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RESEARCH ARTICLE

Optimisation of stress regulation through yoga as a complementary mental preparation method for top tennis players: A case study focused on performance and mental well-being

Sarah Michelle Frasco[1], Kateřina Bočková[2,*], David Anthony Procházka[1], Viera Guzoňová[2]

[1] *University of New York in Prague, School of Business, Londýnská 41, Prague, Czechia*

[2] *DTI University, Department of Economics and Management, Sládkovičova 533/20, 018 41 Dubnica nad Váhom, Slovakia*

*** Corresponding author:** Kateřina Bočková, bockova@dti.sk

ABSTRACT

The presented paper investigates the impact of a one-year yoga intervention on stress regulation among top tennis players. The participants in this study consist of 39 top tennis players who are members of the VICTORIA University Sports Centre of the Ministry of Education, Youth and Sports of the Czech Republic. The targeted tennis players integrated two 60-minute dynamic vinyasa yoga sessions each practice week into their normal tennis routines. This was designed to provide physical and mental benefits to athletes, focussing on stress regulation and improved focus. Assessments were performed before and after the intervention to determine changes in stress regulation, competition anxiety, and the accuracy of the service. To measure stress regulation, the Perceived Stress Scale (PSS) and the Competition Anxiety Inventory for Tennis Players (CAI-T) were used. The accuracy of the tennis player's service was evaluated quarterly. The evaluation of the data sets showed changes in the regulation of anxiety and stress of tennis players. Furthermore, a paired sample t-test showed a significant impact of the yoga intervention on stress regulation. PSS scores showed a reduction, and also the CAI-T test scores showed a significant downward trend. Service accuracy was improved. A paired t-test confirmed that this improvement is statistically significant. We can conclude that the yoga intervention increases tennis players' performance and well-being.

Keywords: mental well-being, performance; stress regulation; tennis player; yoga

1. Introduction

In the world of top tennis, managing stress and regulating emotions is as crucial as a powerful service. The mental strength of a tennis player's mind is as vital as their physical abilities.

Knowing and understanding how athletes can reduce their stress and emotions throughout the game in a competition is vital for the success of the athlete. Especially tennis as an individual sport requires the athletes to frequently adapt to various environmental conditions such as weather, playing surface, crowd, multiple distractions, etc. As a professional tennis player, you must be physically and mentally fit throughout the year[1].

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Mental preparation for a tennis player is crucial throughout the year because it ensures constant psychological resilience, which is essential for high-level performance. It helps athletes manage the stress and pressure associated with professional tournaments, which is important for maintaining consistent performance throughout the season[2]. Regular mental training also improves focus and concentration, which is necessary to endure long and challenging matches[3]. In addition, mental preparation promotes positive thinking and self-confidence, which can significantly influence game strategy and decision-making on the court[4]. Finally, continuous mental training helps prevent burnout and maintains motivation and passion for the game throughout the player's career[5].

Therefore, the objective of this research article is to evaluate the effectiveness of integrating yoga as an intervention in the tennis player training programme and to determine its impact on their physical and mental preparation. Specifically, the research will focus on improving flexibility, balance, muscle strength, reducing levels of stress and anxiety, and improving concentration and mental resilience.

The results of the study will provide information on how regular yoga practice can contribute to improving tennis players and their ability to better handle challenging situations on the court.

With the increasing pressure of competitiveness and demands in professional tennis, knowing effective strategies on how to regulate and control one's stress level throughout the game can change the game and can help the tennis player ahead of their opponents. Regulating stress can improve not only the athlete's well-being, but also their overall performance on the court[6]. It is confirmed by numerous studies, for example, Gergüz and Aras Bayram[7], Hoja and Jansen[8], Kusuma and Bin[9], di Fronso et al.[10] or Joniton et al.[11]. Therefore, integrating yoga into the regular training regime could be the secret strategy to success, according to Kim and Lawlor[12] or Wang et al.[13].

Yoga has been practised since ancient times, it is a Hindu spiritual and ascetic discipline that integrates the mind, body, and soul and is known to improve strength and flexibility and alleviate pain and stress, and has been shown to be beneficial for regulating stress levels in competitive tennis players during the game[14]. For that reason, professional tennis players need a personalised yoga practice integrated into their normal tennis training regimes. Yoga class needs to be customised and adapted to its specific needs to yield optimal benefits by targeting specific muscle groups and using particular yoga positions that help the athlete achieve optimal performance while reducing stress.

Various research, for example Sarode[15], Malipatil[16], Kusuma and Bin[9] or Kanaujia et al.[17] have explored many areas of stress in different types of athletes; however, **there is a noticeable research gap concerning the specific impact of yoga on tennis players' stress regulation.**

Engaging in top tennis is not just about playing the game on a competitive level; it is much more; it is a journey that teaches us valuable life lessons. Through the ups and downs of competing, we learn how to handle setbacks and accept that winning isn't always guaranteed. We also develop the ability to remain focused amidst distractions and persevere through tough training sessions, regardless of the weather. But during actual meaningful matches, with pressure to represent the team and facing tough opponents, this is where we really grow. Each match or competition becomes a test of our mental strength, as we learn to manage stress and stay positive even when things get tough. When tension increases and our muscles tighten, this is where we need the ability to remain focused and calm so that we can exceed our performance. In the end, top tennis teaches us not only to be good at the sport, but also how to face life's challenges with resilience and determination.

The aim of this research study is multifaceted. The essential is to provide evidence, based on our research and with the help of an intervention, showing the significant benefits of yoga for professional

tennis players to improve overall performance and effectively manage stress regulation, integrating yoga into the training regime of tennis players.

