Research Article

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Study on Central Sensitization in Elite Athletes of the National Softball Team

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ABSTRACT

Abbreviations: CS: Central Sensitization; CSI: Central Sensitization Inventory; CSS: Central Sensitization Syndrome; IBS: Irritable Bowel Syndrome; TMJ: Temporomandibular Joint Disorder; IASP: International Association for the Study of Pain; CPSS: Chinese Perceived Stress Scale; ABQ: Athlete Burnout Questionnaire

Introduction

Background of the Study

Softball, originating in Chicago, United States, in 1887, has a history of over a century. It is a multifaceted sport that encompasses the comprehensive evaluation and comparison of athletes' personal skills, physical attributes, psychological traits, team-specific intelligence, and overall tactics [1]. Amidst highly tense and exceptionally intense matches and training sessions, softball athletes exhibit a relatively elevated injury incidence, with an overall injury rate of 0.39% [2]. The majority of injuries in softball affect the shoulder (15.2%), wrist (11.8%), knee (11.2%), and head/face (11.2%). These injuries are classified as contusions (14.2%), sprains (14.1%), and inflammations (14.1%), with concussions (6.8%) being the most frequently reported injury [2]. Based on NCAA reporting data on softball pitching injuries, pitchers are the most commonly injured players on the field, with an injury rate of 26%. Among these cases, the most prevalent scenario is injury during batting, accounting for 22.4% of all game-related injuries [3]. It is estimated that softball results in more emergency room visits for injuries in the United States than any other sport [4]. In China, the youth softball athlete injury rate stands at 66.36%, with a tendency toward younger ages for sports-related injuries [5]. For athletes engaged in sports like softball, which require prolonged and continuous activity, injuries can potentially heighten fears or catastrophes related to pain, further progressing into chronic pain conditions [6].

In recent years, chronic pain continues to pose a significant global public health challenge. Traditionally, athletes' pain has been construed as a consequence of tissue damage, such as acute trauma or overuse [7]. Chronic pain presents formidable challenges for athletes, as it cannot be entirely explained by biomechanical stress or overuse injuries. While pain commonly accompanies sports-related injuries, it can also manifest independently of injury occurrence or persist following injury healing [8]. Central sensitization (CS), as a pivotal factor in chronic pain development, demands recognition. CS was initially introduced by Woolf in 1983 and refers to a distinctive state of the nervous system closely linked to enduring chronic musculoskeletal pain [9]. In 2011, the International Association for the Study of Pain

first defined CS as the heightened reactivity of central pain-signaling neurons to inputs from low-threshold mechanoreceptors [10]. For softball athletes, the majority of pain symptoms stem from overuse or disruptions in the throwing motion chain. Moreover, common chronic elbow and knee pain in softball has been confirmed to correlate with central sensitization [6,11,12]. Nevertheless, the occurrence rate of central sensitization among softball athletes in China remains a research gap. Sports injuries represent one of the most prevalent reasons affecting athletes. Throughout the history of sports injury prediction and prevention, the biomechanical perspective has consistently taken precedence [13].

Over the past two decades, the role of bio-psycho-social factors in sports injury prevention and prediction has been extensively explored [14]. Psychological and socio- cultural aspects influence the injury risk, responses, and recovery of high-intensity athletes [15]. Presently, research concerning the relationship between central sensitization in athletes and adverse psychological states may potentially bridge a gap in this area. Softball participation often leads to pain, with athletes exhibiting lower sensitivity to pain and greater pain tolerance compared to non-athletes [16,17]. Following the onset of acute injuries, persistent maladaptive movement control behaviors provide a foundation for sustained peripheral nociceptive sensitization [18]. Even after the initial injury healing, the nervous system remains in a state of heightened excitability [19], potentially resulting in altered central nervous system sensory processing and dysfunction in pain inhibitory mechanisms [9,20], ultimately culminating in central sensitization (CS). Prolonged CS is frequently accompanied by psychological issues such as depression, anxiety, and sleep disturbances, which may lead to reduced athletic engagement and consequently impact performance [21]. Consequently, the exploration of more effective physical therapy approaches holds significant implications for preventing and reducing central sensitization among softball athletes.

