

Effects of Mindfulness Training and Interference Training on Competitive Shooting Performance under Stress

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Abstract: We aimed to examine the effects of interference training and mindfulness training on the performance of shooting enthusiasts. 57 pistol shooting enthusiasts were equally distributed based on ability to an Interference Training Group (n=19 with mean age of 6.89±2.61; 10 males and 9 females), Mindful Training Group (n=19 with mean age of 16.26±2.57; 10 males and 9 females), and a Control Group (n=19 with a mean age of 16.73±2.10; 10 males and 9 females). A mixed experimental test with 3×6 repeated measures ANOVA was used to test outcomes. The between-group variable was psychological intervention (interference/mindfulness/control) and the within-group independent variable was time (T1-T6). The dependent variables included shooting task performance. The Five Facet Mindfulness Questionnaire, and Competitive State Anxiety Inventory-2. We found that interference training and mindfulness training significantly improved the participants' motor performance and mental state; the control group also showed some improvements. The improvement in shooting performance following interference training was fast but quickly plateaued. Conversely, following mindfulness training, the improvements were continuous and almost linear. Therefore, we suggested that athletes should choose mindfulness training as the main training method if adequate preparatory time is available before competition; we suggest interference training if less than one month's preparation time is available or in the context of inadequate professional psychological support.

1. Introduction

The most widely accepted definition of mindfulness, as proposed by Kabat-Zinn, is that it "is a method of focusing on the present moment purposefully and without judgment". It contains three main points facets: being purposeful, non-judgmental, and in the present moment. Mindfulness training has been shown to positively improve the mental state in diverse settings, such as during medical treatment, education, and problem-solving 00. In addition, it has been exploited by

psychologists to assist athletes in coping with competition pressures. Gardner et al. suggested that the mindfulness-acceptance-commitment approach (MAC) can assist athletes in improving their performance (2007). After the introduction of related concepts in China, Sigangxuan et al. revised the MAC approach, proposing that the mindfulness-accept-in-sight-commitment (MAIC) approach was a more appropriate mindfulness training method for Chinese athletes. Subsequent studies have shown that mindfulness training can improve the level of mindfulness and athletic performance of athletes.

Interference auxiliary training was first proposed by Cui Y, the Chinese men's standard pistol rapid-fire coach. It is a training method to reduce competition anxiety and improve athletes' operational initiative through interrupt habitual motor program during firing. Generally speaking, the recoil of the gun produced upon pistol firing with a large grain bullet will destroy the motor program; in response, practice can be carried out with smaller grain bullets with less recoil so that the athletes can improve their muzzle recoil control. The ISSF shooting rules changed to forbid the use of .22 short cartridges. Based on these new rules, a combination of live and blank ammunition and external forces have been used to interfere with the habitual track of guns during training. However, the outcomes of this training have only been tested qualitatively.

The theory of multidimensional anxiety was first proposed by Liebert & Morris (1967) and later improved by Martens et al. Sports competition anxiety is divided into three aspects: cognitive anxiety, somatic anxiety and self-confidence. Cognitive state anxiety refers to the subjective perception of a dangerous or threatening situation during or immediately before or after a competition. This state of anxiety arises from a negative evaluation of one's ability or a negative expectation of the outcome of a competition (performance). It is characterized by a fear of failure, negative self-talk, and unpleasant visual imaginations. Somatic state anxiety refers to an emotional experience of autonomic nervous system activation or arousal that exists immediately before or after a competition. It involves anxiety resulting from autonomic nervous system arousal that is manifested by increased heart rate, shortness of breath, cold, damp palms, stomach upsets, a lack of clarity of mind, or increased muscle tension. State confidence refers to the belief that an athlete can succeed in his or her sport during or before a competition. Martens developed the Competitive State Anxiety Inventory-2 (CSAI-2), a scale for evaluating relevant indicators that shows high reliability and validity for athletes.

The mental state is a critical factor for optimal sports performance and identifying the best psychological interventions for optimizing it is one of the holy grails of sports psychology research. Previously utilized research studies have conducted trials without a control group or have involved single-subjects and similarly small-sample designs. Generally, this arises from a belief that it is unethical to utilize a no-intervention training group. However, such experimental designs are unable to determine the causality of practice effects or the potential interference from various confounding factors. In addition, the small study sample sizes arise from the practical aspects related to accessing the relatively small high-level athlete populations and their heavy training and competition demands, which complicate the logistics of study recruitment and intervention execution.