Yoga is often preferred as a means of mental preparation for tennis players for several reasons:

- Flexibility and relaxation: Yoga includes exercises to release and improve body flexibility. Tennis players often face intense physical demands and need to keep their bodies in optimal condition. Regular yoga practice helps improve range of motion and relaxes muscles, which can reduce the risk of injury[18,19].
- Breath control and concentration: Yoga involves techniques for breath control (pranayama) and focus (dharana), which are key skills for tennis players. Breath control helps maintain a calm mind even in challenging court situations. Concentration helps players remain focused on their performance and decisions during matches[20].
- Psychological resilience: Yoga practice strengthens psychological resilience and helps tennis players better manage stress associated with professional sports. Meditation and relaxation techniques in yoga can reduce anxiety and improve general mental well-being[21,22].
- Overall physical and mental well-being: Yoga contributes to general physical and mental well-being. Tennis players often travel, train intensively and face pressure in competitive environments. Yoga can help them cope with these demanding conditions and support their general health[23,24].

The positive impact of yoga on an athlete's performance is clearly confirmed by the long-time world number one, tennis player Novak Djokovič, who himself acknowledges this fact, further supported by research studies, e.g. Jekauc et al.[25] or Kumar[26].

Through a comprehensive analysis of existing research, published not only in the aforementioned studies, but also in Chong et al.[27], Khalsa et al.[28], Balasubramaniam et al.[29] or Qi[30], our study tends to provide evidence and insights into how regular yoga practice can help the athlete manage stress regulation, as well as become mentally stronger on the court, resulting in better concentration, as well as reduce negative self-talks and being distracted while playing. When these factors are taken into account, the best tennis player is able to play at his best level of tennis and play 100% on the court. Without being able to properly manage and regulate their stress levels, athletes are prevented from performing at an optimal level, due to muscle tensing, high blood pressure, and reduced concentration, which then reduces focus over time during the match and then results in intrusive negative thoughts that can undermine the athlete's confidence.

In addition, with the help of this paper's intervention, the outcomes should provide a good overview of the beneficial changes in the results of pre- and post-intervention numbers on how yoga can benefit in the areas of stress reduction, mood enhancement, boost self-esteem on the court, and enhance the performance. The intervention should be added as a practical guide on how future tennis players can measure their actual mental well-being before and after a one-year intervention. Furthermore, the study aims to raise awareness among tennis players, coaches, and parents about the importance of prioritising mental well-being alongside physical training for optimal performance on and off the court, which is supported by solid evidence and data cited, for example, in Gergüz and Aras Bayram[7], Haymo and Deol[31] or Yousuf[32].

By highlighting yoga's repetitive major positive impacts on stress management and general mental well-being, the paper seeks to explain how yoga can be used in various settings. With the help of real-life evidence and statistical analysis from existing research, the paper aims to quantify the substantial differences yoga can make in improving general health and mental well-being.

A resilient mind and mindset with clear focus and no distractions, filled with positive thoughts, can account for 90% of tennis success[33]. However, even the most skilled players with exceptional services and

volleys may struggle if they cannot remain focused/stable in challenging, demanding, and stressful situations, such as an unfavourable crowd. These moments highlight the need for mental strength in athletes because physical opportunities are exhausted and are not sufficient.

This research paper is specifically aimed at top tennis players who are experiencing high levels of stress during a competitive match, and is also aimed at tennis coaches. They are the individuals responsible for developing training programmes and strategies to optimise the player's performance and well-being on the court. This specific topic addressed in this research paper may also be interesting for sports psychologists who might want to explore new approaches to stress management and mental health. Professionals might be curious to know whether such an intervention can really help and benefit athletes in their performances and motivate other top tennis players by showing them the results, to motivate them to practice yoga on a regular basis. Yoga instructors can also be targeted, especially those who specialise in yoga for athletes, as they could gain insight into how their expertise could be applied to the world of tennis and expand their market. Lastly, sports organisations and tennis federations, the ones that regulate and check tennis competitions and training programmes, may want to consider integrating yoga-based stress regulation into their guidelines.

The authors of the presented paper are involved in the realisation of the EEIG EU/P-Kr/06.12/23 project titled Are Elite Athletes Good Project Managers?. The presented research paper was processed in the context of research work carried out within the given project and deepens the research outputs already published within the project in Bočková et al.[34], Bočková and Čepelová[35] or Lajčin and Bočková[36].

1.1. Literature Review

Stress regulation is a vital aspect of an athlete's performance. Tennis is a highly competitive, pressurised and dynamic sport that can pose many challenges to tennis players, and mental fortitude is as important as physical demands[13].

During tennis matches, players are often under high pressure, especially when playing a competitive match, due to different stimuli (crowd, opponents, intensity of the match, etc.) and aspects. These negative aspects can affect mental and physical performance, which are visible in cognitive anxiety, reduced concentration, or reduced flexibility[37]. There are different stressors that can lead to a higher level of anxiety, where men and women react differently to these stressors. Men react to differences in performance. Females react more to external stress[38].

This stress can lead to reduced performance of sports skills and in the end to a lower performance[39].

Stress can deeply affect tennis players in various areas, muscle tension being one of the most common symptoms, which significantly impacts the athlete's performance. Due to the tension in the muscle, the flexibility and range of motion is reduced, and therefore the tennis player is not able to hit the ball normally, as he/she no longer has control over the ball. The arm is in tension and cramps and affects the player's ability to move quickly and execute the shot with precision, with an aim to the point the player wants. Tight muscles can cause a decrease in power and accuracy, which affects service, groundstrokes, and volleys[6]. As we know, the service is a very crucial strike in the game; without a service half the games are lost [40-42]. Muscle tension increases the risk of injury[43].

