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Influence of Psychological Stress and Anxiety on Cervical Muscle Activation and Sports Performance Among Competitive Athletes: A Surface Electromyographic study

[1]Hemant chouBisa, [2]Dr. Payal Sharma, [3]Dr. Deepak Lohar, [4]Dr, Jafar Khan, [5]Dr. Dipika Balala, [6]Dr. Saleem Akhtar Naqvi,[7]Dr. Shubham Menaria

*[1]M.P.Th. scholar, Pacific college of Physiotherapy, Pacific medical university, Udaipur, Rajasthan

[2]Assistant Professor, Pacific college of Physiotherapy, Pacific medical university, Udaipur, Rajasthan

[3]Professor, Pacific college of Physiotherapy, Pacific medical university, Udaipur, Rajasthan

[4]Dean & HOD, Pacific college of Physiotherapy, Pacific medical university, Udaipur, Rajasthan

[5] Associate Professor, Pacific college of Physiotherapy, Pacific medical university, Udaipur, Rajasthan

[6]Professor & Head, Physiotherapy Clinical Services, Mahatma Gandhi Physiotherapy College, MGUMST, Jaipur, Rajasthan, India

[7]Assistant Professor, Pacific college of Physiotherapy, Pacific medical university, Udaipur, Rajasthan

Corresponding Author:

Hemant Choubisa

Postgraduate Student, Department of Physiotherapy

Pacific College of Physiotherapy, Pacific Medical University

Udaipur, Rajasthan, India

Email: _____

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Abstract

Background

Psychological stress and anxiety are common among competitive athletes and may influence both neuromuscular function and sports performance. Athletes frequently experience psychological pressure related to training demands, competition expectations, and performance outcomes. These psychological factors may increase muscle tension, alter motor control, and negatively affect athletic performance. However, limited research has objectively examined the relationship between stress, anxiety, cervical muscle activation, and sports performance using surface electromyography (sEMG).

Objective

To investigate the influence of psychological stress and anxiety on cervical muscle activation and sports performance among competitive athletes using surface electromyography.

Methods

A cross-sectional observational study was conducted among 80 competitive athletes aged 18–35 years participating in various sports, including cricket, football, badminton, and athletics. Psychological stress and anxiety were assessed using the Perceived Stress Scale (PSS) and Beck Anxiety Inventory (BAI). Surface electromyography was used to record the activity of the upper trapezius and sternocleidomastoid muscles under resting and sport-specific performance conditions. Athletic performance was evaluated using standardized sport-specific performance indicators. Descriptive statistics, Pearson correlation analysis, and multiple regression analysis were performed to determine the relationship between psychological variables, cervical muscle activity, and performance outcomes. Statistical significance was established at $p < 0.05$.

Results

Athletes with higher levels of psychological stress and anxiety demonstrated significantly greater cervical muscle activation compared to athletes with lower stress levels. Significant positive correlations were observed between PSS scores and upper trapezius EMG activity ($r = 0.62$, $p < 0.001$) and between BAI scores and sternocleidomastoid EMG activity ($r = 0.58$, $p < 0.001$). Increased cervical muscle activation was associated with reduced sports performance scores ($r = -0.54$, $p < 0.001$). Multiple regression analysis identified stress, anxiety, and cervical muscle activity as significant predictors of athletic performance.

Conclusion

Psychological stress and anxiety significantly influence cervical muscle activation and may negatively affect sports performance among competitive athletes. Elevated activation of cervical muscles appears to be associated with reduced athletic efficiency and performance outcomes. These findings highlight the importance of integrating psychological assessment, stress-management strategies, and neuromuscular monitoring within athlete rehabilitation and performance enhancement programs.

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1. INTRODUCTION

Sports performance is influenced by a complex interaction of physical, physiological, psychological, and environmental factors. While physical fitness, technical skills, and tactical preparation are traditionally considered the primary determinants of athletic success, increasing evidence suggests that psychological factors play an equally important role in competitive sports. Among these psychological factors, stress and anxiety have received considerable attention due to their potential impact on athletic performance, neuromuscular function, and injury risk. Competitive athletes are frequently exposed to various stressors, including performance expectations, selection pressure, intensive training schedules, fear of failure, and competitive uncertainty. These factors may influence both mental and physical functioning, ultimately affecting sports performance outcomes.

Psychological stress is defined as the physiological and emotional response that occurs when an individual perceives environmental demands as exceeding available coping resources. Anxiety, on the other hand, refers to feelings of worry, apprehension, nervousness, and heightened arousal associated with anticipated threats or challenging situations. In sports settings, athletes often experience both stress and anxiety before, during, and after competitions. Although moderate levels of psychological arousal may enhance motivation and focus, excessive stress and anxiety can negatively influence concentration, decision-making, motor coordination, reaction time, and overall athletic performance.

The relationship between psychological factors and sports performance has been widely recognized within sports psychology. The Multidimensional Anxiety Theory suggests that cognitive anxiety and somatic anxiety affect performance through different mechanisms. Cognitive anxiety primarily influences attention, concentration, and decision-making abilities, whereas somatic anxiety produces physiological responses such as increased heart rate, elevated blood pressure, excessive sweating, and muscle tension. These physiological changes may interfere with movement efficiency and reduce athletic effectiveness during competition.