Generally, sports performance testing can be segregated into laboratory and sports field-based paradigms. To accurately test the effects of psychological training for high-pressure environments, effective scenarios and appropriate measurement tasks are essential. Under laboratory conditions, it is common to announce testing results to other participants and provide rewards, competition between participants, and punishment for poor performance. But the effectiveness of artificially-induced stressful situations to fully realize real-life scenarios and athlete responses remains controversial. Pressure in sports is believed to arise from competition, points scoring, self-expectations, and environmental factors. However, because the competition environment cannot be controlled, competition pressures vary and are affected by the available incentives and the

competition atmosphere. In psychology research, the evaluation of sports performance is generally based on fine motor skill performance; commonly utilized tests include the football penalty task, dart throwing mission, and the virtual reality shooting mission. In terms of measuring reliability, the football penalty kick and throwing darts require a specific skill set, and show a strong practice effect, and the test results may have contingency. The golf putting task is less sensitive to results and is unable to discern small differences in performance. The use of virtual reality for the simulation of real life is controversial, because the subjects may not be able to fully embed themselves in the environment. Shooting is a sport that requires high technical and mental abilities for high-level performance. Comparatively, it is a high sensitivity and reliability of measurement, which can truly reflect the mental state of participants. In addition, the cost of live-fire shooting can be considered high, and because of this is sometimes not utilized to test participant performance.

Thus, in this study, we aimed to test the effect of two different psychological training approaches (interference training and mindfulness training) on shooting performance. The testing was carried out in parallel with their scheduled annual assessments, which minimized our experimental costs. The participants were divided into different training methods according to their average shooting ability. Participants were matched by their performance on this test to facilitate the perception of intense competition and competitive pressure. We hypothesized that interference training and mindfulness training would improve athlete performance, and that interference training could improve athlete's performance faster than that of mindfulness training, and that mindfulness training would lower anxiety levels and boost confidence significantly.

2. Methods

2.1 Participants

We recruited 57 shooting enthusiasts (30 males and 27 females) with a mean age of 16.63 ± 2.45 years. All were non-professional athletes, specializing in events including the air pistol, men's rapid-fire pistol, 25m standard pistol, and 50m pistol, and have participated in 1-3 ISSF shooting competitions. The cohort was divided into different training methods according to their average shooting ability based on the T1 test; interference training group ($n=19$, mean age of 16.89 ± 2.61 ; 10 males and 9 females), mindful training group ($n=19$, mean age of 16.26 ± 2.57 ; 10 males and 9 females), and a control group ($n=19$, mean age of 16.73 ± 2.10 ; 10 males and 9 females). The study complied with the ethical guidelines of the Declaration of Helsinki and was approved by the Ethics Committee of Beijing Sport University. All participants signed an informed consent form after being informed of the study's purpose, testing procedures, and potential risks. All participants completed all the intervention and test contents.

The sample size required was tested by using G*power 3.1 (Faul et al., 2009). For $f=0.25$, $power=0.80$, the total sample size was 36, which is exceeded by our cohort size.

2.2 Study design

A 3×6 mixed experimental design was adopted to evaluate shooting performance. The inter-group independent variable was the psychological training mode (interference training/mindfulness training/no training), and the intra-group independent variable was test time (set separately on weekends in every week). The dependent variables included shooting performance, the five facet mindfulness questionnaire score, and the competitive state anxiety inventory-2 Score. Psychological factors were measured only at W1, W3, and W6. The time line figure 1 shows the test procedure of experiment.



Figure 1: Procedure of Experiment

2.3 Measurement

2.3.1 Shooting performance

Shooting performance test was assessed at a local shooting range whose measured and environmental conditions comply with ISSF regulations. The Suooter shooting system was used to evaluate participant performance. The measurement range includes scores of 0-400. During the test, eight athletes competed on the same field. Every five shots, a loudspeaker was used to report each athlete's performance and the gap in scores between athletes. Shooter rankings were announced at the end of the competition.