Research Objectives

To investigate the prevalence of central sensitization among national softball team athletes, clarifying the relevant circumstances of central sensitization among softball athletes in China. To examine the correlation between central sensitization and psychological traits among members of the national softball team, exploring the relationship between psychological traits and central sensitization.

Experiment 1: Prevalence of Central Sensitization among National Softball Team Athletes

Study Participants

Study Location: This study was conducted at the training base in Panzhihua, Sichuan, China. A total of 28 athletes from the Chinese national softball team, preparing for the 2022 Asian Games, participated in the research.

Inclusion Criteria:

1. Age of 16 years or older.
2. Complete and comprehensive medical records.
3. Willingness to participate in the study and sign an informed consent form.
4. Absence of relevant medical history involving neurological or psychological conditions.

Exclusion Criteria:

1. Failure to meet the inclusion criteria.
2. Inability to participate in testing due to injuries or other reasons.
3. Presence of abnormal conditions such as alcohol abuse or drug misuse during testing.
4. Other situations not aligned with the research objectives.
5. Any medical conditions that render participation in testing medically inappropriate.

Research Methodology

Experimental Approach: Questionnaire Survey Method: A one-on-one questionnaire survey was conducted with all athletes. Prior to distributing the questionnaires, athletes were provided with detailed explanations of how to complete them and any important considerations. Athletes independently filled out the questionnaires on-site, and the questionnaires were collected immediately after completion. The response rate for this study's questionnaire was 100.00%.

Outcome Measures

Instrument: The Central Sensitization Inventory (CSI) is a self-report symptom assessment tool utilized to evaluate symptoms related to Central Sensitization Syndrome (CSS) [22]. CSS is commonly associated with conditions like fibromyalgia (FM), chronic fatigue syndrome, irritable bowel syndrome (IBS), and temporomandibular joint disorder (TMJ). The CSI consists of Part A and Part B [22,23]. Part A comprises 25 questions designed to assess symptoms related to CSS. Each question employs a 4-point scale ranging from "never" to "always" for scoring. Research indicates a close correlation between CSI scores and the presence and severity of CSS symptoms. A CSI score of 30 points is considered indicative of possible CS, with sensitivity and specificity values of 0.81 and 0.75, respectively [24].

Data Processing: Data post-processing was conducted utilizing the SPSS 26.0 software. Quantitative data (CSI scores) were subjected to independent sample t-tests or F-tests for intergroup comparisons and were presented as "x±s".

Research Results

In the surveyed national volleyball team athletes, the rate of central sensitization was studied. Out of 28 athletes examined, 57% or 16 athletes exhibited central sensitization, whereas 43% or 12 athletes did not. The distribution of the scores was as follows:

a) 0-29 points: 12 athletes

b) 30-39 points: 8 athletes

c) 40-49 points: 6 athletes

d) 50-59 points: 1 athlete

e) 60 points and above: 1 athlete (Figure 1).

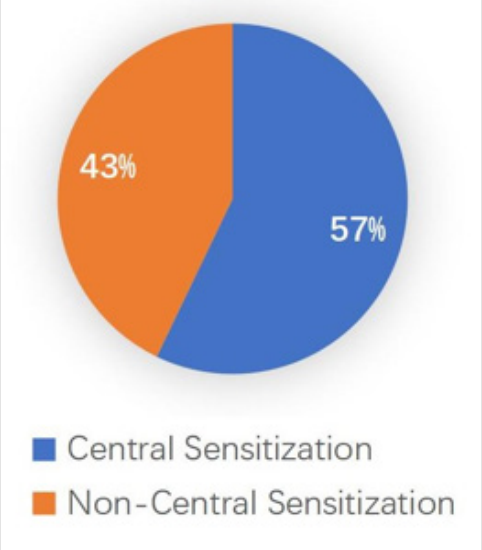

Figure 1: Incidence Rate of Central Sensitization.