One of the most common physiological manifestations of psychological stress and anxiety is increased skeletal muscle tension. Activation of the sympathetic nervous system during stressful situations stimulates the release of catecholamines, including adrenaline and noradrenaline, leading to heightened neuromuscular activity. While short-term activation may enhance readiness for performance, prolonged or excessive muscle tension can impair movement precision, increase energy expenditure, and contribute to fatigue. Such effects are particularly relevant in competitive sports where optimal neuromuscular control is essential for successful performance.

The cervical region plays a critical role in maintaining postural stability, visual orientation, balance, and coordination during athletic activities. Muscles such as the upper trapezius and sternocleidomastoid are continuously involved in head stabilization and postural control during movement. Because of their postural functions, these muscles are highly responsive to psychological and emotional stimuli. Previous research has demonstrated that psychological stress can increase activation of cervical and shoulder musculature even in the absence of physical exertion. Elevated cervical muscle activity has been associated with muscle fatigue, altered movement patterns, reduced motor efficiency, and an increased risk of musculoskeletal pain.

Surface electromyography (sEMG) is a non-invasive technique widely used to assess muscle activity by recording the electrical signals generated during muscle contraction. Surface EMG provides objective information regarding neuromuscular activation, muscle recruitment patterns, and muscular responses under different physiological and psychological conditions. In sports science and rehabilitation, sEMG has become an important tool for evaluating muscle performance, movement efficiency, fatigue, and motor control. More

recently, researchers have utilized sEMG to investigate the influence of psychological stress and anxiety on muscular activation patterns.

Several studies have reported increased electromyographic activity in the upper trapezius muscle during exposure to mental stress tasks. Such findings suggest that psychological stress can directly influence muscle activation independent of physical workload. Similarly, anxiety-related increases in muscle tension have been observed in both clinical and healthy populations. However, despite growing evidence linking psychological factors and muscular activity, relatively few studies have examined these relationships specifically within athletic populations. Athletes may demonstrate unique psychophysiological responses because of their training adaptations, competitive experiences, and performance demands.

Competitive athletes represent an ideal population for investigating the interaction between psychological stress, anxiety, and neuromuscular function. During competition, athletes are required to maintain high levels of concentration, motor control, and physical performance while simultaneously managing psychological pressure. Excessive stress and anxiety may disrupt this balance by increasing muscle tension and altering movement efficiency. For example, increased cervical muscle activation may affect head position, visual tracking, reaction speed, and coordination, all of which are critical components of athletic performance. Understanding these relationships may provide valuable insights into performance optimization and injury prevention strategies.

The psychophysiological model of athletic performance proposes that psychological states influence physiological responses, which subsequently affect motor performance outcomes. According to this model, heightened stress and anxiety may trigger increased autonomic nervous system activity, resulting in elevated muscle activation and altered motor behavior. These physiological changes may reduce movement economy, increase fatigue, and impair performance during competition. Consequently, identifying objective indicators of stress-related neuromuscular responses may help coaches, sports physiotherapists, and sports psychologists develop targeted interventions to improve athletic performance.

In recent years, sports physiotherapy has expanded beyond traditional injury management to include performance enhancement and athlete monitoring. Contemporary rehabilitation approaches emphasize the importance of addressing psychological as well as physical factors that influence athletic performance. Assessment of stress, anxiety, and muscle activation patterns may therefore contribute to more comprehensive athlete evaluation and management programs. Additionally, interventions such as relaxation training, breathing exercises, biofeedback, mindfulness techniques, and psychological skills training have shown promise in reducing anxiety and improving performance outcomes.

Despite increasing interest in sports psychology and neuromuscular performance, limited evidence exists regarding the combined influence of psychological stress, anxiety, cervical muscle activation, and athletic performance. Most previous investigations have examined either psychological variables or physiological variables independently. Few studies have simultaneously assessed psychological stress, anxiety levels, cervical muscle activity, and sports performance using objective electromyographic measures. Therefore, further research is required to better understand the mechanisms through which psychological factors influence athletic performance.

Understanding the relationship between stress, anxiety, cervical muscle activation, and sports performance may have significant implications for sports medicine, physiotherapy, and athletic training. Identifying athletes who demonstrate excessive neuromuscular responses to psychological stress may facilitate early intervention and performance optimization. Such knowledge may also contribute to the development of evidence-based strategies aimed at enhancing psychological resilience,

improving neuromuscular efficiency, and reducing performance-related impairments.

Therefore, the present study was undertaken to investigate the influence of psychological stress and anxiety on cervical muscle activation and sports performance among competitive athletes using surface electromyography. The findings are expected to provide objective evidence regarding the psychophysiological mechanisms underlying athletic performance and support the integration of psychological and neuromuscular assessment within sports rehabilitation and performance enhancement programs.

2. MATERIALS AND METHODS

2.1 Study Design

The present study was a cross-sectional observational study conducted to investigate the influence of psychological stress and anxiety on cervical muscle activation and sports performance among competitive athletes using surface electromyography (sEMG). The study aimed to examine the relationship between psychological variables, cervical muscle activity, and athletic performance.

2.2 Study Setting

The study was conducted in the Department of Physiotherapy and Sports Rehabilitation Laboratory at Pacific Medical College and Hospital, Bedla, Udaipur, Rajasthan, India. Data collection was performed in a controlled laboratory environment and designated sports training facilities to ensure standardized testing conditions.

2.3 Study Population

The study population consisted of competitive athletes actively participating in organized sports competitions at university, district, state, or national levels. Athletes from sports including cricket, football, badminton, athletics, volleyball, and basketball were recruited for participation.