2.3.2 The Five Facet Mindfulness Questionnaire

The five facet mindfulness questionnaire can be used to effectively measure the level of individual mindfulness. The Chinese version was revised by Deng et al.0. The questionnaire consists of 39 questions with a measurement range of 39-195, including observation, description, conscious action, non-judgment, and non-reaction. The questionnaire is scored based on responses to questions on a 5-point Likert scale, with answers ranging from 1 (not at all) to 5 (completely). Higher total scores reflect a higher level of mindfulness. Several studies have shown that the FFMQ has high reliability and validity in sport field.

2.3.3 Competitive State Anxiety Inventory-2

This scale was developed by Martens et al. 0 in 1982 and has been widely used in the field of sports psychology. It shows high reliability and validity. Martens proposed that competition anxiety is divided into cognitive state anxiety, somatic state anxiety, and state confidence. Cognitive state anxiety refers to the subjective perception of a dangerous or threatening situation at the moment of competition or immediately before or after the competition. It arises from a negative evaluation of one's abilities or a negative expectation of the competition outcome and is characterized by fear of failure, negative statements about oneself, and the experience of unpleasant images. Somatic state anxiety refers to the emotional experience of autonomic nervous system activation or arousal during or immediately before or after a competition[7]. It refers to anxiety stemming directly from the arousal of the autonomic nervous system and manifests as increased heart rate, shortness of breath, cold and damp palms, upset stomach, or increased muscle tension. State confidence refers to an athlete's belief in his or her success during or before a competition. The level of state self-confidence is closely related to the nervous level of athletes. In short, the level of self-confidence of high-level athletes and high-performing students is high in their relative fields 0.

3. Experimental Procedures

The study was conducted over 5 weeks; the shooting performance test under pressure was conducted once a week during this time.

3.1 Stress Induction Paradigm

The environment was used to raise the stress levels of the subjects. The pressure was generated by the competitive environment, social approval, and self-expectation. First, each participant's performance and the gap between them and other competitors were displayed on their screens in real-time during the competition, and the results were broadcast in real-time after each group of five shots. Second, the test did not conform exactly to the ISSF competition process but instead allowed the audience to boo disapprovingly when the shooter made a serious mistake. Finally, before the test, the subjects were told that these six competitions would be an important component of their selection to a professional team. The test process was conducted as follows.

6-7 competitors simultaneously entered the shooting field. With their equipment in place, the announcer directed them to face the audience and provided information about each athlete.

After the referee gave the command "preparation and sighting time, start, load", the athletes were provided five minutes to adjust their equipment and start the test.

(3) The referee gave the command to signal the official start of the competition. Each participant had 250 s to complete 5 shots a set, 8 sets in total. After all the competitors had finished shooting or the time had elapsed, the judge declared the set over and all the competitors' shooting scores were posted on a computer in front of them.

(4) The score of each round was recorded according to the score of 5 shoots, and the final score was generated from lowest to highest. If two competitors obtained the same score in the competition, there was a play-off (Shoot-off, 1 shoot, finish within 50 seconds, do not count in total score).

(5) The final results of the competition were announced.

3.2 Validity check on stress setting (pre-experiment)

The effectiveness of the stress-inducing paradigm was tested in a preliminary experiment. We aim to find out if there was physiological and psychological deference in stressful with or without stress as independent variables, heart rate, heart rate variability, and SCAT score as dependent variables. The non-stress group (n=10) conducted the test under the guidance of a coach in the absence of audience and ranking requirements, while the stress group (n=10) conducted the test according to the process of the pressure situation. The independent sample T-test results are shown in Table 1. Table 1 shows pressure group had higher heart rate, higher HF, lower SSDN and higher SCAT result than the group without stress, which indicates that the state anxiety scenario is successfully set.