Muscle tension can cause fatigue, resulting in a reduction in stamina during long matches, which is a crucial aspect in tennis due to the long-known periods of matches. Mental effects are also prominent when muscle tension is prevalent. The feeling of the tennis player's experience can be compared to a never-ending demon circle and the athlete is stuck in self-doubt[44]. Tennis is a very demanding sport in terms of mental toughness and endurance from a physical perspective[45].

Due to this, stress management is a key characteristic of tennis players. Stress regulation involves the use of various techniques to manage and reduce stress levels. Common techniques include visualisation, breathing exercises, and routines that an athlete follows before a competitive match[46]. The study by Sille et al.[47] discusses methods that can be used in sports psychology, such as imagery and relaxation, which are cognitive behavioural techniques that help in stress management for athletes. The study by Swettenham et al.[38] had the objective of conducting the study to understand stressors and coping mechanisms among competitive tennis players in both practice and competition, using the Think Aloud (TA) protocol. This research provides valuable information on the coping mechanisms and stressors that tennis players experience quite frequently in competitions. This can be helpful to coaches, players, and sports psychologists in planning the future. Because based on these insights, coaches will know what to integrate into the players' individualised training plan, what strategies to include, and which coping skills will help the tennis player improve his tennis game. The study also underscores the need to take gender differences into account when creating stress management measures for tennis players. By incorporating this information into our literature analysis, we can gain a better understanding of the stressors tennis players face and uncover effective techniques to help them cope and perform at their best.

In the study by Hoja and Jansen[39] German tennis players were participants in the seven-session mindfulness-based intervention, the main objective being to find out if the organised mindfulness programme helps improve anxiety levels in sport, and specifically in the service accuracy test. Based on the results, the study saw that the intervention group saw a significant reduction in sport-related anxiety, and in terms of focus disruptions. These findings suggest that the incorporation of mindfulness-based therapies is useful when trying to reduce competitive stress in tennis players. The study's findings also stated that mindfulness activities could help with concerns such as "choking under pressure," which is a typical problem among athletes in stressful settings. However, the study did not find a significant change in service precision, implying that the pressure in the experimental environment may not have been sufficient to alter performance outcomes. Despite this, the viability of mindfulness-based therapies for amateur tennis players was proven, paving the way for additional research into mindfulness as a stress management method in competitive sports. These findings contribute to the broader discussion on stress regulation techniques for tennis players.

The players must learn to cope with these persistent challenges. Too much anxiety can take away too much valuable energy from athletes or hinder decision making and disrupt the stroke flow of the game. On the other hand, a bit of stress known as 'positive stress' can also be good as an athlete as a source of motivation and to push players to perform to their full potential. Knowing how to remain focused and how to manage your emotions during a game is vital for the player to play its best. Tennis players who are able to regulate their emotions and manage their stress levels on the court are generally able to perform better under pressure. Petra Kvitova is a good example of knowing how to manage stress when the match is crucial, as in the Wimbledon final in 2014, due to her good mental preparations she is able to perform well in high-stake circumstances[37,48].

Top tennis players frequently employ mindfulness exercises to stay focused and keep negative thoughts away. Practices such as meditation, imagination, visualisation, and Depp breathing exercises can all help players stay focused and be right present in the moment. This underlines the correlation between stress management and mindfulness in tennis[46,49].

This approach advocates integrating yoga-based methods into tennis training, in order to improve mental readiness and reduce stress. The study by Rathod et al.[43] produced and verified an Integrated Yoga Module (IYM) specifically made for tennis players. The IYM aims to improve mental health, emphasising stress management and mindfulness, as well as psychophysiological aspects such as cardiovascular fitness and

flexibility. Both Cote et al.[50] and Lever et al.[51] emphasise the benefits of mindfulness and yoga for competitive tennis players. Cote et al.´s[50] emphasis on mindfulness is consistent with Lever et al.'s[51] development of a yoga module that includes a variety of practices to improve athletic performance.

Goodman et al.[52] discovered that short yoga interventions resulted in higher energy, lower stress, and greater mindfulness in athletes. These data show that yoga is a possible stress management option. Bucea-Manea-Țoniș et al.[53] highlighted that yoga can help players fight PTSD, what shows that that yoga can be a therapeutic way to regulate the stress of tennis players.

The performance and flexibility of athletes are positively impacted by practising yoga. Yoga leads to a reduction in stress in tennis athletes. Additionally, yoga is known as a possible therapeutic path to manage PTSD in pro athletes[53]. Yoga can influence not only the performance of a pro player, but also the performance on a non-pro level of tennis playing tennis[54]. This is also shown by Cohn[37], he confirms the findings of Stankovic[54]. Yoga increases the concentration that is relevant to reduce anxiety during competitive matches. Including yoga sessions in a training programme of athletes can lead to better health of these athletes[55].

The use of yoga in the preparation of tennis players represents a growing area of interest within sports science and psychology. Although there is a growing body of research that examines the benefits of yoga in various athletic contexts, the specific application of yoga to tennis players remains relatively underexplored and deserves further investigation. Although preliminary evidence suggests that yoga holds promise as a beneficial adjunct to tennis training, there remains a significant gap in the literature regarding its specific applications and optimal integration into athlete routines. Closing this gap through rigorous scientific inquiry and collaborative efforts between sports scientists, coaches, and players will be essential to unlocking the full potential of yoga in improving the preparation and performance of tennis players. Therefore, the presented study will explore how these two physical activities, yoga and tennis, when combined, may offer unique pathways for tennis players to regulate their emotional well-being (stress, anxiety, nervousness) and thus enhance their overall performance on the court.

