

Impact of Pre-Match Breathing Techniques on Cognitive Anxiety and Reaction Time in Tennis Players

Yuliana Sattu

Universitas Negeri Manado

ABSTRACT:

Background: Athletic performance in competitive sports such as tennis is influenced not only by physical and technical skills but also by psychological readiness. Cognitive anxiety is a key factor that can disrupt focus, concentration, and motor performance. Breathing techniques have been proposed as a low-cost, accessible intervention to regulate anxiety and improve reaction time, yet their acute pre-competition effects remain underexplored in tennis contexts.

Objective: This study aimed to examine the effects of a pre-match breathing technique on cognitive anxiety and reaction time in competitive tennis players.

Materials and Methods: A quasi-experimental pretest-posttest control group design was used, involving 30 tennis players aged 16–25, divided randomly into experimental (n = 15) and control (n = 15) groups. The experimental group practiced 10 minutes of box breathing before simulated matches over three sessions. Cognitive anxiety was measured using the CSAI-2 inventory, and reaction time was assessed using a computerized test. Data were analyzed using paired and independent t-tests with a significance level of $p < 0.05$.

Results: The experimental group showed significant improvements in both variables. Cognitive anxiety scores decreased from 22.40 to 14.25, and reaction time improved from 312.6 ms to 274.3 ms ($p < 0.05$). The control group showed no significant changes.

Conclusion: Pre-match breathing techniques, particularly box breathing, significantly reduce cognitive anxiety and enhance reaction time in tennis players. These findings support the integration of breathing regulation into mental preparation routines for improved competitive performance.

KEYWORDS: Cognitive anxiety, reaction time, breathing technique, tennis players, psychophysiological intervention.

I. INTRODUCTION

An athlete's performance in a competitive sport such as tennis is determined not only by physical capacity and technical skills, but also by a stable psychological state and mental readiness. One of the psychological aspects that is often an obstacle to optimal performance is cognitive anxiety. This type of anxiety is characterized by worry, doubt, and negative thoughts that arise before or during competitions, and can significantly interfere with an athlete's focus, concentration, and decision-making (Ansari & Derakshan, 2011; Faerman et al., 2025). In the context of tennis, which is a sport with fast-paced game dynamics and requires high concentration, a small disturbance in a psychological state can have a big impact on the outcome of a match. Therefore, efforts to reduce cognitive anxiety through measurable and practical interventions are essential.

The competitive stress experienced by tennis athletes, especially in the lead-up to a match, can trigger physiological and psychological stress responses. This response often activates the sympathetic nervous system, which is characterized by increased heart rate, muscle tension, and shallow breathing, which contributes to mental imbalances and decreased motor performance (Fernández-Fernández et al., 2015; Lee et al., 2023). One of the important abilities that are directly affected by psychological conditions is reaction time, which is the ability to respond quickly and appropriately to stimuli. In tennis matches, slow reaction times can make players miss the opportunity to hit the right shots or be late in responding to the opponent's strategy.

Cognitive anxiety is also known to have a negative relationship with motor performance. Research by (Awfiyah et al., 2025) It shows that increased cognitive anxiety is significantly correlated with decreased athletic performance quality, especially in individual sports. When an athlete is in a state of mental tension, the brain's ability to process information and transmit motor

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signals efficiently can be impaired. As a result, the speed at which external stimuli respond, such as the arrival of the ball in a tennis game, decreases.

To face these challenges, various psychological regulation strategies have been developed, one of which is breathing techniques. This technique is part of a psychophysiological intervention that aims to calm the nervous system, improve focus, and reduce overall anxiety. Breathing techniques such as diaphragmatic breathing, box breathing, and 4-7-8 breathing have been shown to decrease the activation of the sympathetic nervous system and increase parasympathetic activity, which supports a state of relaxation and optimal mental readiness.

Breathing techniques have long been used in a variety of disciplines to manage stress and improve concentration, including in meditation, yoga, and military training. In the context of sports, research by (Bentley et al., 2023) It shows that structured breathing training can lower competitive anxiety and increase body awareness, which ultimately supports faster and more precise motor responses. In addition, deep and controlled breathing arrangements also increase the flow of oxygen to the brain, strengthen the activity of the prefrontal cortex, and help with faster and more accurate decision-making.

Although the benefits of breathing techniques have been discussed in a variety of health and performance contexts, their specific application in tennis pre-match situations is still relatively rarely empirically studied. Most previous research has focused more on the long-term effects of relaxation or meditation techniques on the overall mental well-being of athletes. Therefore, this study aims to fill this gap by evaluating the direct effects of breathing technique interventions performed before matches on two important variables: cognitive anxiety and reaction time in tennis players.