Table 1: Test results of state anxiety setting

Independent Variable	Without Stress	With Stress	t	p
HR(bpm)	88.28±9.02	109.91±7.03	-5.98	<0.001
LF/HF	1.89±0.50	2.53±0.49	-2.93	0.009
SSDN	153.75±19.30	128.41±32.16	2.14	0.47
SCAT	16.10±3.73	23.90±3.21	-5.01	<0.001

3.3 Measurement Procedure

First, participants provided written informed consent. Then in the W1 test stage, the referee guided the athletes to enter the shooting ground line and complete the competition according to the competition commands. The audience was instructed to cheer for the participants as much as possible to create a realistic sense of a competitive atmosphere. After completing the competition, all athletes filled in the FFMQ and CSAI-2 questionnaires. The total test scores were calculated, and the subjects

were divided into the three test groups as described. The intervention training was then conducted twice a week for 5 weeks. Follow-up tests were completed as in W1, once a week; however, the questionnaire was completed only in W1, W3, and W6.

3.4 Intervention

The intervention lasted for 5 weeks and was conducted after the participants' daily training class (contents are described below). To ensure the training quality of each intervention, the interference training was completed by a retired pistol athlete, the mindfulness training was completed by a college student majoring in psychology, and the physical activity of the control group was completed by a physical trainer. The potential benefits of such training were explained to the group (other groups do not aware of it). The interference training was conducted at an ISSF-authenticated shooting range (not a test venue). The psychology course was conducted in a quiet room where conditions were comfortable and free of disturbances. In addition, the participants were given certain rewards (price and souvenirs included) after all intervention to encourage them focus on intervention. As an additional control, the interference and mindfulness groups also performed the daily activities as the control group when they did not receive the intervention.

3.4.1 Interference Training

Interference training was carried out twice a week for 40 minutes at the end of the athletes' training session. They received 30 bullets. The training involved interference in live fire shooting. In the first method, after the subject entered the shooting position, an experimenter smacked the subject on the pistol grip from different directions before they fired, to break the sway rule of the gun during aiming. The second method involved the experimenter loading ammunition into the magazine for the participants, and randomly inserting blank bullets, to disturb the participants' concentration. It is important to note that such interference did not occur in every round. At the same time, the training requires players focus on pulling trigger and to maintain their original firing technique as much as possible (don't wait for interference).

3.4.2 Mindfulness Training

Mindfulness training was conducted twice a week. The content was based on the Athlete Mindfulness Training Manual (Version 2) as below. Each session was around 45 minutes duration. The course content included the content outlined in Table 2.

Table 2: Content of the Mindfulness Course

Time	Theme	Content in brief
T1-T2	Familiarization with the concept of mindfulness	<ul style="list-style-type: none"> ① Introducing the basic concept of mindfulness training ② Informing the mindfulness training plan and establishing a trusting relationship with the subjects
T2-T3	respiratory training	<ul style="list-style-type: none"> ① Focus your attention and feel the tense part of your body from beginning to end ② The sensation of bringing your attention to the tense part. ③ Gently bring your breath to the tense part as you breathe and then exhale from the tense part.

(Continued) - Table 2: Control Group

Time	Theme	Content in brief
T3-T4	Decentrism and body scanning exercises	<p>① Pay attention to scanning the body from the feet to the head, pay attention to the fleeting sensations of the body, and try to imagine a light shining steadily and gently on the body.</p> <p>② Try to move down, focus your attention on where the light shines, and pay attention to how different parts of the body might perceive;</p> <p>③ Don't try to change your feelings or resist any discomfort. Instead, try to build up a picture of your whole body. Try to be as objective, interested, and curious as possible.</p>
T4-T5	Stress reduction training	<p>① Choose an object to pay attention to (breath/body sensation/motion sensation/an anxious racing experience)</p> <p>② Adjust your breathing and focus your attention on the object of your choice.</p> <p>③ If something goes on in your mind, don't worry or be annoyed, don't judge, just return your attention to your breath.</p>
T5-T6	Observing emotion and thought exercise	<p>① Imagine yourself standing on a balcony, looking down at the traffic, each car is its own emotional content, emotions that are coming and going, you are just a static observer.</p> <p>② When you notice a negative emotion (anxiety/anger/irritability), remind yourself: the emotion is not mine.</p> <p>③ By analogy with other negative emotions, accept a remorseful experience.</p> <p>④ Capture the instant information (whatever it is) in your mind. Don't judge it subjectively</p> <p>⑤ Use your breath as a background and pay attention to the thoughts that come to your mind. Be immersed in a thought that has just passed, enter the moment of awareness.</p> <p>⑥ If you find a lot of interferences, it can be difficult to calm down enough to observe the idea, you may want to return to the breathing or body sensation, after settling down to observe.</p>

The control group performed other physical activities, including playing football, basketball, running, and physical training every week.