2. Materials and methods

Tennis players are faced daily with demanding situations during a competitive game that require specific coping skills to reduce stress to ensure success and high performance throughout their career. One of many coping skills will be analysed on how yoga might impact tennis players' stress regulation with the help of a one-year yoga intervention for at least 2x 60 minutes per week and, in addition, integrating 10 minutes per day the recommended yoga poses (cat and cow movement, pigeon pose, revolved triangle poses, tree pose) for tennis players.

The 30 targeted participants, top tennis players (18 men, 12 women), aged 16 – 30, members of the VICTORIA University Sports Centre of the Ministry of Education, Youth and Sports of the Czech Republic (https://www.vsc.cz/sporty/tenis) must integrate two times a week on Monday and Friday a 60-minute Dynamic Vinyasa for body and soul session, in addition to their normal tennis routines. Two sessions of yoga per week, include: mindfulness and meditation, deep breathing exercises, ujjayi breathing, "Dirga Pranayama," three-part breathing, positive self-talk, stretching, postures (all these techniques that yoga contains help improve balance, endurance, improve concentration and focus, improve resilience to stress and coping skills, physical relaxation and release of muscle tension, and stress reduction[56]).

We are aware that the sample of respondents may appear limited for significant scientific research; however, it is important to emphasise that this sample consists of all Czech national tennis players team participating in major events such as the Olympic Games, Wimbledon, Roland Garros, US Open, Australian

Open, and other significant tennis competitions (30 respondents voluntarily participated in the research, 9 of the approached respondents refused to participate). Therefore, these are professional athletes. This is also why our study does not include a control group, as it is not feasible to find a similar group of athletes of the same quality and size. Dividing our study group into two small groups was deemed inappropriate.

For Dynamic Vinyasa yoga, we have decided because all scientific studies, whose conclusions we have attempted to present and generalise through secondary analysis in the Introduction and Literature Review sections of the presented scientific article, focus solely on the implementation of traditional yoga into athletes' training programmes or individuals. Therefore, we see a significant gap in the literature, science, and research on the positive impact of yoga on athletes' performance. Additionally, dynamic vinyasa yoga is considered to be the most athletic style of yoga, because it coordinates different types of movements with breath work to flow from one pose to another. Therefore, it fits best for tennis players, as confirmed by Hollingshead[57] or Gulati and Sharma[58]. This type of style is supposed to be the most helpful for those who struggle to relax and are experiencing a great deal of stress[59].

All participants undergo the same intervention; the visited the same yoga studio for one year two times a week for one hour of vinyasa.

In addition to the one-year intervention, four yoga poses that are specifically suitable and most beneficial for tennis players must be followed every day at home: cat and cow movement, pigeon pose, revolved triangle poses, tree pose[7]. The duration of the poses takes an average of 10 minutes when done properly (the pose cat and cow movement must be done 5 times in a row to really gain the multiple benefits of this pose. The pigeon pose is recommended to be held for around 30 seconds to 1 minute on each side. The revolved triangle poses, also known as Parivrtta Trikonasana, can be held for approximately 30 seconds to 1 minute on each side. And in the fourth pose, the tree pose should be held on each leg around 30 seconds to 1 minute). Incorporating these four additional yoga poses in combination with the 1-year yoga intervention can provide physical, mental, and emotional benefits to tennis players.

The independent variable in this research is the implemented yoga intervention, while the dependent variable is the stress levels of the tennis players.

To see what impacts stress and its related factors have on the physical as well as mental performance of the tennis player, two questionnaires were carried out.

Stress levels will be measured using different questionnaires consisting of two self-reporting tools: the Perceived Stress Scale (PSS), the Competition Anxiety Inventory for Tennis Players (CAI-T), and a service accuracy test inspired by the research study Hoja and Jansen[8]. With the help of these questionnaires within the yoga intervention, the research can be further investigated by integrating both quantitative and qualitative data. Before starting the intervention, all participants must fill out both questionnaires, the Perceived Stress Scale (PSS), Competition Anxiety Inventory for Tennis Players (CAI-T) and complete the service accuracy test in order to find out where the players current stress levels are at the start of the intervention and how they overall improved after integrating regular yoga sessions into their normal training plan for one year.

The Perceived Stress Questionnaire (PSQ) was used to gather information about tennis players' physical and mental stress levels during competitive matches. It examined commonly occurring stress factors in tennis matches, such as having difficulties in concentrating and being present in the current moment, feeling physical tension in stressful moments, and emotionally having problems accepting the mistake which was made in the match. Changes in all participants were assessed both in physical as well as mental stress.

In the second questionnaire, the Competition Anxiety Inventory for Tennis Players (CAI-T), it only focusses on the mental stressors that result in anxiety during the match. With the help of this questionnaire, key stressor components were identified, such as self-doubt, anxiety, nervousness, and pressure from external sources (coaches, parents, teammates or self-expectations).

The first two questionnaires will be carried out twice before and after the intervention to compare the results. Results were compared from the pre- and postinterventions.

However, the service accuracy test will be completed prior to the intervention and then continue throughout the process of the intervention for one year. Each quarter the service accuracy test will be taken and the atmosphere will be created as if the tennis players were in a competitive tennis match. Meaning that while the one participant was serving, the other players were allowed to talk quietly and give comments to create an uncomfortable situation, as well as to create stress within the athlete to test if yoga really has a significant impact in regulating stress and making the players feel more at ease when being in a competitive scenario.