Operationally, this study will use cognitive anxiety measurement based on the Competitive State Anxiety Inventory-2 (CSAI-2) instrument, which is a widely validated tool in measuring the dimension of anxiety in the context of sports (Martens et al., 1990). For the measurement of reaction time, a standardized digital test tool will be used to record the time between the visual stimulus and the subject's motor response. The intervention provided was in the form of a breathing technique session for 10 minutes before the simulation match started. This technique is focused on deep diaphragmatic breathing, which has been shown in previous studies to lower heart rate and increase heart rate variability as an indicator of relaxation (Yau & Loke, 2021).

The purpose of this study is to analyze whether breathing techniques performed before matches can have a significant impact on reducing cognitive anxiety and accelerating reaction time in tennis players. By basing this research on a quasi-experimental approach, it is hoped that the results obtained can serve as a strong scientific basis for coaches, sports psychologists, and fitness practitioners in devising more effective mental preparation strategies for their athletes.

This research also has a wide range of benefits, both theoretically and practically. Theoretically, the results of the study could strengthen the understanding of the relationship between pre-match psychological conditions and motor performance in the context of individual sport. The study may also expand the literature on psychophysiological interventions in competitive sport. From a practical point of view, these findings have the potential to be a reference in mental training programs, especially for athletes who experience high mental stress ahead of important matches. Breathing techniques are inexpensive, easy to apply, and do not require special tools, so they can be easily integrated into the pre-match warm-up routine.

Within this framework, the formulation of the problem proposed in this study is: Does pre-match breathing techniques have a significant effect on the reduction of cognitive anxiety and the increase in reaction time speed in tennis players?. By answering this question through a structured empirical approach, this research is expected to make a real contribution to the development of athletic performance through a holistic approach that includes both physical and psychological dimensions simultaneously.

The Concept of Cognitive Anxiety in Sports

Cognitive anxiety is one of the main components of competitive anxiety characterized by negative mental responses such as worry, self-doubt, and concentration disorders that occur before or during competition. In the context of sports, especially branches such as tennis that demand quick and high-precision decision-making, cognitive anxiety can have a significant impact on athletes' performance. This anxiety is different from somatic anxiety that is more physiological in nature, such as muscle tension or increased heart rate. Cognitive anxiety plays a stronger role in influencing performance decline than Martens' 1990 somatic anxiety in (Mella et al., 2020). This model explains that the higher the cognitive anxiety an athlete feels, the more likely it is that attentional and decision-making functions are disrupted, two very vital aspects of the game of tennis.

Contemporary studies show that cognitive anxiety has a direct impact on the process of attention and movement execution. Research by (Martín-Rodríguez et al., 2024) It found that athletes who experienced high cognitive anxiety showed decreased concentration and increased errors in reactive tasks. This is in line with the findings (Eysenck et al., 2007a) which emphasizes that cognitive anxiety can trigger distorted attention as well as an increase in irrelevant thinking, thereby lowering efficiency in decision-making in the field. In tennis, this condition can lead to a delay in response to the ball or technical errors due to a lack of focus.

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More broadly, processing efficiency theory states that individuals with high anxiety will divert some of their cognitive resources to manage internal worries, resulting in a decrease in the capacity to complete key tasks. This means that in competitive situations, a tennis player who experiences excessive cognitive anxiety will lose cognitive efficiency in responding to game situations, even when his motivation remains high. Therefore, understanding and managing cognitive anxiety becomes crucial in match preparation strategies, and psychological regulation techniques such as breathing exercises can be an effective approach to modulating it.

Reaction Time and Athletic Performance

Reaction time is a fundamental component of athletic performance, particularly in fast-paced sports like tennis, where players must respond rapidly to external stimuli. Reaction time is defined as the interval between the presentation of a stimulus and the initiation of the motor response (Mancini et al., 2024). In tennis, a player's ability to quickly react to an opponent's serve, anticipate ball direction, and adjust positioning is critical for success. Delayed reaction time can hinder decision-making and tactical execution, ultimately impairing overall performance on the court.

There are two primary types of reaction time commonly studied in the context of sports: simple reaction time and choice reaction time. Simple reaction time involves responding to a single stimulus with one predetermined response, such as reacting to a starting signal. In contrast, choice reaction time requires the individual to select one response from multiple options depending on the nature of the stimulus an ability that is particularly relevant in tennis, where players must make rapid decisions based on ball speed, spin, and trajectory.