4. Results

Table 3: The overall Repeated Measures Anova of Each Test Program

variable	Source of variation	df	MS	F	p	Hp2
shooting performance	Test Time	4.649	3366.297	55.380	0.000	0.506
	Test Time*method of training	9.298	482.492	7.938	0.000	0.227
Cognitive state anxiety	Test Time	1.739	789.288	35.139	0.000	0.394
	Test Time*method of training	3.479	49.578	2.207	0.083	0.076
somatic-state anxiety	Test Time	1.998	705.300	55.899	0.000	0.509
	Test Time*method of training	3.995	3.343	0.265	0.900	0.010
Cognitive state anxiety	Test Time	1.856	853.488	74.637	0.000	0.580
	Test Time*method of training	3.713	112.627	9.849	0.000	0.267
Five Facet Mindfulness Measure	Test Time	1.998	705.300	55.899	0.000	0.509
	Test Time*method of training	3.995	3.343	0.265	0.900	0.010

Using SPSS 26.0, Repeated Measures Anova and simple effect analyze were conducted to analyze shooting performance, Five Facet Mindfulness Measure, CSAI-2 scores. Recession analyze was used to compare if there was intersection between 3 groups.

The overall Repeated Measures Anova was showed as table 3.

Overall, Test time was a significant main effect of all the scores. Marginal significance was found in the interaction between Test time* method of training on shooting performance, somatic-state anxiety, and Cognitive state anxiety ($P < .05$). The detailed result and simple effect analysis are showed.

4.1 Shooting performance

The descriptive statistics of the shooting performances of the groups are shown in Table 4. The full marks of shooting performance were 0-400 score.

Table 4: Descriptive Statistical Analysis of the Shooting Performance of Each Group

Test Time	Interference Training Group (n=19)		Mindfulness Training Group (n=19)		Control Group (n=19)	
	M	SD	M	SD	M	SD
W1	331.7	8.85	330.8	8.12	327.5	5.24
W2	345.1	6.66	334.7	8.88	330.7	7.45
W3	354.4	7.79	340.7	6.38	331.1	7.86
W4	357.5	5.40	344.3	6.30	331.2	8.63
W5	360.3	9.44	349.1	6.82	334.3	7.13
W6	360.4	9.57	354.4	6.61	335.3	8.23

The simple effect analysis outputted by spss showed that the shooting performance of the interference group significantly increased between W1-W2 ($p < 0.001$) and T2-T3 ($p = 0.003$), but the changes after T3 were no longer significant. For the mindfulness group, the shooting scores increased significantly from W1-W3 ($p = 0.002$) and T3-T5 ($P = 0.025$). In the control group, shooting scores increased significantly from W1-W5 ($p = 0.045$). Through recession analysis showed on table 5, interference group and mindfulness group. It can be inferred that the shooting performance of mindfulness group might overtake interference group on the seventh week.

The three training groups showed no significant difference at W1 ($p > 0.05$), the interference group showed a significant difference from two other groups in W2-W5 ($p < 0.05$), and the three groups showed a significant difference in W3-W5. At W6, the difference between the interference group and the mindfulness group was no longer significant ($p > 0.05$), while the control group remained significantly lower compared to the other two groups ($p < 0.001$).

The Figure 2 shows the above results more intuitively.