The test focussing on service accuracy targets an important area for tennis players. Service is a crucial aspect of tennis performance and therefore, focussing on this specific skill can directly help the athlete improve the strike. The objective measurement is a benefit of the test. The accuracy test provides quantifiable data for research on the athlete's performance and allows objective assessment of service before and after intervention.

The negative point of this type of test is the limited scope. Since it is only testing one of many strikes in tennis, it can only show results in performances for this one strike. The service test is perhaps not the best way to see whether integrated yoga positively impacts tennis player performance positively because many external factors such as wind, rain and fatigue can affect the outcomes. Although the service tests show some visible limitations, it still provides good and helpful insight into the immediate effect of the yoga intervention on the players´ performance.

In the context of the presented test, it should be noted that our respondents are professional athletes whose technical development has long been completed, and it cannot be assumed that regular service training will lead to a technical improvement that could negatively influence, rather literally negate, the outcome of the test. We proceed on the assumption that a tennis player's service is such a complex and crucial stroke primarily influenced by the athlete's current condition, especially their current mental state and well-being, as evidenced by Meffert[60], Beckmann[61] or Wang[62].

The method used in the intervention is the paired sample t-test to conduct the results from the performance metrics > service accuracy, questionnaires in the form of Likert scale questions, rating from the level of extremely agree or extremely disagree.

The research was carried out from 1.3.2023 - 29.2.2024. All participants voluntarily agreed to participate in the one-year intervention and to fulfil all the requirements and guidelines that come with it. They gave their consent to use their data for this research paper.

Using various assessment techniques provides for a more comprehensive examination, providing insight into both the emotional and physical components of performance. The advantages of this technique, the employment of both questionnaires and performance tests offers various benefits: Provides a thorough and comprehensive study that allows the reader to gain a better understanding of how stress affects tennis players, both psychologically and physically.

Another advantage is the factor of receiving an objective measurement, with the help of service accuracy tests tangible data was provided to support the qualitative feedback from questionnaires. Lastly, the positive

aspect is the intervention insight; having the combined results helps determine the success of the 1-year intervention and identifies areas for further improvement.

Given the positive outcomes observed, this study underscores the importance of integrating stress management practices, such as yoga, into the training regimens of competitive athletes.

Based on the above, we formulate the research question as follows. **RQ Can the implementation of Dynamic Vinyasa yoga over one year, with a frequency of 2 hours per week during training periods and the inclusion of recommended Dynamic Vinyasa yoga practices in the daily life of a top tennis player, reduce their stress levels to a degree that is perceptible and demonstrably affects their service, the most crucial stroke in tennis?**

3. Results

3.1. Data Analysis from Perceived Stress Scale (PSS) Questionnaire

Pre-Intervention

Average total numerical value of participants' responses = 115,98

Number of responses = 30

Average stress level for participants = Average total numerical value / Number of responses = 115,98 / 30 3.866

Post-Intervention

Average total numerical value of participants' responses = 85,92

Number of responses = 30

Average stress level for participants = Average total numerical value / Number of responses = 85,92 / 30 2.864

Percentage difference = ((New Value - Old Value) / Old Value) * 100 = ((2,864 – 3,866)/3,866) * 100 = 25,91%

The stress level decreased by approximately 25,91% after the intervention compared to before.

After the intervention, one can see that all participants improved significantly in different aspects, which gives us valuable information, and we can conclude that the yoga intervention has been effective in managing stress in tennis players during competitive matches.

From the results, it is visible that the stress levels decreased significantly. Most of the participants after taking the Perceived Stress Questionnaire (PSQ) again, post the intervention showed a reduction in stress levels. As indicated in the results, there has been a decrease in the frequency of responses indicating high stress levels by answering with "Very Often" and "Often." This suggests that the yoga intervention must have been effective in helping tennis players manage stress better during competitive matches.

From the results, it can be analysed that there is a range of variability in responses, meaning that while most participants experienced a reduction in stress levels after the one-year intervention experience, there was a variability in the scale of improvements among the respondents. Some participants showed more significant improvements than others; this indicates that individual factors may influence the effectiveness of the intervention based on their background mentioned above. Due to this factor and having personal insight into the participants, we know that other personal stressors also affected the results.

3.1.1. Short Case Study Based on Results of the Perceived Stress Scale (PSS) Questionnaire

Before the yoga intervention, the stress level of the participant X was relatively high, with an average of 3.8 on the perceived stress questionnaire. He frequently felt physically tense during matches and struggled with distractions due to overthinking. His tendency to dwell on past errors instead of focussing on the present game could be a significant reason for his elevated stress levels.

The primary weakness seems to be his propensity to let mistakes weigh on him, causing his performance to decline. His nervousness before even entering the court indicates a mental block that needs to be addressed. After the yoga intervention, the Participant X stress level dropped to 2.33, indicating a significant improvement.

From the results, it can be affirmed that yoga techniques helped the participant manage his stress levels better and allowed him to be more focused during the match. Yoga practice benefited him with tools that helped him get rid of his negative thoughts and refocus on the match, as well as being in the present moment, helping him reduce his mental distractions and allowing him to be calmer when stress occurs.

Negative thoughts during a competitive match trigger the confidence of the tennis player and therefore result in more stress. However, the strength of the tennis player lies in his ability to enjoy the game and his generally laid-back attitude, but his stressors undermine his performance. Due to the yoga intervention, the participant improved his ability to manage his stress levels, which then led to improved focus and less anxiety on the court. This participant found a way to help himself cope with stress in stressful situations by integrating yoga techniques such as meditation, breathing exercises, and mindfulness, which positively improved his performance[63].