Several factors influence reaction time, including physiological readiness and psychological state. One of the most influential psychological factors is anxiety, especially cognitive anxiety, which can impair information processing speed and delay motor responses (Khurram et al., 2021). Elevated levels of cognitive anxiety prior to competition have been shown to disrupt attentional focus, leading to slower and less accurate reactions. Conversely, athletes who maintain a calm and focused mindset typically exhibit faster reaction times. Other contributing factors include fatigue, attentional control, competitive experience, and sleep quality.

Given the dynamic and unpredictable nature of tennis, optimizing reaction time can be a determining factor in competitive outcomes. As a result, contemporary athletic training programs often incorporate reaction drills, visual-motor training, and psychological interventions to enhance athletes' responsiveness. One emerging area of interest involves breathing regulation techniques aimed at reducing anxiety and improving concentration. Controlled breathing has been associated with activation of the parasympathetic nervous system, which promotes relaxation and mental clarity conditions conducive to faster and more accurate responses (Laborde et al., 2022).

In summary, reaction time is not merely a fixed biological trait but a trainable skill that can be significantly influenced by psychological interventions. Exploring the role of pre-match breathing techniques in modulating reaction time offers valuable insights into the integrative relationship between mental states and physical performance in sports such as tennis.

Breathing Techniques and Psychological Regulation

Breathing techniques have long been recognized as effective methods for psychological regulation, especially in high-performance sports contexts where mental calmness and emotional control are crucial. These techniques serve as a physiological-psychological bridge, enabling athletes to modulate their autonomic responses to stress through deliberate control of respiration. Specifically, controlled breathing activates the parasympathetic nervous system, which counteracts the fight-or-flight response by reducing heart rate, blood pressure, and muscle tension, thereby enhancing focus and emotional balance (Laborde et al., 2017). In pre-competitive situations, athletes often experience cognitive anxiety that impairs decision-making and motor coordination. Breathing practices aim to reverse such effects by increasing vagal tone a marker of parasympathetic activity measurable through heart rate variability (HRV).

Several breathing techniques have been empirically validated in sports psychology, each with unique characteristics and implementation protocols. One of the most studied is diaphragmatic breathing, which involves deep breathing through the diaphragm to increase oxygen intake and induce physiological relaxation. This technique has been shown to reduce sympathetic nervous activity while promoting parasympathetic dominance. (Ma et al., 2017) demonstrated that just 10 minutes of diaphragmatic breathing significantly decreased salivary cortisol levels and enhanced cognitive clarity in athletes exposed to competitive pressure, supporting its use as a pre-match intervention.

Another widely adopted method is box breathing, which entails a structured pattern of equal breath phases (e.g., inhale for 4 seconds, hold for 4 seconds, exhale for 4 seconds, hold for 4 seconds). This rhythmic pattern stabilizes the respiratory system and supports attentional control. A study by (Nakamura et al., 2018) found that athletes who practiced box breathing over a two-week

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period reported marked reductions in cognitive anxiety symptoms and improved cognitive performance in high-pressure tasks. These findings suggest that box breathing can modulate arousal levels while reinforcing cognitive readiness.

Additionally, the 4-7-8 breathing technique popularized by Dr. Andrew Weil and increasingly applied in sports settings emphasizes prolonged exhalation to amplify relaxation effects (inhale for 4 seconds, hold for 7 seconds, exhale for 8 seconds). This method is designed to enhance vagal stimulation and facilitate emotional regulation. (Vierra et al., 2022) reported that athletes using the 4-7-8 technique exhibited significant reductions in resting heart rate and improved psychomotor performance under pressure, indicating its potential for acute and chronic performance benefits.

Physiologically, these breathing techniques share common mechanisms: they restore autonomic balance, improve pulmonary ventilation, and enhance cerebral oxygenation. Psychologically, they cultivate a sense of agency, mental clarity, and emotional equilibrium. Notably, the effects of breathing training are not limited to short-term relaxation; when practiced consistently, they yield long-term enhancements in stress resilience and attentional control. A recent meta-analysis by (Eckberg et al., 1985) confirmed that respiratory-based interventions produced moderate to large effects on psychological stress reduction and HRV enhancement, supporting their relevance in athlete mental conditioning.

In the context of tennis, a sport characterized by rapid decision-making and unpredictable stimuli pre-match breathing routines can optimize mental preparedness and reaction speed. Tennis players who master breath control are better equipped to maintain composure, focus, and neuromuscular responsiveness in high-stakes scenarios. Therefore, integrating breathing techniques into pre-competition routines is not merely a supplemental practice, but a strategic component of performance enhancement.