Table 5: Regression Analysis Results of Interference Group and Mindfulness Group

Group	Model	β	Standard error	R2ADJ	P
Interference	Ln (case series)	16.721	1.489	0.962	< 0.001
	constant	333.287	1.865		< 0.001
Mindfulness	case series	4.698	0.138	0.997	< 0.001
	constant	325.944	0.537		< 0.001

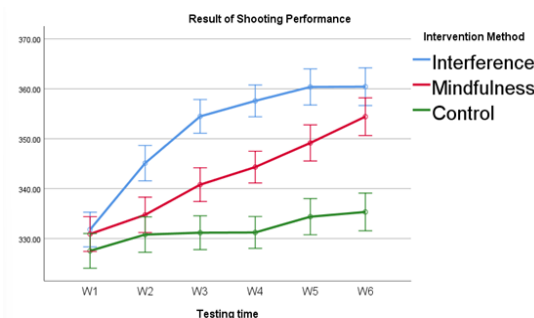


Figure 2: Shooting Performance over time by group

4.2 Five Facet Mindfulness Measure

The descriptive statistics of the Five Facet Mindfulness Measure of the groups are shown in Table 6.

Table 6: Five Facet Mindfulness Measure scores by group

Test Time	Interference Training Group (n=19)		Mindfulness Training Group (n=19)		Control Group (n=19)	
	M	SD	M	SD	M	SD
T1	115.052	10.421	113.877	6.826	113.877	7.172
T3	118.421	10.001	123.157	15.395	115.421	14.856
T6	115.578	9.895	132.947	11.063	115.053	10.464

The simple effect outputted by SPSS showed that there were significant increase in the levels of mindfulness at W3 ($P < 0.05$) and W6 ($P < 0.05$) in the mindfulness group, while no significant changes were observed in the interference training group and the control group. In short, only the mindfulness group experienced improved mindfulness over time. The data are also shown in Figure 3.

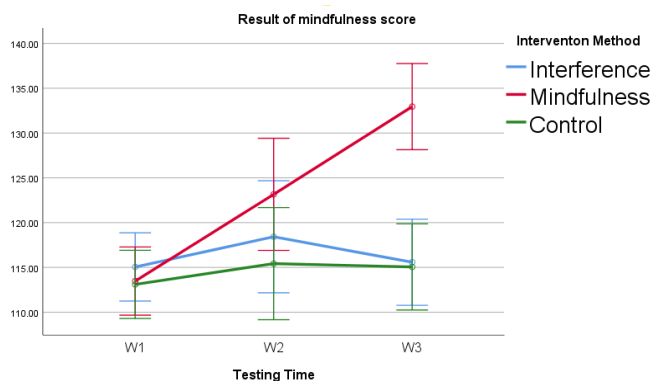


Figure 3: Mindfulness scores over time by group

4.3 CSAI-2

The participant CSAI-2 results are shown in Table 7.

Figure 4 demonstrates that Cognitive state anxiety of Interference group showed most significant decrease under the condition of test time ($P < 0.05$). Mindfulness group and control group had little differences on Cognitive state anxiety. In short, interference training result in largest decrease of Cognitive state anxiety.

Table 7: Descriptive Statistical Analysis of CSAI-2

Test Time	Interference Training Group (n=19)			Mindfulness Training Group (n=19)			Control Group (n=19)		
	Cognitive state anxiety	somatic-state anxiety	state self-confidence	Cognitive state anxiety	somatic-state anxiety	state self-confidence	Cognitive state anxiety	somatic-state anxiety	state self-confidence
T1	26.74 ±4.66	23.00 ±3.16	17.00 ±2.79	26.26 ±2.98	23.95 ±3.85	17.00 ±3.34	27.16 ±3.64	25.26 ±3.98	16.58 ±2.55
T3	24.84 ±3.24	19.63 ±3.80	25.68 ±5.49	22.84 ±5.33	21.79 ±2.32	22.73 ±2.77	23.73 ±3.74	22.84 ±4.05	18.31 ±2.21
T6	20.89 ±3.98	16.21 ±3.59	28.63 ±3.86	16.37 ±4.90	17.05 ±5.82	24.11 ±2.69	22.16 ±5.01	18.05 ±3.03	19.32 ±3.51