In summary, this participant proves that the intervention was successful and can help tennis players to manage their stress, particularly those individuals who are prone to self-doubt and overthinking. Participant X has noticed a notable change in his competitive mindset since implementing these stress relief tactics, which allows him to stay in the present rather than in the past, resulting in improved focus and potentially better results in matches.

3.1.2. Suggestion for Future Studies

Consequently, a potential research gap and a suggestion for future studies is to increase the sample size for a more comprehensive understanding of how the intervention influences stress levels among top tennis players. An option is to include foreign professional tennis players among the respondents, for example, from Slovakia, Poland, or Ukraine. This should include collecting information about the participants' personal backgrounds to ensure a diverse sample.

The results of the post intervention seem to be promising, but assessing the long-term effects of the intervention is equally important. Doing further assessments later in time after the intervention could help to see whether the improvements have been sustained or if they have been reduced.

In terms of results, the yoga intervention holds promise as a method of regulating stress levels among the top tennis players.

3.1.3. Summary

The areas of greatest improvement were reduced nervousness and anxiety, as well as improved composure under pressure, reduced physical tension, and improved focus and concentration. Several participants showed a marked reduction in feelings of nervousness and anxiety after the yoga intervention. This implements that the various techniques of yoga like mindfulness and controlled breathing effectively tackled the pre-match anxiety. The participant shows reduced nervousness, which means that the techniques have been used correctly.

Participants significantly improve in knowing how to act during high pressure moments in tennis matches. This change indicates that the intervention helped them develop a stronger sense of inner calm, even in intense competitive situations.

The ability to stay composed under pressure is critical for tennis players, as it affects their performance and decision-making.

Throughout the session, several individuals reported less physical tension, as well as a reduction in symptoms such as muscle strain and elevated heart rate. Participant X showed a decrease in physical tension, which means that yoga helped him stay relaxed during his matches, and therefore his results improved.

The intervention also helped the participants increase their focus and concentration during the game, which they had previously struggled with. The fact that the participants improved in that area is due to mindfulness which helps the players stay in the present moment and enhance their focus.

Due to the significant improvements made after the intervention, yoga is considered an effective tool to manage stress, which goes back to our research question. **To conclude, the results of the post-intervention suggest that yoga-based stress management interventions are beneficial for tennis players to learn how to cope under pressure and integrate the various strategies and techniques consisting of yoga into the competition day.**

3.2. Data Analysis from Anxiety Inventory for Tennis Players (CAI-T) Questionnaire

This questionnaire aims to assess the level of competition anxiety experienced by tennis players and their perception of stress regulation. It can provide valuable information on the effectiveness of stress management techniques such as yoga in mitigating competition-related anxiety and improving performance on the tennis court.

Pre-Intervention Score: 53,6

Post-Intervention Score: 35,6

Percentage Change: ((53,6 – 35,6) / 53,6) * 100 = 33,58%

Before the intervention started, the participants had the average total score of 53,6 for competitive anxiety. The results show that the participants have a high level of nervousness and anxiety before playing a match. This score indicates that tennis players have problems regulating their stress in competitive environments.

After the intervention, the participants' anxiety levels improved significantly, indicating that they improved their stress management abilities and now less anxiety during competitive matches.

Based on the high results, we can tell that including yoga to the tennis players´ regular training plan helps to improve stress during competitive matches. Yoga practice shows that it helps players develop better stress strategies, which then helps them feel less pressure in matches.

Based on the findings of the intervention, the essential of this paper can be confirmed that practising yoga on a regular basis improves mental well-being and boosts mental resilience, which then results in better performance. These findings highlight the value of holistic techniques, such as yoga, in promoting mental and emotional health in players, thus improving their total performance and well-being on the tennis court.

3.3. Service Accuracy Test

In order to objectively measure performance, this intervention conducted a service precision test to see whether there has been an improvement in this particular strike. These accuracy scores represent the

performance of the participants over the course of the one-year intervention, with variations observed from quarter to quarter.

In the next part of this paper, the service accuracy test will be presented with the given calculations. The service accuracy test measures how many services from 10 are entered into the box. The results are cited in **Table 1** and **Table 2** below.

Table 1. Pre-Intervention Service Accuracy.

Quarter	Services in the box (average values)
1/4	7/10
2/4	6,2/10
3/4	6/10
4/4	7/10

*(**Source:** own)*

Table 2. Post-Intervention Service Accuracy.

Quarter	Services in the box (average values)
1/4	8/10

*(**Source:** own)*

All participants showed individual progress, with varying degrees, in serving accuracy over the time of the one-year intervention. This indicates the efficiency of the intervention, which aimed to improve the performance and concentration during the match. Most of the participants showed improvement in general during the year, but there were some minor fluctuations in the service accuracy scores. This insight given of the change in service accuracy could be influenced by factors such as fatigue, external stressors, or the learning curve associated with the implementation of new approaches acquired during the intervention.

The willingness of the participants to engage effectively and intensively with the intervention also had an effect on the progress. Participants who actively participated in the four yoga sessions and did the regular poses at home and implemented the new stress management strategies have experienced greater improvements in the service accuracy test.

Future research should explore whether after the intervention the benefits sustained over a longer period of time.

In general, the results suggest that the integration of yoga and stress management strategies into the athlete's training plan leads to satisfactory improvements.

The positive aspects of the physical test for this intervention were the immediate feedback that the participants would receive on their accuracy of the service, which helps them track their performance throughout the intervention and allows them to see improvements that can motivate the tennis player to integrate yoga into their regular tennis training plan. Another upside of this test is the easy implementation, it requires minimal equipment and time, and it is a practical way for assessing performance in a competitive environment.