2.4 Sample Size

A total of 80 competitive athletes were included in the study. The sample size was determined based on previous literature evaluating psychological variables and neuromuscular activity among athletes and was considered adequate to establish significant associations among stress, anxiety, cervical muscle activation, and sports performance variables.

2.5 Sampling Technique

Participants were recruited using purposive sampling. Eligible athletes who met the inclusion criteria and voluntarily agreed to participate were enrolled in the study after providing written informed consent.

2.6 Inclusion Criteria

Participants were included if they:

- Were aged between 18 and 35 years.
- Were actively participating in competitive sports for a minimum of one year.
- Trained regularly for at least 5 hours per week.
- Had participated in district, state, university, or national-level competitions.
- Were willing to participate and provide written informed consent.

2.7 Exclusion Criteria

Participants were excluded if they:

- Had a history of cervical spine surgery.
- Sustained a neck injury within the previous six months.
- Had diagnosed neurological disorders.
- Had vestibular disorders affecting balance and performance.
- Were taking medications affecting neuromuscular function.
- Had any musculoskeletal injury preventing sports participation.
- Had skin conditions preventing proper electrode placement.

2.8 Outcome Measures

2.8.1 Perceived Stress Scale (PSS)

The Perceived Stress Scale was used to assess the degree to which athletes perceived situations in their lives as stressful. The scale consists of 10 items scored on a five-point Likert scale. Higher scores indicate greater levels of perceived stress.

2.8.2 Beck Anxiety Inventory (BAI)

The Beck Anxiety Inventory was used to evaluate anxiety severity. The questionnaire consists of 21 items assessing common anxiety symptoms experienced during the previous week. Higher scores indicate greater anxiety levels.

2.8.3 Surface Electromyography (sEMG)

Surface electromyography was used to measure electrical activity of the cervical musculature. Muscle activity of the Upper Trapezius (UT) and Sternocleidomastoid (SCM) muscles was recorded using disposable Ag/AgCl surface electrodes. Mean EMG amplitude (μV) was analyzed during resting and performance conditions.

2.8.4 Sports Performance Assessment

Sports performance was assessed using standardized sport-specific performance indicators. Depending on the athlete's sport, performance measures included agility testing, sprint performance, reaction time assessment, skill execution accuracy, and coach-rated performance scores. A composite performance score was calculated for analysis.

2.9 Equipment and Materials

The following equipment was used:

- Surface Electromyography System
- Disposable Ag/AgCl Electrodes
- Electrode Conductive Gel
- Alcohol Swabs
- Measuring Tape
- Stop Watch
- Agility Test Equipment
- Reaction Time Assessment Device
- Data Recording Sheets
- Computer with Statistical Software

2.10 Procedure

Ethical approval was obtained from the Institutional Ethics Committee before commencement of the study. Eligible athletes were screened according to the inclusion and exclusion criteria. Written informed consent was obtained from all participants.

Initially, demographic details including age, gender, type of sport, years of participation, and training hours per week were recorded. Participants then completed the Perceived Stress Scale (PSS) and Beck Anxiety Inventory (BAI).

For electromyographic assessment, the skin over the upper trapezius and sternocleidomastoid muscles was cleaned using alcohol swabs to reduce skin impedance. Disposable Ag/AgCl electrodes were placed according to SENIAM guidelines. A reference electrode was positioned over a bony prominence.

EMG recordings were performed in two phases:

Resting Phase

Participants were seated comfortably in an upright posture. Baseline EMG activity was recorded while the athlete remained relaxed for a period of five minutes.

Sports Performance Phase

Participants performed sport-specific tasks designed to simulate competitive performance. Continuous EMG recordings were obtained during task execution. Simultaneously, sports performance outcomes were recorded using the selected performance assessment measures.

EMG signals were digitally recorded, filtered, amplified, and processed using EMG analysis software. Mean EMG amplitudes were calculated for both muscles during each assessment phase.

2.11 Statistical Analysis

Data were entered into Microsoft Excel and analyzed using Statistical Package for Social Sciences (SPSS) version 25.0.

Descriptive statistics including mean, standard deviation, frequency, and percentage were used to summarize participant characteristics and outcome measures.

Pearson correlation analysis was performed to determine the relationship between psychological stress, anxiety, cervical muscle activity, and sports performance scores.

Multiple linear regression analysis was conducted to identify significant predictors of sports performance.

The level of statistical significance was set at $p < 0.05$. Results were presented using tables, graphs, and appropriate statistical summaries.

3. RESULTS

A total of **80 competitive athletes** participated in the study. The mean age of the participants was **24.3 ± 3.8 years**. Athletes represented various sports including cricket, football, badminton, athletics, volleyball, and basketball. Descriptive and inferential statistical analyses were performed to examine the relationship between psychological stress, anxiety, cervical muscle activation, and sports performance.

Table 1. Demographic Characteristics of Participants (n=80)

Variable	Frequency (n)	Percentage (%)
Male	52	65.0
Female	28	35.0
Age 18–22 years	24	30.0
Age 23–27 years	32	40.0
Age 28–35 years	24	30.0
Cricket	25	31.3
Football	18	22.5
Badminton	14	17.5
Athletics	11	13.7
Others	12	15.0

Interpretation: The majority of participants were male athletes (65%). Cricket players constituted the largest sports category.