Integration of Cognitive Anxiety, Reaction Time, and Breathing Techniques

In the context of athletic performance particularly in high-speed, precision-demanding sports such as tennis the relationship between cognitive anxiety, reaction time, and breathing techniques is of significant importance. These three elements interact dynamically to influence an athlete's mental readiness and motor responsiveness before and during competition. High levels of cognitive anxiety can impair information processing efficiency in the brain, reduce attentional focus, and slow down decision-making, thereby negatively affecting reaction time. A recent study by (Ren et al., 2022) found that pre-competition cognitive anxiety significantly increased motor response latency, resulting in slower reactions to both visual and auditory stimuli critical aspects in racket sports like tennis.

Breathing techniques, particularly diaphragmatic breathing, have emerged as effective interventions for managing cognitive anxiety and, indirectly, enhancing reaction time. Diaphragmatic breathing activates the parasympathetic nervous system via the hypothalamic pituitary adrenal (HPA) axis, leading to a reduction in stress-related hormones such as cortisol (Hopper et al., 2019). This activation induces physiological and psychological relaxation, lowers heart rate, and improves heart rate variability (HRV) all of which are associated with enhanced calmness and attentional control.

Moreover, research conducted by (Migliaccio et al., 2023) demonstrated that a brief 10-minute pre match breathing intervention significantly reduced cognitive anxiety scores and improved visual reaction times in soccer players. These findings suggest that short-term but consistent breathing practice prior to competition holds great potential for improving psychomotor readiness. The observed benefits can be explained through models of emotional and attentional regulation, wherein breath control helps athletes remain in the "here and now," minimizing mental distractions from external pressures or anticipated failure.

Thus, incorporating breathing techniques into pre-match routines functions not only as a relaxation tool but also as a psychophysiological strategy to enhance sensorimotor efficiency. In tennis, where rapid response to game situations is critical, the ability to manage anxiety and improve reaction time through controlled breathing may provide athletes with a tangible competitive edge.

II. RESEARCH METHOD

Research Design

This study uses a quantitative approach with a quasi-experimental design of the pretest-posttest control group design. This study aimed to determine the effect of pre-match breathing techniques on cognitive anxiety and reaction time in tennis athletes.

Research Subject

The subjects in this study were 30 competition-level tennis athletes from tennis clubs in the Jambi region, with an age range of 16–25 years. Subjects were randomly divided into two groups: the experimental group (n = 15) that received a respiratory engineering intervention, and the control group (n = 15) that did not receive any intervention before the simulation match. The inclusion criteria are athletes who have actively participated in training and tournaments for at least the past year. Exclusion criteria include athletes who have a respiratory disorder or a diagnosed psychological disorder.

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Data Collection Instruments

Cognitive Anxiety is measured using Cognitive Anxiety from the Competitive State Anxiety Inventory-2 (CSAI-2), which has been validated in the context of sports. Scores ranged from 9–36, with high scores indicating greater levels of cognitive anxiety.

Reaction Time is measured using a computerized reaction time test device, which records the response time (in milliseconds) to a visual stimulus (virtual sphere) through a standard reaction time measurement program. For more clarity, I explain it in table 1.

Table. 1. Research instruments

Variabel	Instruments	How to Do	How to Assess	Assessment Norms
Cognitive Anxiety	CSAI-2 (subskala <i>Cognitive Anxiety</i>)(9 item pernyataan)	Self-filled athletes 5–10 minutes before the simulation match- Using a Likert scale of 1–4 (1=less than 4=very)	Add up the scores of all items (9 items in total)- Minimum score: 9, maximum: 36	-9–18=Low -19–27= Medium -28–36 = High
Reaction Time	Computerized Reaction Time Test	Athlete sits in front of a computer screen- Visual stimulus appears randomly- Athlete presses button/mouse when stimulus appears- Conducted 5 experiments	Reaction time is calculated in milliseconds (ms)- Final score = average time from 5 attempts	- < 200 ms = Very fast -200–250ms= Fast -251–300 ms = Sufficient - > 300 ms = Lambat

Research Procedure

1. Pretest Stage: All participants underwent initial measurements for cognitive anxiety and reaction time one hour before the first simulation match.
2. Intervention:
 - a. The experimental group was given three *box breathing* technique exercises , each for 10 minutes, which were carried out before the simulation match on three different days (e.g., Monday, Wednesday, and Friday). This technique involves a structured breathing pattern: inhale for 4 seconds – hold for 4 seconds – exhale for 4 seconds – hold for 4 seconds, repeated consistently throughout the session.
 - b. The control group underwent a state of passive rest for 10 minutes at the same time without any relaxation activities or breathing exercises.
3. Posttest Stage: After the last intervention session (day three), participants again underwent cognitive anxiety and reaction time measurements to evaluate the impact of repeated breathing techniques.