The calculations of the quarterly means for the postintervention are cited below using data from **Table 1** and **Table 2**. To calculate the percentage improvement, we need to compare the quarter 4 mean with the Postintervention quarter (date of intervention termination) mean.

Percentage change = ((8−7)/7) ×100= (1/7) ×100 = 14.29%

This indicates that service accuracy improved by approximately 14.29% from preintervention to postintervention.

3.3.1. Statistical analysis

To perform a paired t-test to determine if there is a significant difference in the accuracy scores before and after the intervention, we used the data from **Table 1** and **Table 2**. Given that the data are provided as mean service accuracy scores per participant over time, the paired t-test will be performed to check for significance. To conduct a paired t-test, we compare the means between the pre- and post-intervention and look at the standard deviation to determine if the improvement is statistically significant. To conduct a paired t-test, we need to determine the differences and then calculate the t-statistic and p-value.

- Statistical Significance: If the p-value is less than 0.05, it indicates that the difference is statistically significant.
    - Based on the interventions, the p-value given as "<0.0001," indicates that the difference between the pre- and post-intervention means is statistically significant. This suggests that there is a very low probability that the observed differences occurred by chance.
- Confidence interval
    - 95% confidence interval: This indicates the range of values that likely contains the true difference between the pre- and post-intervention means.
    - The confidence interval of "- 1.5888 to -1.3112" indicates that we can be 95% confident that the true difference lies within this range.
- Intermediate Values
    - t-statistic: A t-statistic of 29.0000 suggests a significant difference between the pre- and post-intervention means, indicating that the difference is not due to random variation.
    - Standard Error of Difference: Given as 0.050, this value indicates the variability in the sample means relative to the number of samples.
- Summary Statistics
    - Mean: For preintervention, the mean is given as 6.5500, and for postintervention, it is 8.0000. This confirms the previously calculated averages and demonstrates a noticeable improvement in service accuracy after the intervention.
    - Standard Deviation (SD): The standard deviation for both pre- and post-intervention is approximately 0.71, indicating a consistent spread around the means.
    - Standard Error of the Mean (SEM): The SEMs for both the pre- and postintervention are consistent with the calculated values, reflecting the variability in the data.

When comparing the findings before and after the intervention, a statistically significant improvement in service accuracy was visible, supporting the good benefits of the yoga intervention.

In general, the statistical significance and the confidence interval indicate a significant and meaningful improvement in service accuracy after the intervention. **Given these results, the conclusion that the yoga intervention likely had a positive effect on the service accuracy of the participants can be confirmed.**

4. Discussion

Many athletes find the competitive environment to be a stressful environment that causes problems with both physical and mental results. This is seen in an increase in fear and in a decrease in muscle coordination. The first step in reducing performance anxiety is addressing the underlying stress.

The questionnaires included in this research paper indicate the results that athletes experience nervousness, increased heart rate, and other stress-related symptoms during competitions based on their repeated responses. The study by Maddux et al.[64] showed that a random group of 90 participants (control group) reported without an intervention a medium to high stress level, as athletes in our research.

Therefore, the correlation was made within a 16-week yoga intervention, the study participants significantly reduced stress and psychological distress compared to the control group. Study participants experienced lower stress, anxiety, and depression after participating in yoga practice[64].

The findings of Maddux et al.[64] correlate with the results of our research and show that the participants show a lower stress level and a lower anxiety.

In a study by Tripathi[65] a total of 70 participants were divided equally between a yoga group (N = 35) and a control group (N = 35) to analyse the effect of yoga on psychological well-being. The results indicated a significant improvement in self-esteem, an increase in positive affect, and a substantial reduction in negative affect among participants in the yoga group compared to the control group. This research indicates that yoga can effectively improve self-esteem and regulate emotional states, highlighting its viability as a useful psychological therapy. These results also correlate with the results of our study.

The study by Khursheed and Azhar[66] aimed to explore the impact of yoga on psychological well-being, life enhancement, and quality of life among adults in Islamabad. For this purpose, 30 respondents aged 18-30 were selected as a sample and approached in the two Yoga Centres. A questionnaire was sent to the study participants to get answers to the research objectives. The results show that yoga was effective in daily life, increasing the range of positivity and reducing the level of any other disease, but new trainers were found to produce significant yoga results among adults with psychological well-being, enhancement of life and quality of life.

College students showed a significant reduction in their anxiety level, when performing a yoga programme over six weeks. Here, the intervention consisted of a 60-minute Vinyasa flow yoga class once a week, followed by guided meditation from trained faculty members. Students complete pre-and postintervention questionnaires to assess changes in the outcomes of stress levels, anxiety levels, and mindfulness skills. Amongst the study reduction of stress, the participants reported an increase of their mindfulness, which corresponds to different literature reports that yoga leads to a balanced mindset, which leads to a calm reaction during pressure situations. Changes in categorical data from preintervention to postintervention on the BAI and PSS were significant, with no students scoring in the "high" category for stress or anxiety on the post-intervention questionnaire. It emphasises that even a short-duration yoga intervention can lead to positive outcomes[67].

Performance anxiety often manifests physically through muscle tension, tightness, and decreased flexibility. The results of the questionnaire showed that athletes felt less flexible and more prone to injuries due to stress-related muscle tension[68]. The Marks's[69] study highlighted the physical benefits of yoga, demonstrating improved flexibility, muscular strength, and endurance. These findings suggest that yoga can counteract the adverse effects of stress, leading to greater agility and mobility during athletic performances.