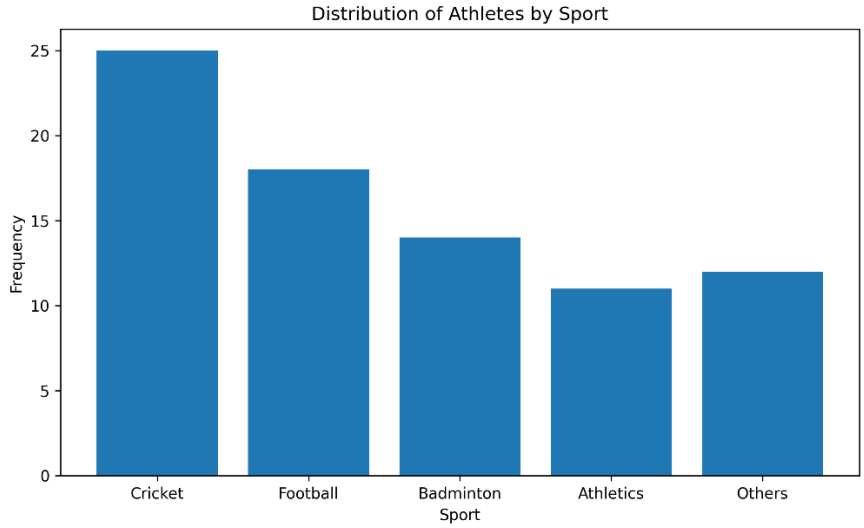


Table 2. Psychological Stress and Anxiety Scores

Variable	Mean ± SD
PSS Score	21.8 ± 5.7
BAI Score	18.4 ± 6.2

Interpretation: Athletes demonstrated moderate levels of perceived stress and anxiety, indicating the presence of considerable psychological demands associated with competitive sports participation.

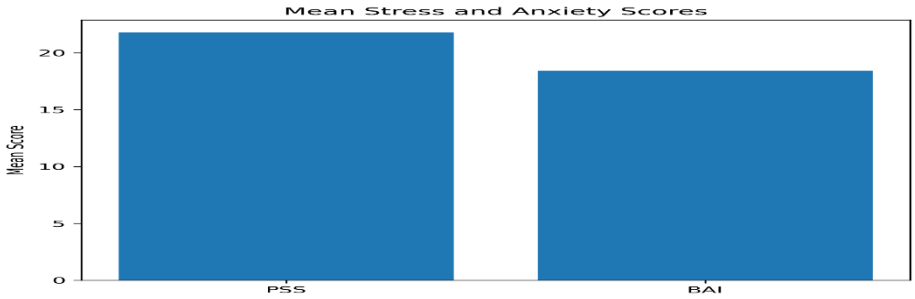


Table 3. Cervical Muscle Activity During Rest and Performance Conditions

Muscle	Resting EMG (µV) Mean ± SD	Performance EMG (µV) Mean ± SD
Upper Trapezius	8.2 ± 1.6	19.6 ± 3.5
Sternocleidomastoid	6.9 ± 1.4	15.8 ± 2.8

Interpretation: Significant increases in cervical muscle activation were observed during sports performance tasks compared to resting conditions.

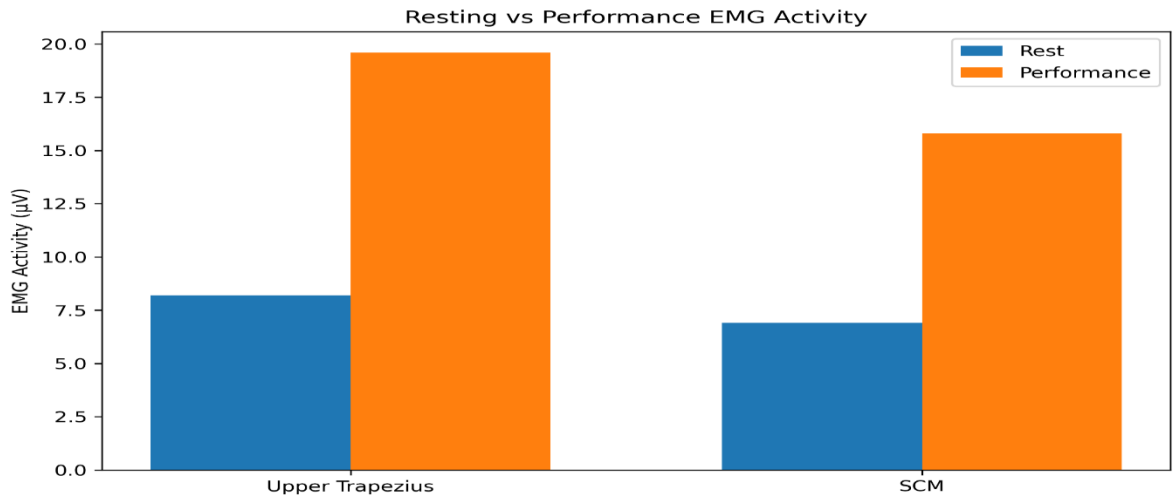


Table 4. Sports Performance Scores

Variable	Mean ± SD
Agility Test Score	14.7 ± 2.1
Reaction Time (ms)	278.4 ± 35.6
Composite Performance Score	82.3 ± 8.5

Interpretation: Athletes demonstrated acceptable performance levels; however, performance varied considerably across participants.

