

# Analysis of the Association of Professional Sports with Athletes' Cranial Nerve Dysfunction and Mental Health Problems

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**Abstract.** This article discusses the association of professional sports with athletes' cranial nerve dysfunction and mental health problems by conducting a literature review of the latest researches and theories. Professional or elite athletes, especially those in collision, combat and contact sports, are very likely to get multiple concussions or repeated traumatic brain injuries, which are often associated with cranial nerve dysfunction and chronic traumatic encephalopathy, resulting in various neurological impairments and diseases as well as mental health problems (e.g. depression and anxiety). In addition, other factors can also cause psychological problems among professional athletes, such as pre-competition stress and adverse life events. In order to improve the physical and mental health of professional or elite athletes, there should be more policies and measures to promote the early identification, treatment and prevention of psychopathology and other sequelae of brain trauma. Besides, a proper mechanism and system should be set up to enable those athletes to get aware of and seek suitable assistance when these dysfunctions and disorders occur.

## 1 Introduction

Nowadays, there are more and more people who are aware of the occupational diseases of professional athletes, especially the sequelae of sports-induced injuries among retired athletes. This research tries to investigate the association between professional sports and athletes' cranial nerve dysfunction, as well as the association between professional sports and athletes' psychological problems. Some damages associated with professional sports can be identified and diagnosed easily such as physical trauma, and athletes can get timely treatment and corresponding compensation. However, there are some damages associated with professional sports that cannot be identified easily, such as psychological problems and the cranial nerve dysfunction. These problems are deeply inside the patients' heart and brain, and often have long-term symptoms and disorders. Firstly, it needs patients themselves or others to identify these problems. Secondly, it needs professional physicians to diagnose these problems and some symptoms need special equipment to detect. However, these problems will exert enduring and penetrating influences over their life and career. Therefore, it is meaningful to conduct more researches about relevant topics so that both the athletes and people around them can increase the awareness thus help people prevent, identify, diagnose and treat them timely. It can also help the public know more about the professional sports' association with psychological problems and cranial nerve dysfunction so that they can

better protect themselves from the negative influences of sports, and better understand the contributions of those professional athletes. This article will conduct a literature review on this topic to help other researchers and scholars understand the current research status and achievements regarding this area, and help the public gain more knowledge and awareness.

## 2 Methodology

This paper applies the research method of narrative literature review to investigate the association of professional sports with athletes' cranial nerve dysfunction and psychological problems. Therefore, this research mainly collects the secondary data which refers to the data collected originally by other researchers for their research purposes. Previous literature and existing theories are searched from digital databases such as Google Scholar and Springer. In order to ensure the reliability of the results, there are a set of inclusion and exclusion criteria regarding the selection of the literature and articles in this essay. More specifically, this essay selects the research articles from authoritative sources (such as professional journals, professional conference reports) to ensure their quality and reliability. In order to ensure the cutting-edge of the research results, this article basically uses the research literature in the last ten years.

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## 3 Analysis of Literature

### 3.1 Mental health disorders and symptoms

#### 3.1.1 Higher risks of psychological problems among elite athletes

There are lots of researches investigating the mental health disorders and symptoms among professional or elite athletes. However, mental health disorders and symptoms are not exclusively owned by athletes. Instead, a recent meta-analysis and systematic review performed in 59 countries and across 155 general populations showed that about 20% adults experienced one kind of mental health disorders during the past 12 months, of which about one third of would experience it across their lifetime [1]. As for the mental health disorders among professional or elite athletes, some researches showed that prevalence of mental health disorders and symptoms among both former and current elite athletes seemed substantial, and similar to their prevalence in the mass population [2]. One study showed that an elite or professional sport career was characterized by over 640 distinct stressors which could stimulate mental health disorders and symptoms [3]. Besides, transitioning out of sports could be a hard time for athletes when the possibility of developing mental health disorders and symptoms could increase.