Pascoe et al.[70] reviewed 42 studies which were focusing on the reduction of stress (reduction of blood pressure and heart rate, as well as cortisol levels) when doing yoga regularly. Especially the reduction in heart rate and blood pressure is relevant for athletes like tennis players because of the accompanying muscle relaxation and the reduced risk of injuries. Athletes must maintain sharp focus and composure to succeed under pressure. In the questionnaire, the participants reported difficulty concentrating and staying focused during the competitions.

The study by Kanaujia et al.[17] revealed that yoga and mindfulness practices enhance focus and help athletes achieve a "flow state." Tennis player flow in Czechia and Slovakia was investigated within Bočková et al. [34]. This improved focus is essential for athletes to maintain peak performance during critical moments.

In the study by Kanaujia et al.[17] the topic that was researched is almost identical to our research: "the impact of yoga and mindfulness practice in reducing stress and anxiety to improve sports performance." The results that were analysed show an overall significant effect of yoga and mindfulness and flow state.

The results of our research confirmed with the secondary analysis of information sources state that yoga has a beneficial effect on the mindfulness of athletes accompanied by better performance.

However, while yoga is widely praised for its numerous physical and mental benefits, it is important to recognise that there are potential negative aspects associated with its practice. One of the most commonly reported negative effects of yoga is physical injury[71]. Then yoga is often associated with a calm and stress-free environment, but for some individuals, it can become a source of psychological pressure [72]. Yoga has deep spiritual roots, and some individuals may find certain practices or philosophies in conflict with their personal beliefs[73].

Various experts from different fields, including physicians, physiotherapists, psychologists and researchers in health and sports, publish on the topic of the negative effects of yoga, e.g. Neumark-Sztainer et al.[74] or Haden et al.[75]. Their studies provide important information on the potential negative effects of yoga, which can be useful for practitioners, instructors, and healthcare professionals to minimise risks and maximise the benefits of yoga, which, however, are the primary focus of our research, and we state that during our research we did not encounter the negative effects of yoga as specified and argued by the aforementioned studies.

Implementing yoga sessions in training plans can be an approach of managing athlete anxiety of the athletes and at the same time enables athletes to focus on their game to show the best performance. This can be a valuable extension of the training plans of top athletes that underlays the importance of the paper's aim.

In general, the combination of subjective (questionnaires) and objective (service accuracy test) assessments provides a complete picture of the impact of the yoga intervention. The statistically significant reduction in stress and anxiety levels, as well as the improvement in service accuracy, indicate that yoga can be a useful strategy for stress management and performance enhancement in competitive tennis players. Using various assessment techniques provides for a more comprehensive examination, providing insight into both the emotional and physical components of performance.

We therefore clearly state that the results of our research provide a relevant and valid answer to the research question, and thus that the implementation of Dynamic Vinyasa yoga over one year, with a frequency of 2 hours per week during training periods and the inclusion of recommended Dynamic Vinyasa yoga practices in the daily life of a top tennis player, reduce their stress levels to a degree that is perceptible and demonstrably affects their service, the most crucial stroke in tennis.

4.1. Limitations

This study did not include independent variables such as blood pressure, heart beat rates, or cholesterol levels, which could have provided valuable information on the physiological effects of yoga. No additional tools were available to measure stress and there were no performance outcomes for tennis players, which potentially limited the accuracy and comprehensiveness of the data collected.

This intervention assessed the participants in a competitive environment, without performing an analysis during a real competition. These limitations suggest future research to address these gaps and provide a deeper and more comprehensive understanding of the effects of yoga on tennis player well-being and performance.

5. Conclusion

The results of our research and the feedback from the participants suggest that elite tennis players who have incorporated yoga into their training regimen experience lower stress levels and exhibit better stress resilience during play, which can later improve their physical performance.

The experiences of these athletes, based on the analysis of qualitative data, indicate that after incorporating yoga into their training programmes for a year, they feel calmer, more focused, and more confident on the court. They also reported that they now handle internal and external pressure better, which they could not control. They confirm having noticed a significant improvement in their ability to manage critical and stressful moments during play.

To track measurable changes after the intervention, we also examined the available quantitative data. The results show greater accuracy and power in serving, which is a key and easily measurable stroke. This suggests a more relaxed and calmer physical state in which it is easier to perform at the highest level.

The results based on both quantitative and qualitative analysis provide a clear answer to the research question: yoga positively influences and improves stress regulation in elite tennis players. Post-intervention results show a significant decrease in stress for most participants, indicating that the combination of physical postures, breathing exercises, mindfulness, and meditation can be effective in managing stress and improving performance on court. Participants in this intervention experienced improvements in various factors, such as lower stress levels, reduced anxiety, better focus, and improved resilience in stressful situations, due to the benefits of yoga.

These improvements are consistent with previous research that has highlighted the numerous benefits of yoga for mental clarity, improved flexibility, stress relief, and fewer negative thoughts during a tennis match.

Therefore, our research results confirm that the implementation of yoga in the training regimen of elite tennis players can be an effective means of reducing stress and improving physical performance, which is especially evident in key moments during competitive matches. These findings provide valuable information for further research and the application of yoga in sports psychology and training methodologies, with the aim of optimising the physical and mental performance of athletes.

Author contributions

Conceptualization, K.B., S.M.F, and D.A.P.; methodology, S.F.M and K.B.; software, S.F.M.; validation, K.B., D.P. and S.M.F.; formal analysis, V.G.; investigation, K.B. and S.M.F. ; resources, V.G., S.M.F. and D.A.P..; data curation, V.G.; writing - original draft preparation, K.B. and S.M.F.; writing - review and editing, D.A.P.; visualization, K.B. and S.M.F; supervision, D.A.P. All authors have read and agreed to the published version of the manuscript.

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Conflict of interest

The authors declare no conflict of interest.

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