quickly changing, training and competition situations (Czajkowski, 1988). Mindfulness trait is a predictor of internal locus of control in general population (Sulphey, 2016). Mindfulness ability allows also to control internal locus of control (West, 1987). The meta-analysis shows also that mindfulness training increases athletes' sport performance (Si et al., 2024). Mindfulness training conducted in this study did not significantly increase internal LOC on either the overall scale or the subscales: success, failure, training, and relationships. However, statistical significance was obtained on the competition scale between the experimental group and the active control in the difference between the results of these groups from the second and first measurement. The experimental group increased their internal locus of control in the second measurement in contrast to the active control group, which is consistent with other researchers' results (Bühlmayer et al., 2017; Doron et al., 2020). It can be stated that the participants of mindfulness training acquired certain skills that increased their

internal sense of control in the performing situation, while the active control group during their workshops did not acquire such skills. Although there were no significant differences between the experimental and passive control groups, it is worth noting that the passive control group decreased its results on the competition scale in the second measurement. Perhaps, over the course of the season and due to participation in subsequent competitions, fencers gradually lose their internal LOC in this situation, and regular mindfulness training could be one of the elements of mental training to prevent this phenomenon.

The analysis of response times to the Blaze Pod study showed no difference, which is consistent with the results obtained in a study by van den Hurk et al. (2010) among people practicing meditation and not being athletes.

When analyzing the obtained results, one should remember about the limitations of the conducted research. Undoubtedly, the biggest of them was the small number of people tested, which means that the power of testing hypotheses is low and statistical tests may not have detected differences between the groups. Other limitation was the lack of control over the course of fencing training in individual clubs, which could be important mainly in the context of reaction times and also non controlled variables. This study is did not examine other individual characteristics that may also be related to LOC. Other studies indicate a correlation between intrinsic LOC and high levels of such traits as Conscientiousness, Openness to Experience, and Agreeableness among polish sixth-graders (Filipiak & Łubianka, 2021). Also, athletes characterized by autonomous motivation more frequently perceive internal LOC (Neves et al., 2022).The strengths of the presented study, in turn, were the examination of both the experimental group and two control groups, and the measurement postponed five weeks after the second measurement. In the context of conducting research among athletes, an important aspect is to combine psychological and fitness tests, which was also done in the described study.

The results of the experiment brought further questions. Conclusive results confirming the effect of mindfulness training on strengthening sports self-confidence and internal locus of control, were not obtained. Participation in mindfulness workshops also did not shorten the reaction time. Perhaps there were too few classes or they were too short. It is worth mentioning that individual characteristics may also affect the speed and effectiveness of assimilating mindfulness techniques. Therefore, it is worth looking further for factors influencing LOC and sports confidence among fencers. It would also be necessary to conduct research on the reaction time taking into account the

latent period, and not only the execution time, which can be improved by fitness preparation. The results obtained suggest that it is worth continuing to study the effect of mindfulness training on these variables with a larger study group. Mindfulness training can undoubtedly be a valuable element of mental training for fencers. The obtained results may have influenced strengthening the psychological skills used by the players during training and during competitions. The ability of insight acquired during mindfulness practice can also be used by them in non-sport activities.

CRediT Author Statement

ANGELIKA MARSZOŁEK (85%): conceptualization, methodology, formal analysis, resources, writing (original draft).

GAZDOWSKA ZUZANNA (15%): supervision, writing (review and editing).

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