Gouttebauge et al. used systematic review and meta-analysis to find out that the prevalence of mental health symptoms of depress/anxiety, sleep disturbance, and distress was higher in the current athletes than in those former athletes [4]. For example, prevalence of sleep disturbance among former and current athletes were 21% and 26% respectively. Sleep disturbance among athletes could be caused by early morning travel and training, night-time sports events, pre-competition stress and etc. [5]. Besides, there were 34% for depression/anxiety in current elite athletes, and 16% for distress and 26% for depression/anxiety in former elite athletes, and might be slightly higher than those among the general population. For instance, according to other studies, prevalence of depression/anxiety ranged from 13%-19% among the general population in Australia, from 17%-25% among general population and clinical practice population of young male workers in the Netherlands, and from 17%-21% among general population in Denmark, which were all lower than the results of Gouttebauge et al. [4].

Mental health disorders and symptoms were found among current athletes might be because that elite athletes were exposed to sport-specific stressors, and also to generic factors like adverse life events [3]. Some researchers showed that the elite athletes with maladaptive perfectionism, decreased sport performance, multiple surgeries, and severe musculoskeletal injuries might have a higher overall risk of developing mental health disorders and symptoms [6, 7].

#### 3.1.2 Inadequate sports-specific mental health support

Even though many researches have showed that physical activities can positively influence mental health, Rice et al. conducted a literature review and found evidences that intense physical activities at the professional athlete level could compromise mental well-being of athletes, stimulating the occurrence of symptoms such as depression and anxiety via burnout, injury, and overtraining [2]. Some researches suggested that elite athletes suffered from increased risks of mental health issues such as suicide and eating disorders. Besides, emerging researches showed that retired professional athletes might have particularly increased risks of mental illness, which corresponded to both low rates of the athletes' perceived insufficient availability of relevant mental health support and formal mental health screening procedures for athletes [8].

As the sports psychiatry and relevant researches are still in the early stage of development, currently, the mental health services for the professional athletes may not consider those sport-related factors that can possibly influence athletes' vulnerability to various mental health problems, nor treatment or diagnostic issues that are unique to the population of elite athletes [9]. Therefore, to develop a comprehensive and in-depth understanding of the psychological well-being and mental health specific to professional athletes can help advance models of management and care of this population. This may stimulate performance gains in turn. Such a kind of understanding should provide instructions for sport practitioners (e.g. sport psychologists, medical staff, and coaches) to help elite athletes develop coping abilities and improve their psychological well-being.

### 3.2 Cranial nerve dysfunction

#### 3.2.1 Influence of exhaustion and fatigue on stability of functional connectivity between brain regions

Dapeng and et al. selected eleven male athletes with good endurance qualities, and used BOLD-fMRI to observe the functional connectivity (FC) changes between the athletes' brain regions before and after exhaustion [10]. It was found that compared with the resting state, during exercise at moderate intensity until exhaustion, the connections between sensorimotor cortex (SMC) and cerebellum, parahippocampal gyrus and cerebellum, frontal lobe and cerebellum were weakened. The researchers concluded that the brain areas in the resting state default network of athletes are all based on the cerebellum to form a stable network system; the connection function declines after exhaustion occurs. In 2019, the researchers conducted a similar test to observe the functional connectivity changes between the athletes' brain regions before and after fatigue, and found that compared with the resting state, the primary motor area (M1) and cerebellum, sensorimotor cortex (SMC) and cerebellum, hippocampus/para hippocampus and the cerebellum were weakened. They concluded that the

brain areas in the resting state default network of the athletes are all centered on the cerebellum to form a stable network system, and the connection function decreases after fatigue occurs [11]. These two studies showed that the exercise-induced exhaustion and fatigue can reduce the stability of functional connectivity between the athletes' brain regions, however, these two studies did not show the long-term effects of these changes.

### 3.2.2 Concussion and cranial nerve dysfunction

Buckley et al. selected sixty-three student-athletes and found that athletes with prior concussion history had subtle impairments in their postural control during gait which can indicate future neurological deficiencies [12]. However, this research had a limitation which might also exist in other similar researches, that is, the participants' self-reporting of the concussion history only had only moderate reliability, so the grouping of the participants based on the concussion history might be incorrect.