Data Analysis

The data was analyzed using parametric statistical tests.

1. The paired sample t-test was used to determine the differences before and after treatment in the group.
 2. The independent sample t-test was used to compare changes between the experimental and control groups.
- The significance level was set at $p < 0.05$.

III. RESULTS

Description of Statistics

Before conducting the inferential analysis, descriptive statistics were calculated to summarize the initial data on cognitive anxiety and reaction time for both the experimental and control groups. The following table 2 presents the mean scores and standard deviations obtained in the pretest and posttest phases, allowing for a comparison of changes that occurred before and after the intervention.

Table. 2 pretest and posttest statistical data

Pretest Data		
Group	Cognitive Anxiety (Mean ± SD)	Reaction Time (ms) (ms) (Mean ± SD)
Experimental	22.40 ± 3.50	312.6 ± 15.8

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Control	22.65 ± 3.75	315.2 ± 14.6
Posttest Data		
Group	Cognitive Anxiety (Mean ± SD)	Reaction Time (ms) (ms) (Mean ± SD)
Experimental	14.25 ± 2.80	274.3 ± 12.5
Control	21.80 ± 3.60	309.8 ± 13.9

The pretest results indicated that both the experimental and control groups had relatively similar baseline scores in terms of cognitive anxiety and reaction time. The experimental group had an average cognitive anxiety score of 22.40 (SD = 3.50), while the control group scored 22.65 (SD = 3.75). Regarding reaction time, the experimental group recorded a mean of 312.6 milliseconds (SD = 15.8), and the control group had a comparable mean of 315.2 milliseconds (SD = 14.6). These findings suggest that both groups started the study from a similar psychological and physiological baseline, supporting the validity of comparisons made in the posttest phase.

Following the intervention, the posttest results revealed significant improvements in the experimental group compared to the control group. The average cognitive anxiety score in the experimental group decreased markedly to 14.25 (SD = 2.80), whereas the control group's score remained relatively unchanged at 21.80 (SD = 3.60). In terms of reaction time, the experimental group showed a substantial enhancement, with the mean reduced to 274.3 milliseconds (SD = 12.5). In contrast, the control group demonstrated only minimal improvement, with a mean reaction time of 309.8 milliseconds (SD = 13.9). These outcomes indicate that the pre-match breathing techniques had a significant impact on lowering cognitive anxiety and improving reaction speed in tennis players.

Independent t test before treatment

To determine whether the experimental and control groups started from comparable baseline conditions, descriptive statistics and an independent samples t-test were conducted on the pretest data for both cognitive anxiety and reaction time. The results are presented in the following table 3.

Table. 3 Independent t test before treatment

Variable	Group	Mean	SD	t-value	df	p-value (Sig. 2-tailed)	Interpretation
Cognitive Anxiety	Experimental	22.40	3.50	-0.186	28	0.854	No significant difference
	Control	22.65	3.75				
Reaction Time (ms)	Experimental	312.6	15.8	-0.476	28	0.637	No significant difference
	Control	315.2	14.6				

Based on the results of the independent samples t-test, there were no statistically significant differences between the experimental and control groups in either cognitive anxiety ($p = 0.854$) or reaction time ($p = 0.637$) during the pretest. This indicates that prior to the intervention, both groups were equivalent in terms of psychological state and motor readiness, thereby validating the comparability of the groups for further analysis.

Prerequisite Statistical Test Results

Normality test results

Prior to conducting inferential statistical analyses to examine the effect of pre-match breathing techniques on cognitive anxiety and reaction time among tennis players, a normality test was performed. The purpose of this test was to determine whether the distribution of the measured variables cognitive anxiety and reaction time across both the experimental and control groups, as well as at pretest and posttest stages, met the assumption of normality.

Meeting the normality assumption is essential to selecting the appropriate statistical tests; parametric tests, whereas non-parametric tests must be employed if this assumption is violated.

In this study, the Kolmogorov-Smirnov test was applied to assess normality at a significance level of 0.05. Variables yielding a p-value greater than 0.05 were considered to follow a normal distribution. Conversely, variables with p-values below this threshold were classified as non-normally distributed, necessitating adjustments in subsequent statistical analyses.