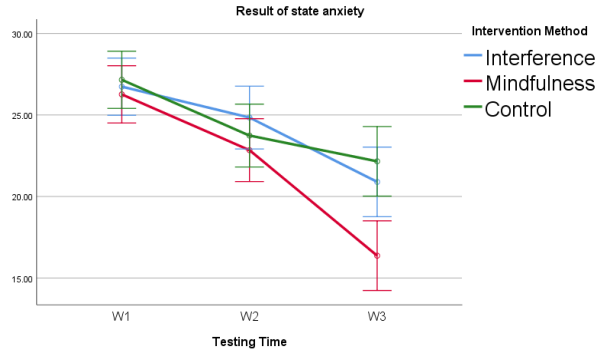


Figure 4: Cognitive state anxiety over time by group

Figure 5 shows that Somatic state anxiety significantly reduced over time [F (2, 54) =55.899, P<0.001, $\eta^2=0.509$]. There was no significant interaction effect between time point and training style. In the simple effect analysis, we found that the state anxiety of the three groups showed significant changes at T1-T3 (p<0.05). However, they all reduced over time, regardless of the intervention. (P=0.19).

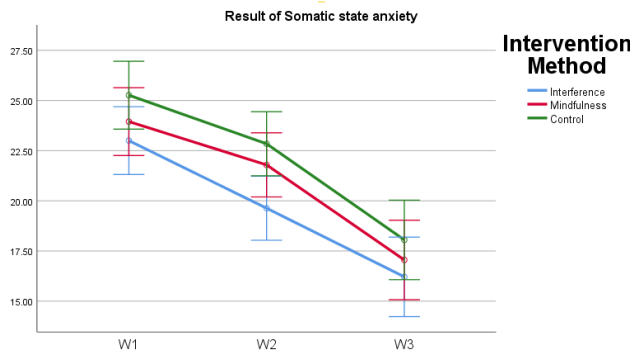


Figure 5: Somatic-state anxiety over time by group

State confidence also changed over time [F (2, 54) =74.637, P<0.001, $\eta^2=0.580$].

Simple effect analysis of time points (in Figure 6 below) showed that the interference group had significant improvement at T1-T2 (p <0.001) and T2-T3 (p<0.05). The mindfulness group showed significant improvements at T1-T3 (p<0.001). The control group showed a significant increase at T1-T3 (P=0.018). Since T2, there were significant differences between the mindfulness group and the interference group, and the training group (P<0.05). There were significant differences among the three groups at T3. Overall, Interference training resulted in the largest increase in State confidence, Mindfulness training the second, control group the last.

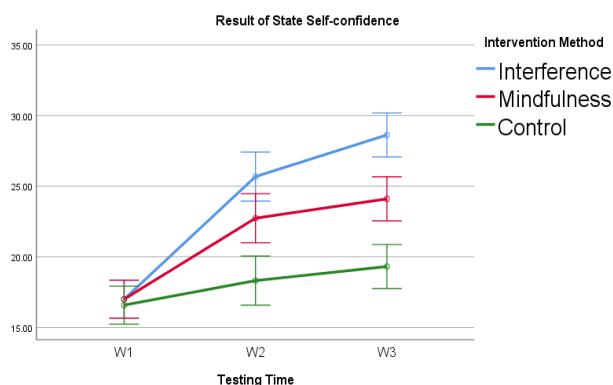


Figure 6: State Self-confidence over Time by Group

5. Discussion

We aimed to test the effects of different psychological training approaches on the performance of shooting enthusiasts under high-pressure conditions and to identify the best training plan to improve the performance of athletes and reduce sports anxiety.

This study shows that both interference training and mindfulness training can improve athletes' athletic performance and significantly improve their mental state, but they each have more suitable application scenarios. When training conditions are not sufficient, simple and easy interference training can be chosen as a way to improve athletic performance [17]. When qualified psychological counselors are training with the team, mindfulness training can better regulate the overall physical and mental state, as a means of long-term intervention.

5.1 The intervention effects on performance

Overall, after 5 weeks of training, all three groups showed improved performance $P < 0.05$. The interference training group showed the greatest improvement in shooting performance in the first three weeks but this plateaued after the fourth week. In contrast, in the mindfulness group, shooting performance improved over time in an almost linear fashion. The control group also showed significant improvement from T1 to T6, indicating that this test still has some practice effect. The quick improvement in the interference training group may stem from the intuitive nature of the exercise, whereas mindfulness training requires a period of training before the participant understands and can apply its concepts. The plateau in the interference group may have occurred because, over time, the training was found to be monotonous, resulting in participant boredom.