Among those retired NFL (National Football League) players, the players with a history of three or more concussions in their lifetime history self-reported an increased risk of a clinically diagnosed depression as well as mild cognitive impairment [13]. For example, Guskiewicz, Marshall investigated 2,552 professional football players who had retired and were averagely 53.8 years old, and found that there was a possible relationship between increased clinical depression and recurrent sport-related concussion. However, this study was also limited by the moderate reliability of the self-reporting symptoms like the accuracy of MCI diagnosis. Besides, other limitations included varying diagnostic criteria for traumatic brain injury and its severity, varying depression-grading scales and etc. The NFL players often had a higher mortality rate related with neurodegenerative diseases than the general public [14]. In addition, even though the specific epidemiology and neuropathology remained debated, some case reports have showed the presence of a chronic traumatic encephalopathy among deceased athletes of collision sport [15]. Studies in military settings found a positive relationship between a growing number of traumatic brain injuries (mild) and an increased risk of post-traumatic stress disorder, depression, and suicide risk, but this finding cannot prove it to be independent of other kinds of confounding variables [16]. Conversely, other researchers have provided limited evidences of neurological impairments in either a patient-sampled or a population-based neurological study.

There are inconsistent results about the potential short-term impairments among young individuals who had multiple concussions. The influence of past concussions on the self-reported symptoms could be split when some found increased symptoms and some found no differences. For example, some studies found that the history of concussion did not adversely influence the performance on a computerized neuropsychological test in young individuals in high school or college [17]. Some other studies showed that past concussions have been related with altered electrophysiological responses which can last for months to years after the last concussion [18]. Besides, a history of three or more concussions was associated with lower life quality such as headache, social functioning disorder and bodily pain [19].

Manley et al. conducted a systematic review of 3,819 studies in order to find out the possible long-term effects of the sports-related concussions among retired athletes, and concluded that there was evidence to prove that some former athletes in collision, combat and contact sports suffered from cognitive deficits and depression later in their lives, and an association between a history of multiple concussions and these deficits was found in the literature review. However, this study did not provide statistical and scientific data to prove this kind of association due to the limitations of the research method of literature review. The researchers also pointed out that more research should be done to get better understanding of the prevalence and reasons of chronic traumatic encephalopathy as well as other neurological diseases and conditions, and the extent to which they are associated with a history of concussion(s) and/or repetitive neurotrauma got in professional sports.

### 3.2.3 Repetitive traumatic brain injuries and chronic traumatic encephalopathy

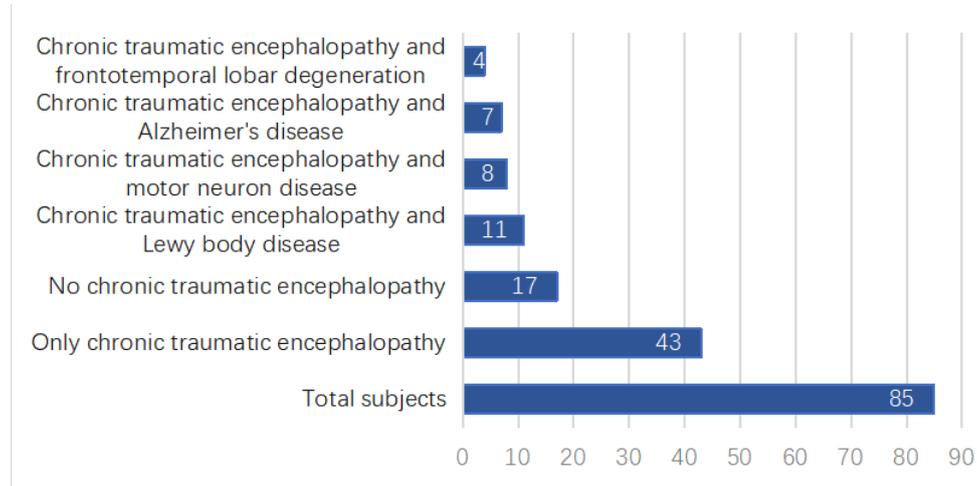
McKee et al. studied sixty-four professional athletes and twenty-one military veterans (86% of these military veterans were also athletes) with a history of repeated mild traumatic brain injuries, and found that the majority of them had chronic traumatic encephalopathy [15].

Chronic traumatic encephalopathy refers to a progressive tauopathy occurring after repeated mild traumatic brain injuries. The hyperphosphorylated tau pathology in chronic traumatic encephalopathy has a spectrum of severity ranging from neurofibrillary tangles' focal perivascular epicentres located in the frontal neocortex to severer tauopathy influencing wider brain regions (such as medial temporal lobe), leading to a progressive pathology staging from stage I to stage IV.