Analysis and Discussion

This research investigated the prevalence of central sensitization (CS) in national team volleyball athletes, revealing that a significant 57% of them exhibit signs of CS, indicating a high prevalence rate among this group. Central sensitization was first introduced by Woolf in 1983 as a specific state of the nervous system closely associated with persistent chronic musculoskeletal pain [9]. In 2011, the International Association for the Study of Pain (IASP) formally defined CS as an enhanced reactivity of central pain-signal neurons to input from low-threshold mechanical receptors [10]. Among athletes, enduring periods of intense training and competition, which impose physical burdens, may lead to heightened excitability in the nervous system, potentially triggering CS [22]. The central nervous system can alter, distort, or amplify pain, magnifying its intensity, duration, and spatial extent. Such manifestations do not directly reflect the specificity of peripheral noxious stimuli but rather denote the functional state of specific circuits within the central nervous system [23]. The results from this study underscore the pervasive nature of CS among national team volleyball athletes, suggesting that this condition could adversely impact both their performance and health. Athletes, over extended periods of high-intensity training, undergo bodily adaptations and changes, aiming to achieve heightened training levels. However, excessive training without adequate recovery might precipitate the onset of CS [24].

This is attributed to the fatigue imposed on the nervous system and psychological state from prolonged and intense athletic training, heightening neuronal sensitivity to external stimuli [25]. Moreover, CS might detrimentally influence the psychological well-being of volleyball athletes, elevating their susceptibility to negative emotions and anxiety, subsequently affecting their quality of life and competitive performance. Future research endeavors will delve deeper into the ramifications of CS on the psychological resilience of volleyball athletes, exploring its correlation with central sensitization.

Research Conclusion

Among the volleyball team, 57% of the athletes were found to exhibit central sensitization, while 43% did not. Given the notably high prevalence of central sensitization, it merits further investigation in future research endeavors.

Experiment II: A Correlation Study on Central Sensitization and Psychological Resilience in National Volleyball Athletes

Subjects of Study

Study Population: The research was conducted at the training base in Panzhihua, Sichuan, China. It involved 28 athletes from the Chinese volleyball team preparing for the 2022 Asian Games. The criteria for inclusion and exclusion remained consistent with the previous study.

Research Methods

Experimental Approach: Questionnaire Survey: Each athlete was individually surveyed. Before distributing the questionnaires, athletes were thoroughly briefed on how to fill them out, what to pay attention to, and other relevant instructions. Athletes completed the questionnaires independently, and they were distributed, filled out, and collected on the spot. The response rate for the questionnaire in this study was 100.00%.

Outcome Measures

Chinese Perceived Stress Scale (CPSS): The CPSS was developed by Cohen in 1983. The scale utilizes a 1-5 grading system, with scores ranging from 0 (never) to 4 (very often). Questions 4, 5, 6, 7, 9, and 10 are reverse-scored. A normal stress range is between 0-28 points, moderate stress is from 29-42 points, and high stress ranges from 43-56 points. A positive correlation exists between perceived stress and the score value. The Cronbach's alpha coefficient is 0.816, indicating good reliability and validity [26]. Athlete Burnout Questionnaire (ABQ): The ABQ is an instrument designed to measure athlete fatigue and overtraining. Developed by Raedeke and Smith in 2001, it is widely used in both research and practice within the field of sports psychology [27,28]. The ABQ comprises 15 items spanning three dimensions: emotional exhaustion, physical/physiological fatigue, and cognitive/value-based fatigue. Respondents rate items on a 5-point scale ranging from 1 (strongly disagree) to 5 (strongly agree). Higher scores indicate greater levels of fatigue. Based on Raedeke's burnout theory, the ABQ was created by Raedeke and Smith to gauge the psychological fatigue of athletes. It has a Cronbach's alpha coefficient of 0.887, signifying good reliability and validity [28]. Central Sensitization Inventory (CSI): The CSI is a self-reported symptom evaluation tool employed to assess symptoms associated with Central Sensitization Syndrome (CSS) [29,30].