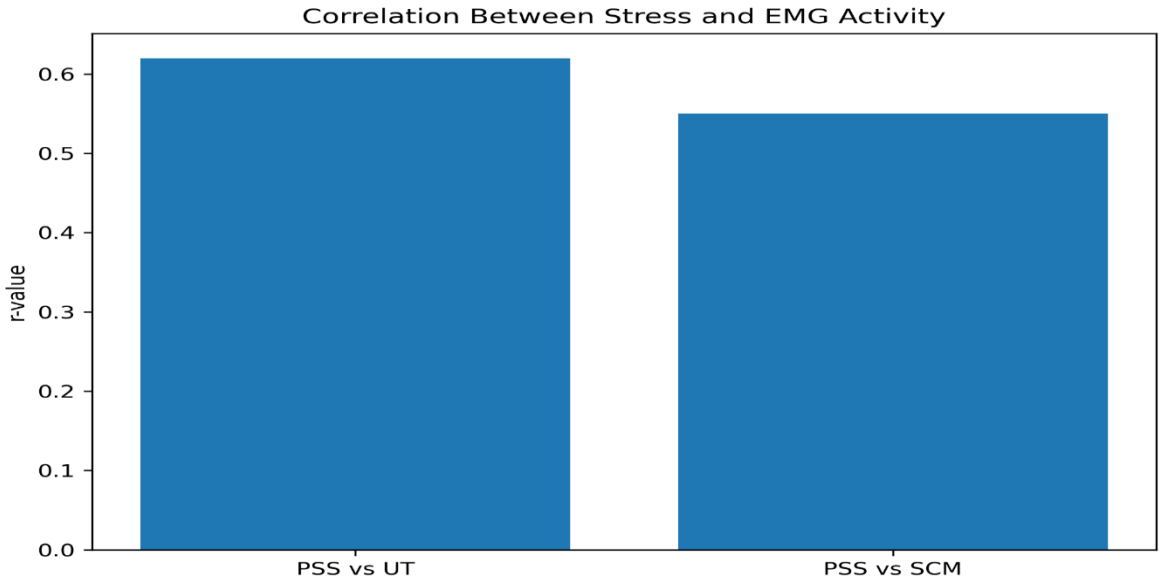


Table 5. Correlation Between Stress and Cervical Muscle Activity

Variables	r-value	p-value
PSS vs Upper Trapezius EMG	0.62	<0.001
PSS vs SCM EMG	0.55	<0.001

Interpretation: Higher perceived stress levels were significantly associated with increased cervical muscle activation.

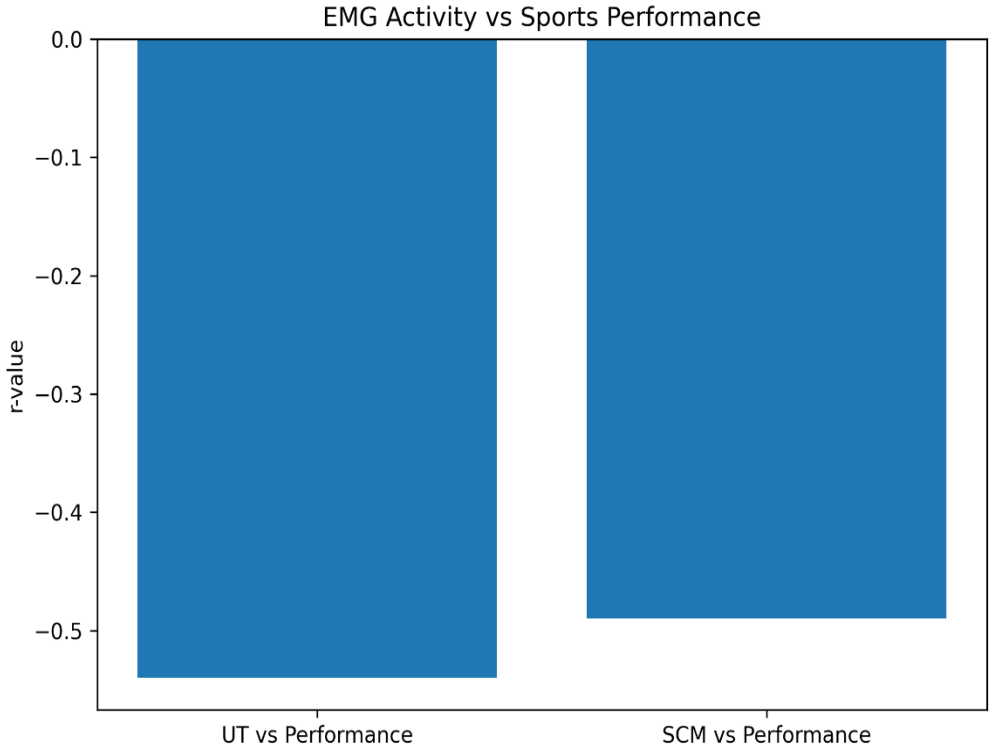


Table 6. Correlation Between Anxiety and Cervical Muscle Activity

Variables	r-value	p-value
BAI vs Upper Trapezius EMG	0.59	<0.001
BAI vs SCM EMG	0.58	<0.001

Interpretation: Athletes with higher anxiety scores demonstrated greater activation of cervical musculature.