Further regression analysis was conducted on the interference training group and the mindfulness training group, and the results are shown in Table 6. Based on the results, the sports performance of different groups was speculated. Under the premise of ensuring the training effect, the shooting performance of the mindfulness training group would be better than that of the interference training group in the seventh to the eighth week. However, it should be noted that the sports performance is complex, and the variation of performance is affected by many factors, so this result can only be used as a reference.

5.2 Influence of intervention on psychological indices

After 5 weeks of mental training, the level of mindfulness was significantly improved in the mindfulness training group. The interference and traditional training groups were not exposed to concepts related to mindfulness, so mindfulness levels remained stable throughout. Due to the length

of the experiment, participants did not completely experience all the mindfulness-related courses according to the whole manual. Therefore, it remains to be determined whether participants with more established and mature mindfulness practice can achieve even better athletic performance and psychological scores.

In addition, after undergoing psychological training, the level of cognitive state anxiety decreased most in the mindfulness training group compared to the other two groups; there was no significant change between the other two groups. This indicates that mindfulness training can significantly improve the cognitive level of participants, making them less worried about expectation of the recoil or somatic anxiety subjectively during or before the test, and less negative evaluation of their abilities or negative expectations of the results of the competition. There was also a slight decrease in cognitive state anxiety in both the training and control groups; this may suggest that anxiety about the competition may be partly attributable to a lack of familiarity with the competitive environment and that cognitive state anxiety can be reduced after familiarization with the competition [26].

Significant declines in somatic state anxiety were observed in all three groups. This is not consistent with our initial assumption that there would be no significant change in this measure in the control group. This may be because this phase of the stress test was intensive and novel for all participants. With practice, participants may have habituated to the test, resulting in a reduction in their physiological arousal index.

In terms of state confidence, the interference training group showed the most significant improvement in state confidence, while the mindfulness training group showed a slight improvement and the control group showed no significant change. This increase suggests a higher belief by the participants in their success during or before the competition. Some studies report that the level of state self-confidence is closely related to the athletic level.

After the entire test was completed, several athletes in the intervention group were randomly selected and asked about their perceptions of the training program. During oral questioning following the intervention, participants reported a significant improvement in their aiming stability, resulting in increased confidence during the test. However, improving motor stability to such a degree in a short period of time is nearly impossible. So we speculate that the interference training may reduce the athletes' expectation of gun stability, and this hypothesis needs to be investigated in the future.

5.3 Test scenario Setting

Previous studies have shown that multiple stressors have a greater impact than a single stressor. In our pre-experiment of the stress test, the psychological and physiological indexes of the athletes were significantly higher than those of the non-pressure group, and the pressure setting played the expected effect and compared with the reaction of the athletes in the competition. After the end of the whole experiment, some participants reported that the greatest stressor was finding out that the professional team would use their current results as part of the selection process, followed by their expectation to impress the audience in the competition. This highlights that the pressure-inducing paradigm utilized in this experiment was effective.

5.4 Limitations

There are some limitations of this study. First, the test samples included shooting enthusiasts; elite athletes may show different responses. Second, due to the experimental conditions and time, participants did not receive a complete course of mindfulness training. Third, the setting of stressful situations will inevitably lead to the participants' adaptation effect, and there is no good solution at present. Third, we lack condition to conduct tracking test, as their coach advocate to arrange their own plan. Finally, only three measurements of the psychological state were used. This aspect of the

study was designed in consultation with the shooting coach and a team psychologist, who believed that additional indices may result in participant fatigue and a concomitant reduction in response veracity and data quality. However, our experimental design was largely in line with other similar studies. In future studies, a certain sample size of high-level athletes can be selected for long-term intervention, and feasible pressure programs can be explored.

6. Conclusion

This study investigated the effects of interference training and mindfulness training on competitive shooting performance under stressful situations. We found that both training methods produced positive psychological benefits. In general, interference training is simple and has a strong immediate performance improvement effect, but plateaus. In contrast, the benefits of the mindfulness training were gradual and continuous. Therefore, we suggest that athletes are provided mindfulness training as a primary tool if they have adequate time to prepare for competition; interference training is recommended as the main training method if less than one month of preparation time is available or if they are unable to access appropriate psychological assistance.

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