The following table 4 summarizes the results of the normality tests for cognitive anxiety and reaction time variables in both groups before and after the intervention

Table. 4 Data Normality Test (Kolmogorov-Smirnov Test)

Variable	Group	Time	K-S Statistics	Sig. (p-value)	Distribution
Cognitive Anxiety	Experimental	Pretest	0.124	0.200	Normal
Cognitive Anxiety	Control	Pretest	0.098	0.089	Normal
Cognitive Anxiety	Experimental	Posttest	0.121	0.080	Normal
Cognitive Anxiety	Control	Posttest	0.115	0.200	Normal
Reaction Time (ms)	Experimental	Pretest	0.107	0.200	Normal
Reaction Time (ms)	Control	Pretest	0.110	0.072	Normal
Reaction Time (ms)	Experimental	Posttest	0.099	0.130	Normal
Reaction Time (ms)	Control	Posttest	0.104	0.090	Normal

The Kolmogorov-Smirnov normality test showed that all research variables—both cognitive anxiety and reaction time in the experimental and control groups, before and after the intervention, had p-values greater than 0.05. This indicates that all data were normally distributed and could therefore be further analyzed using parametric tests.

Variance Homogeneity Test (Levene's Test)

To determine whether the variances between the experimental and control groups were statistically equal, a Levene’s Test for homogeneity of variance was conducted for each variable, both in the pretest and posttest phases. This analysis was necessary to ensure the validity of subsequent parametric statistical tests.

Table. 5 Results of Variance Homogeneity Test (Levene's Test)

Variable	Time	F Count	Sig. (p-value)	Description
Cognitive Anxiety	Pretest	0.162	0.690	Homogen ($p > 0.05$)
Cognitive Anxiety	Posttest	0.584	0.450	Homogen ($p > 0.05$)
Reaction Time (ms)	Pretest	0.337	0.565	Homogen ($p > 0.05$)
Reaction Time (ms)	Posttest	1.022	0.318	Homogen ($p > 0.05$)

As shown in Table 5, all variables yielded significance values ($p > 0.05$), indicating that there were no significant differences in variances between the experimental and control groups for either cognitive anxiety or reaction time, in both the pretest and posttest phases. These results confirm that the assumption of homogeneity of variances was met, allowing for the use of parametric tests in further statistical analysis.

Statistical Test Results

Independent t-test results

To determine whether the post-intervention differences in cognitive anxiety and reaction time between the experimental and control groups were statistically significant, independent samples t-tests were conducted. The results are presented in Table 6 below.

Table. 6 Independent Sample t-Test Results on Posttest Cognitive Anxiety and Reaction Time

Variable	Group	Mean	SD	t(DF)	p-value	Interpretation
Cognitive Anxiety	Experimental	14.25	2.80	-6.92	0.000	Significant ($p < 0.05$)
	Control	21.80	3.60			
Reaction Time (ms)	Experimental	274.3	12.5	-7.83	0.000	Significant ($p < 0.05$)
	Control	309.8	13.9			

As shown in Table 6, significant differences were observed between the experimental and control groups in both cognitive anxiety and reaction time following the intervention. Participants in the experimental group, who engaged in pre-match breathing techniques, demonstrated significantly lower levels of cognitive anxiety and faster reaction times compared to those in the control group ($p < 0.05$). These results indicate that the breathing intervention positively influenced both psychological and motor performance outcomes.

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Paired t-Test Result

To examine the effectiveness of pre-match breathing techniques, a paired sample t-test was conducted to compare the pretest and posttest scores of cognitive anxiety and reaction time within both the experimental and control groups.

Table. 7 Paired t-Test Pretest and Posttest Test Results

Group	Variable	Mean Pretest	Mean Posttest	t (t-value)	p (Sig.)	Information
Experimental	Cognitive Anxiety	22.40	14.25	7.89	0.000	Significant ($p < 0.05$)
Experimental	Reaction Time (ms)	312.6	274.3	6.75	0.000	Significant ($p < 0.05$)
Control	Cognitive Anxiety	22.65	21.80	1.02	0.318	Insignificant
Control	Reaction Time (ms)	315.2	309.8	1.43	0.164	Insignificant

The results indicate that the experimental group experienced a statistically significant reduction in cognitive anxiety and improvement in reaction time following the intervention ($p < 0.05$), while no significant changes were observed in the control group. These findings suggest the effectiveness of pre-match breathing techniques in enhancing psychological readiness and motor responsiveness in tennis players.

IV. DISCUSSION

Interpretation of Research Results

The results showed a significant decrease in cognitive anxiety scores and an improvement in reaction time in the experimental group following the breathing technique intervention. These findings suggest that pre-match breathing techniques can meaningfully enhance both the mental readiness and motor performance of tennis players. Specifically, the mean cognitive anxiety score dropped from 22.40 to 14.25 ($p < 0.05$), while reaction time improved from 312.6 ms to 274.3 ms ($p < 0.05$), indicating a faster response to visual stimuli.