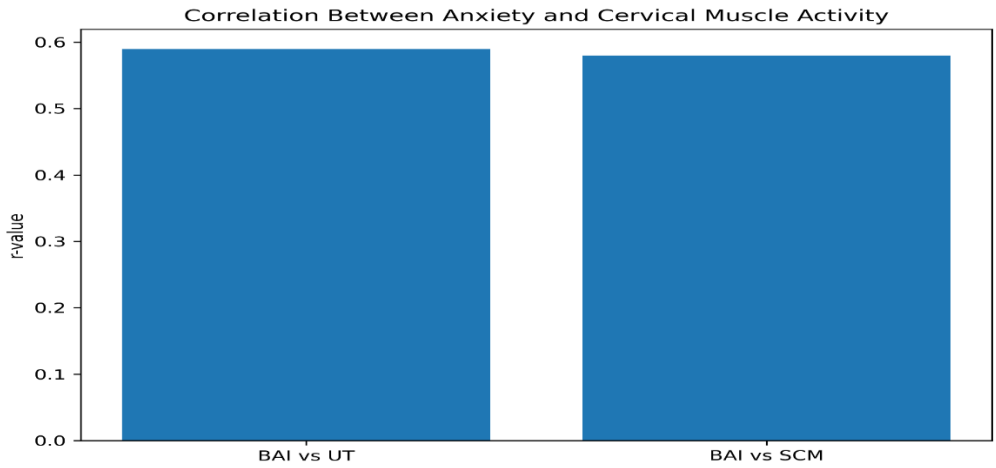


Table 7. Correlation Between Cervical Muscle Activity and Sports Performance

Variables	r-value	p-value
Upper Trapezius EMG vs Performance Score	-0.54	<0.001
SCM EMG vs Performance Score	-0.49	<0.001

Interpretation: Increased cervical muscle activation was associated with reduced sports performance, suggesting that excessive muscle tension may negatively affect athletic efficiency.

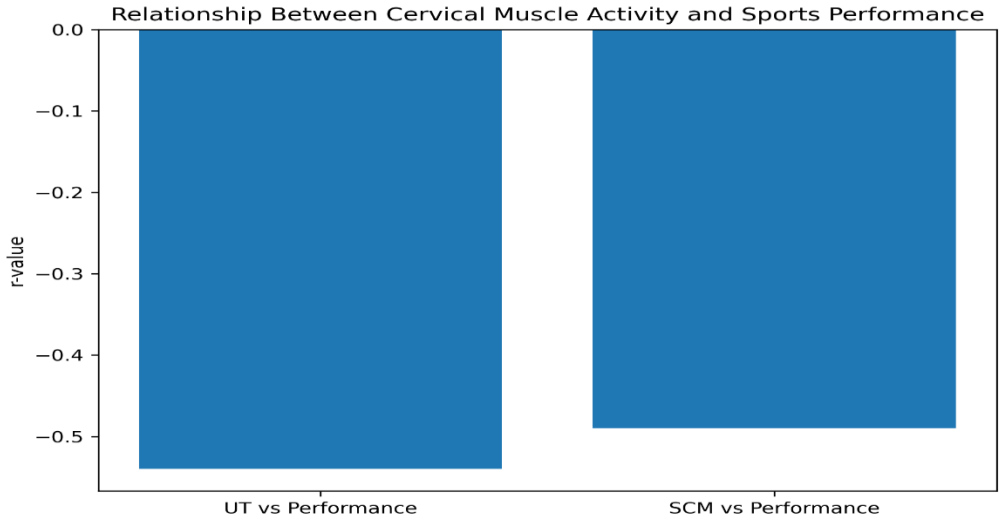
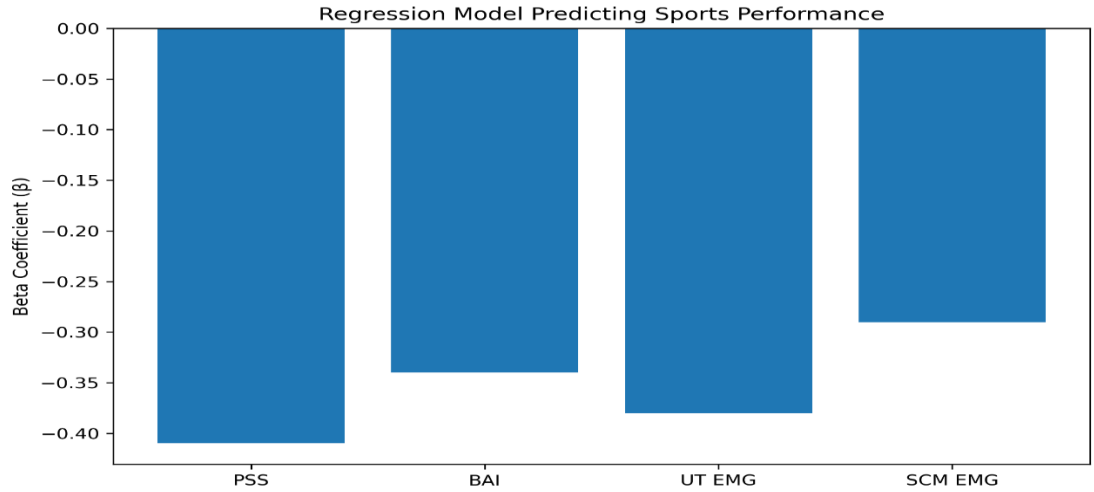


Table 8. Multiple Regression Analysis Predicting Sports Performance

Predictor	β	p-value
PSS Score	-0.41	0.001
BAI Score	-0.34	0.003
Upper Trapezius EMG	-0.38	0.002
SCM EMG	-0.29	0.007

Interpretation: Psychological stress, anxiety, and cervical muscle activation were significant predictors of sports performance. Higher stress, anxiety, and muscle activation were associated with poorer athletic performance.