Data Processing: Data post-processed were statistically analyzed using SPSS 26.0 software. Quantitative data (CPSS scores, ABQ scores, and CSI scores) were subjected to independent sample t-tests or F-tests for between-group comparisons, represented as "x±s". Pearson analysis was employed to examine the correlation between CSI scores and ABQ scores, as well as CPSS scores. A p-value of less than 0.05 indicates statistical significance.

Research Results

Among the 28 athletes studied, the average stress scores in the central sensitization group were higher than those in the non-central sensitization group, with a p-value of less than 0.05. Details can be found in (Table 1). A positive correlation was observed between the CSI scores and both CPSS and ABQ scores, with P<0.05. Refer to (Table 2) for details (Figures 2-4).

Table 1: CPSS and ABQ scores across varying Central Sensitization groups.

Group	CPSS Score (mean ± SD)	ABQ Score (mean ± SD)
Central Sensitization	31.36±5.12	40.57±7.05
Non-Central Sensitization	19.27±5.26	27.27±8.53
t	5.55	4.09
P	0.0000	0.0004

Note: **P < 0.01 indicates a highly significant difference.

Table 2: Correlation between Central Sensitization and CPSS & ABQ Scores.

Variable	CPSS Score		ABQ Score	
CSI Score	R 0.80	P<0.0001	R 0.72	P<0.0001

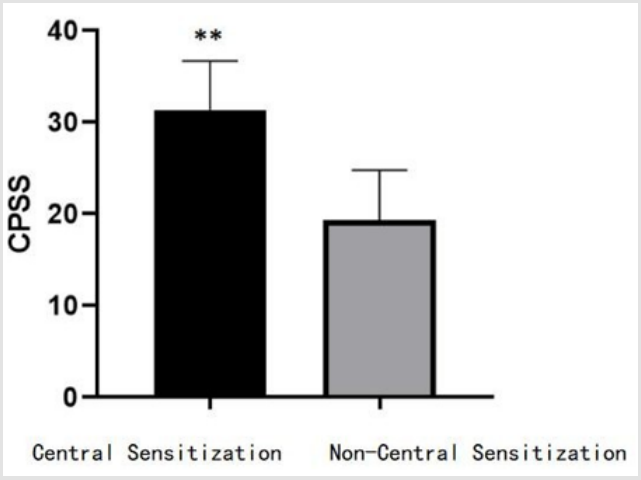

Figure 2: CPSS Scores by Different Groups.

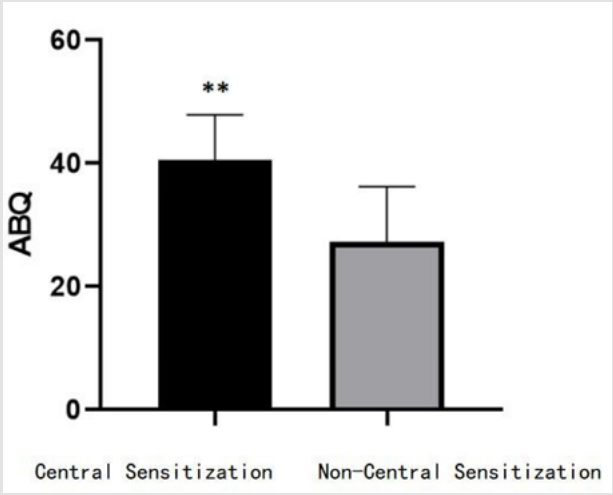

Figure 3: ABQ Scores by Different Groups.