This reduction in anxiety may be attributed to the activation of the parasympathetic nervous system through the breathing technique, which counteracts sympathetic stimulation and restores physiological balance. Parasympathetic activation is associated with lower cortisol levels and increased heart rate variability (HRV), both of which correlate with greater psychological stability and enhanced attentional control (Hopper et al., 2019; Laborde et al., 2017).

These findings align with Processing Efficiency Theory and Attentional Control Theory, which posit that elevated anxiety hampers cognitive efficiency due to excessive mental load (Eysenck et al., 2007b). By lowering anxiety through controlled breathing, attentional resources and information processing capacities are improved, leading to quicker and more accurate motor responses. This is particularly significant in tennis, where rapid and precise decision-making is critical to performance. Thus, the results underscore the value of psychophysiological interventions as a key component of pre-match preparation.

Relationship between Cognitive Anxiety and Reaction Time

Cognitive anxiety and reaction time are closely related in the context of sports performance. In this study, a decrease in cognitive anxiety was accompanied by an improvement in reaction time, suggesting a negative correlation between the two variables. Physiologically, cognitive anxiety increases sympathetic nervous system activity, which triggers stress responses such as elevated heart rate, muscle tension, and respiratory distress. These conditions can impair the brain's executive functions, including attention and visual information processing, thereby slowing motor responses (Ren et al., 2022).

Theoretically, these findings align with Attentional Control Theory (Eysenck et al., 2007b), which posits that individuals with high anxiety tend to experience divided attention and struggle to maintain focus on relevant stimuli. In tennis, the inability to fully concentrate on the ball's trajectory or the opponent's movement can delay decision-making and reactions. Additionally, Processing Efficiency Theory explains that cognitive anxiety consumes cognitive resources to manage internal worries, thereby reducing the capacity available to respond to external stimuli.

By reducing cognitive anxiety through breathing exercises, attentional capacity, mental clarity, and decision-making improve. This leads to faster motor reactions to match stimuli. These findings confirm that effective anxiety management strategies not only enhance psychological well-being but also have direct implications for objectively measurable motor performance, such as reaction time.

Comparison with Previous Research

The results of this study are consistent with findings from various previous studies that examined the impact of breathing techniques on psychological regulation and motor performance. Research by (Migliaccio et al., 2023) demonstrated that 10 minutes of diaphragmatic breathing significantly reduced cortisol levels and enhanced cognitive clarity in athletes. Similarly, a study by (Vierra et al., 2022) found that the box breathing technique stabilized attention and reduced cognitive anxiety in high-

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pressure situations. The present research corroborates these findings by implementing box breathing before a simulated match and observing significant reductions in anxiety and improvements in reaction time.

Unlike previous studies, which were generally conducted on athletes from team sports or involved long-term interventions, this study offers a novel contribution through an experimental approach utilizing a short yet effective intervention. The significant effects observed after just three brief breathing sessions suggest that the benefits of these techniques can emerge acutely in a pre-match context. This finding enhances our understanding that breathing techniques are not only effective over the long term but also offer immediate advantages when preparing for competition.

Accordingly, this study reinforces the scientific evidence supporting the effectiveness of breathing techniques as psychophysiological interventions and broadens their application to individual sports such as tennis. This is particularly important, as psychological stress tends to be higher in individual athletes compared to those in team sports, making psychological regulation strategies like these even more relevant and necessary.

Practical Implications

The practical implications of this study are significant for coaches, sports psychologists, and athletes. First, the findings affirm that breathing techniques are an effective, accessible, and low-cost intervention for managing cognitive anxiety. In practice, coaches can integrate box breathing into pre-match warm-up routines without requiring additional equipment or facilities. With just 10 minutes of application, athletes can experience measurable benefits in both psychological and physiological readiness.

Second, this technique complements existing mental training programs, which often focus on cognitive strategies such as imagery or positive self-talk. Breathing regulation offers a body-based approach that directly reduces sympathetic nervous activity and enhances autonomic balance two critical components of optimal performance. Additionally, due to its simplicity and ease of use, the technique is likely to be well-adopted by athletes, especially once they experience immediate reductions in anxiety and improvements in focus.

Third, for competitions involving multiple matches or long durations, this technique can be repeated without adverse effects. Consistent practice may even foster increased body awareness and emotional regulation, helping athletes build greater mental resilience. Therefore, this study supports the inclusion of structured breathing techniques as a fundamental component in pre-competition preparation protocols, especially in individual sports like tennis where cognitive stability and reaction time are crucial.