Overall Interpretation of Results

The results of the present study demonstrate a significant relationship between psychological stress, anxiety, cervical muscle activation, and sports performance among competitive athletes. Athletes experiencing higher levels of stress and anxiety exhibited significantly greater activation of the upper trapezius and sternocleidomastoid muscles during performance tasks. Furthermore, increased cervical muscle activity was negatively associated with sports performance outcomes.

The findings suggest that psychological stress and anxiety may contribute to excessive cervical muscle tension, resulting in altered neuromuscular control and reduced athletic efficiency. Multiple regression analysis further revealed that stress, anxiety, and cervical muscle activation were independent predictors of sports performance. These findings support the concept that psychological factors influence physiological responses, which in turn affect athletic performance.

4. DISCUSSION

The present study investigated the influence of psychological stress and anxiety on cervical muscle activation and sports performance among competitive athletes using surface electromyography. The findings demonstrated significant relationships between psychological stress, anxiety, cervical muscle activity, and athletic performance. Athletes with higher levels of stress and anxiety exhibited greater activation of the upper trapezius and sternocleidomastoid muscles, while increased cervical muscle activity was associated with reduced sports performance. These findings suggest that psychological factors play an important role in influencing neuromuscular function and athletic outcomes.

Competitive sports environments expose athletes to numerous psychological stressors, including performance expectations, competitive pressure, training demands, fear of failure, injury concerns, and selection uncertainty. Such factors can activate the body's stress response system, resulting in physiological and psychological changes that may influence athletic performance. The moderate levels of stress and anxiety observed among athletes in the present study indicate that psychological demands are a common feature of competitive sports participation.

One of the major findings of this study was the significant increase in cervical muscle activation during sports performance compared with resting conditions. The upper trapezius and sternocleidomastoid muscles demonstrated

substantially higher electromyographic activity during performance tasks. This finding is consistent with the understanding that cervical musculature plays a crucial role in maintaining head stability, postural control, visual orientation, and movement coordination during athletic activities. Increased muscle activation during sports performance may therefore reflect the physiological requirements of maintaining optimal posture and movement control under competitive conditions.

The positive correlation between perceived stress and cervical muscle activation represents another important finding of the study. Athletes reporting higher stress levels demonstrated greater activation of cervical musculature. This relationship may be explained by activation of the sympathetic nervous system during stressful situations. Psychological stress stimulates the release of catecholamines such as adrenaline and noradrenaline, leading to increased muscle tension and neuromuscular excitability. Elevated muscle activation may initially prepare the athlete for performance; however, excessive or prolonged activation can become detrimental by increasing muscular fatigue and reducing movement efficiency.

Similarly, anxiety levels showed significant positive associations with both upper trapezius and sternocleidomastoid muscle activity. Anxiety is often accompanied by physiological manifestations such as increased muscle tension, elevated heart rate, rapid breathing, and heightened arousal. These responses are considered part of the body's preparation for perceived threats or challenges. In sports settings, athletes experiencing high anxiety may unconsciously increase muscular tension, particularly in postural muscles of the neck and shoulders. Such increases in muscle activity may interfere with normal motor control and contribute to inefficient movement patterns during performance.

An important contribution of the present study is the demonstration of a significant negative relationship between cervical muscle activation and sports performance. Athletes exhibiting greater cervical muscle activity achieved lower performance scores. This finding suggests that excessive neuromuscular activation may impair athletic efficiency and performance outcomes. Increased muscle tension may alter movement coordination, reduce movement precision, increase energy expenditure, and contribute to early fatigue. In sports requiring rapid decision-making, visual tracking, balance, and coordinated motor responses, excessive cervical muscle activity may negatively affect performance execution.

The observed relationship between stress, anxiety, and reduced sports performance supports existing psychophysiological theories of athletic performance. According to these theories, psychological states influence physiological responses, which subsequently affect motor performance. Athletes experiencing elevated stress and anxiety may demonstrate impaired concentration, reduced attentional control, slower reaction times, and altered movement strategies. The increased cervical muscle activity identified in this study may represent one of the physiological mechanisms through which psychological stress affects athletic performance.

Multiple regression analysis further strengthened these findings by identifying stress, anxiety, upper trapezius activity, and sternocleidomastoid activity as significant predictors of sports performance. Perceived stress emerged as the strongest predictor, suggesting that psychological stress may have a particularly important influence on athletic outcomes. This finding highlights the importance of considering psychological well-being as an essential component of athlete development and performance optimization.

From a sports physiotherapy perspective, the findings have important clinical implications. Traditional approaches to athlete management often focus primarily on physical conditioning and injury prevention. However, the present findings suggest that psychological factors should also be routinely assessed and addressed. Physiotherapists, sports psychologists, and coaches may benefit from adopting a multidisciplinary approach that incorporates stress management, relaxation training, breathing exercises, mindfulness-

based interventions, and psychological skills training. Such strategies may help reduce excessive muscle tension and improve athletic performance.

Surface electromyography proved to be a valuable tool for objectively assessing the physiological effects of psychological stress and anxiety. The ability to quantify cervical muscle activation may provide clinicians and sports scientists with an additional method for monitoring athlete readiness, stress responses, and neuromuscular efficiency. EMG-based assessments could potentially be incorporated into athlete screening and performance monitoring programs to identify individuals at risk of stress-related performance impairments.