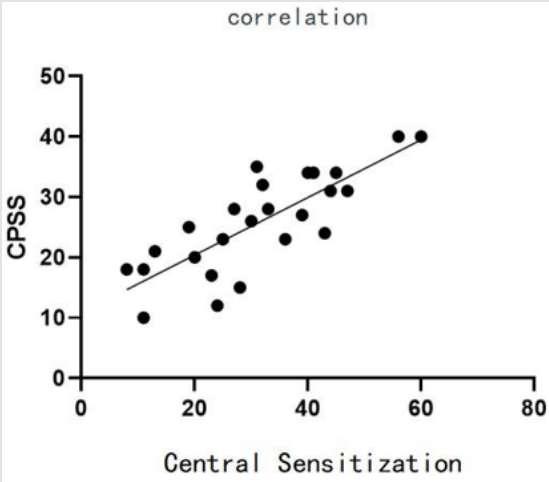

Figure 4: Correlation between Central Sensitization and CPSS Score.

Analysis and Discussion

This study examined the correlation between central sensitization and psychological quality in national softball team athletes. The results indicated that athletes with central sensitization scored higher on the CPSS and ABQ scales than those without central sensitization. This suggests that athletes with central sensitization are more prone to stress reactions and stress-related emotions, potentially affecting their performance and outcomes in competitions. In competitive sports, an athlete's psychological quality is one of the critical factors. Psychological elements can also lead to central sensitization. For instance, chronic stress and anxiety might lead to neuron activation and remodeling [31]. Psychological factors play a vital role in pain and an athlete's reaction to pain and injury (Figure 5). When psychosocial problems arise or pain persists beyond the expected healing time, a psychological assessment should be conducted. The assessment should consider understanding the athlete's perception of their pain, assessing pain and its impact, cognitive and behavioral responses, and levels of psychological stress and distress. There exists a bidirectional relationship between pain and anxiety, depression, stress, and anger, and assessments should consider its complex psychological state [32]. Furthermore, the study found a significant positive correlation between CSI scores and CPSS and ABQ scores. This implies that athletes with central sensitization often display poorer psychological states.

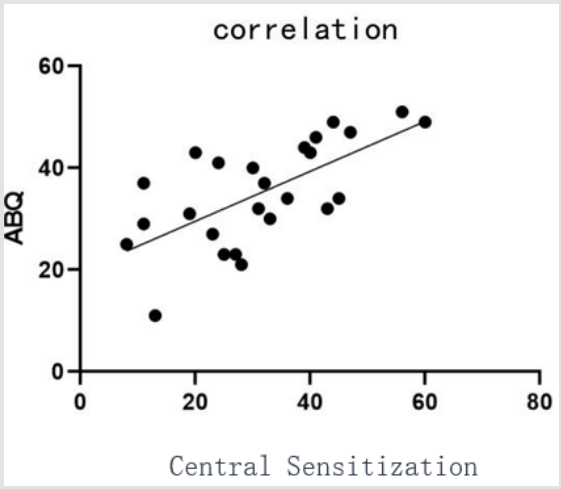

Figure 5: Correlation between Central Sensitization and ABQ Score.

Studies have confirmed that increased stress in athletes correlates with the likelihood of injuries [27]. When softball athletes maintain focus on their performance, they might also desire quick pain symptom relief to "immediately" return to the field [33,34]. In such scenarios, pain behaviors might get "reinforced" in stressful, unpleasant, or unwelcome environments. According to available data, while the technical actions, training levels, and physical fitness of softball athletes are becoming increasingly similar, the competition results often vary widely. The disparity is primarily because athletes' psychological factors lag far behind the demands of techniques and tactics [35]. Therefore, in competitive sports, emphasis should be placed on providing psychological counseling to athletes with central sensitization, aiming to alleviate perceived stress and negative emotions. This is to enhance their stress resilience and ability to cope with stressors.

Research Conclusion

Athletes with central sensitization display a positive correlation between perceived stress and fatigue levels. Clinically, there should be an emphasis on providing psychological counseling to athletes with central sensitization. This is to reduce their perceived stress and negative emotions as much as possible, preventing the exacerbation and progression of the condition.

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