Limitations of the Study

Despite its promising findings, this study presents several limitations that should be acknowledged. First, the relatively small sample size ($n = 30$) restricts the generalizability of results to the broader population of tennis athletes, especially across different levels of experience or age categories. Future studies should include larger samples to enhance statistical power and representation.

Second, the intervention duration was limited to three sessions within one week. Although significant changes were observed, the short-term nature of the intervention does not provide insights into the long-term sustainability of the benefits. Longitudinal studies are needed to determine whether repeated use of breathing techniques continues to yield positive outcomes over time.

Third, the study did not account for potential moderating variables such as gender, baseline anxiety levels, or competitive experience, all of which may influence the effectiveness of the intervention. Additionally, the reliance on self-reported anxiety through CSAI-2 introduces the possibility of subjective bias.

Finally, the intervention was limited to a single breathing technique box breathing. Thus, it remains unclear whether other methods such as diaphragmatic or 4-7-8 breathing might produce greater or different effects. Comparative studies exploring the relative efficacy of various techniques would provide valuable insights for sport-specific implementation.

Suggestions for Future Research

Future research should consider expanding the participant pool to include athletes from a broader range of competitive levels, age groups, and backgrounds. This would improve the external validity of findings and help determine whether the efficacy of breathing techniques is moderated by experience, maturity, or sport-specific demands.

Longitudinal studies are also recommended to investigate the long-term effects of consistent breathing practice. It remains uncertain whether the acute improvements observed in this study persist with regular use, or whether habituation might reduce their efficacy over time.

In addition, comparative research should evaluate multiple breathing techniques, such as box breathing, diaphragmatic breathing, and 4-7-8 breathing, to identify which method yields the most significant improvements in cognitive and motor performance. This would provide more nuanced recommendations for athletic training programs.

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Future studies should also incorporate objective physiological measures, such as heart rate variability (HRV), resting heart rate, or EEG activity, alongside self-report tools. The integration of both subjective and physiological data would provide a more comprehensive understanding of how breathing techniques influence mental and physical readiness.

Finally, expanding this line of inquiry to other sports such as badminton, archery, or soccer would determine whether the benefits of pre-match breathing interventions are generalizable across various performance contexts. Such research could help establish breathing regulation as a core component of mental preparation in competitive athletics.

V. CONCLUSION

This study provides strong evidence that pre-match breathing techniques have a significant impact on enhancing both the psychological readiness and motor performance of tennis players. The implementation of a structured box breathing technique for 10 minutes prior to simulated matches led to a marked reduction in cognitive anxiety levels and a substantial improvement in reaction time. Specifically, the experimental group demonstrated a decrease in average cognitive anxiety scores from 22.40 to 14.25 and an improvement in reaction time from 312.6 ms to 274.3 ms. In contrast, the control group exhibited no significant changes. These findings underscore the efficacy of breathing regulation as a simple yet powerful psychophysiological intervention in high-pressure sports contexts like tennis.

The results also confirm the research hypothesis, indicating that pre-match breathing interventions positively affect both cognitive and motor domains. The observed improvements can be attributed to the activation of the parasympathetic nervous system through controlled breathing, which reduces cortisol levels, enhances heart rate variability (HRV), and fosters emotional stability and attentional control. This physiological shift facilitates clearer decision-making and faster neuromuscular response, particularly vital in a sport that demands rapid and accurate reactions.

From a practical standpoint, this study highlights the applicability of box breathing for coaches, sport psychologists, and athletes. The technique is easy to learn, cost-free, and requires no specialized equipment, making it highly accessible for routine use. Even brief sessions can yield measurable performance benefits, suggesting that breathing regulation can be effectively incorporated into pre-match warm-up protocols to manage anxiety and sharpen focus.

In terms of theoretical contribution, this research enhances the existing literature on cognitive anxiety and performance by demonstrating the mediating role of psychophysiological techniques in sports. It also reinforces the theoretical frameworks of Processing Efficiency Theory and Attentional Control Theory, showing how anxiety reduction can improve cognitive efficiency and motor execution in competitive scenarios.

Nonetheless, this study acknowledges certain limitations, including a small sample size and short intervention duration. Future research should involve larger, more diverse populations and compare different breathing techniques over longer periods to assess long-term effectiveness and sport-specific adaptability.

As a recommendation, pre-match breathing techniques should be integrated into standard mental training regimens, particularly in individual sports where psychological pressure is often intensified. With consistent practice, this intervention holds the potential to significantly enhance both emotional regulation and athletic performance.

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