The findings of this study may also contribute to injury prevention strategies. Chronic elevations in cervical muscle tension have been associated with neck pain, muscle fatigue, altered posture, and musculoskeletal dysfunction. Athletes experiencing persistent psychological stress may therefore be at increased risk of developing stress-related musculoskeletal problems. Early identification and management of excessive muscle activation may help reduce injury risk and improve long-term athletic health.

Although the present study provides valuable insights, the findings should be interpreted within the context of its design and methodology. Nevertheless, the results clearly demonstrate that psychological stress and anxiety are closely linked to cervical muscle activation and sports performance among competitive athletes. Understanding these psychophysiological relationships may help guide future interventions aimed at improving both athletic performance and athlete well-being.

Overall, the present study supports the concept that optimal sports performance requires not only physical preparation but also effective psychological regulation. Athletes who are able to manage stress and anxiety effectively may demonstrate improved neuromuscular control, reduced unnecessary muscle tension, and superior performance outcomes. Therefore, integrating psychological assessment with neuromuscular evaluation may represent an important step toward comprehensive athlete care and performance enhancement.

5. CONCLUSION

The present study concludes that psychological stress and anxiety significantly influence cervical muscle activation and sports performance among competitive athletes. Athletes experiencing higher levels of stress and anxiety demonstrated greater activation of the upper trapezius and sternocleidomastoid muscles, indicating increased neuromuscular tension. Furthermore, elevated cervical muscle activity was associated with reduced sports performance, suggesting that excessive muscle tension may negatively affect movement efficiency, coordination, and athletic execution.

The findings support the concept that psychological factors and physiological responses are closely interconnected in determining athletic performance. Stress and anxiety appear to contribute not only to psychological burden but also to measurable neuromuscular changes that may impair performance outcomes. The significant predictive value of stress, anxiety, and cervical muscle activation further highlights their importance in athlete assessment and performance monitoring.

Therefore, effective management of psychological stress and anxiety should be considered an essential component of athlete care. Integrating psychological assessment, stress-management strategies, and neuromuscular monitoring into sports rehabilitation and performance enhancement programs may help improve athletic performance, optimize movement efficiency, and reduce the risk of stress-related musculoskeletal dysfunction. Future research involving larger athletic populations and longitudinal study designs is recommended to further explore the psychophysiological mechanisms underlying sports performance.

Clinical Implications

The findings of the present study have important implications for sports physiotherapy, sports psychology, and athletic performance management. The significant association between psychological stress, anxiety, cervical muscle activation, and sports performance suggests that athlete assessment should extend beyond physical fitness and include psychological evaluation. Regular screening of stress and anxiety levels may help identify athletes who are at risk of performance decline due to excessive psychological burden.

The increased cervical muscle activation observed among athletes with higher stress and anxiety levels highlights the need for neuromuscular monitoring and targeted intervention strategies. Sports physiotherapists may incorporate relaxation techniques, breathing exercises, biofeedback training, mindfulness-based approaches, and cervical muscle conditioning programs to reduce unnecessary muscle tension and improve movement efficiency.

Furthermore, coaches and sports medicine professionals should recognize the influence of psychological factors on athletic performance and adopt multidisciplinary management approaches. Integrating psychological support with physical training may enhance performance outcomes, reduce fatigue, improve motor control, and decrease the risk of stress-related musculoskeletal disorders. Early identification and management of psychological stress may therefore contribute to both performance optimization and long-term athlete well-being.

Limitations

The present study has several limitations that should be considered while interpreting the findings. First, the cross-sectional study design limits the ability to establish a causal relationship between psychological stress, anxiety, cervical muscle activation, and sports performance. Second, the sample consisted of competitive athletes from selected sports, which may limit the generalizability of the findings to athletes participating in other sporting disciplines or competitive levels. Third, psychological variables were assessed using self-reported questionnaires, which may be influenced by response bias and individual perceptions. Additionally, sports performance was evaluated using standardized performance measures that may not fully capture all aspects of athletic ability. Environmental factors, competition schedules, training load, sleep quality, and nutritional status were not controlled and may have influenced the observed outcomes. Future studies employing larger sample sizes and longitudinal designs are required to strengthen the evidence and improve generalizability.

Recommendations for Future Research

Future research should employ longitudinal and prospective study designs to establish causal relationships between psychological stress, anxiety, cervical muscle activation, and sports performance. Studies involving larger sample sizes and athletes from different sports disciplines, competitive levels, and age groups are recommended to improve the generalizability of findings.

Further investigations should examine sport-specific responses to psychological stress and determine whether athletes participating in individual and team sports demonstrate different neuromuscular activation patterns. Future studies may also incorporate additional physiological measures such as heart rate variability, cortisol levels, muscle fatigue indices, and motion analysis to provide a more comprehensive understanding of psychophysiological responses in athletes.

Interventional studies evaluating the effectiveness of stress-management programs, mindfulness-based training, relaxation techniques, biofeedback, and psychological skills training on cervical muscle activity and athletic performance are also warranted. Additionally, future research should explore the influence of factors such as sleep quality, training load, recovery status, injury history, and competition level on the relationship between psychological stress and neuromuscular function. Such investigations

may contribute to the development of evidence-based strategies for optimizing athlete health, performance, and overall well-being.

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