**Table 1.** Different symptoms during the four stages of chronic traumatic encephalopathy

|          | Particular symptoms                           | Common symptoms  |
|----------|---|--|
| Stage I  | Loss of concentration and attention, headache | At all four stages, there are axonal loss and multifocal axonal varicosities in the deep cortex and the subcortical white matter; in 85 percent of the cases, TDP-43 (TAR DNA-binding protein 43) immunoreactive intragial and intraneuronal |
| Stage II | Add short-term memory loss, depression        |  |

|                  |   |  |
|------------------|---|--|
| <b>Stage III</b> | Cognitive impairment and executive dysfunction                                      | neurites and inclusions are found, such as in focal pathology during stage I, II, III and widespread neurites and inclusions during stage IV [15]. |
| <b>Stage IV</b>  | Characteristic symptoms including aggression, word-finding difficulty, and dementia |  |



**Fig. 1.** Diagnosis of related diseases among subjects

The frequent association between other neurodegenerative disorders and the chronic traumatic encephalopathy indicates that the repetitive brain injuries as well as the deposition of the hyperphosphorylated tau protein can let other abnormally aggregated proteins (e.g. amyloid beta protein, alpha-synuclein, and TDP-43) [15]. Besides, the researchers could get athletic exposure data among thirty-four subjects who were American football players, and found that the stages of chronic traumatic encephalopathy were correlated with the football play duration, after-football survival, as well as age at death.

## 4 Discussion

Based on the above literature review, it can be said that elite athletes generally had higher risks of developing some certain mental health disorders and symptoms (e.g. depression/anxiety) than the general population, which may be due to the sports-induced factors or generic factors. However, athletes often do not seek support for their mental health problems due to various reasons such as regarding help-seeking as a behaviour of weak people, lacking an understanding of psychological well-being and its effects on performance and stigma. Even though there are more and more efforts in disseminating mental health findings in sports field in order to promote the early identification, treatment and prevention of psychopathology among elite athletes, it is also suggested that relevant sports governing organizations should enhance relevant policies and measures to reduce mental ill-health among these people.

As for the cranial nerve dysfunction, this paper discusses about the reduced stability of functional connectivity between different brain regions after sports-induced exhaustion and fatigue, which is related to

cranial nerve dysfunction during the sports. As for the sequelae of concussions, even though there are different research results about the potential short-term impairments among young individuals who had multiple concussions, the literature review shows that there is a frequent association between a history of multiple concussions (at least three concussions) and various neurological impairments such as subtle impairments in postural control during gait, increased risks of clinically diagnosed depression as well as cognitive impairment and deficits, neurodegenerative diseases, post-traumatic stress disorder, suicide risk, lower life quality (headache, social functioning disorder, bodily pain), and chronic traumatic encephalopathy. This shows that concussions can also cause mental ill-health and psychological problems such as depression, post-traumatic stress disorder, suicide risk, social functioning disorder.

Chronic traumatic encephalopathy can occur after repeated mild traumatic brain injuries such as after multiple concussions. There are cranial nerve dysfunctions happening at different stages of chronic traumatic encephalopathy, resulting in symptoms like loss of concentration and attention, short-term memory loss, cognitive impairment and executive dysfunction, word-finding difficulty, dementia, as well as psychological problems such as depression and aggression. It can be said that multiple concussions and/or repetitive traumatic brain injuries got in professional sports can cause cranial nerve dysfunction, resulting in various neurological impairments and diseases as well as some psychological problems. As stated above, professional athletes have a higher risk of depression/anxiety and distress due to generic factors and sports-specific factors, and multiple concussions and repetitive neurotrauma can be a major sports-specific factor.

## 5 Conclusion

Based on the above discussion, it can be said that professional sports have a certain level of association with athletes' cranial nerve dysfunction and mental health problems. Professional sports often include physical collision, contact and combat, in which the athletes are likely to get injured (for example, concussions or traumatic brain injuries). Even though the short-term symptoms and trauma can be relatively easy to be identified and cured, many long-term symptoms and sequelae related with cranial nerve dysfunction and mental health problems are harder to get identified and treated timely. Multiple concussions or repetitive traumatic brain injuries can cause chronic traumatic encephalopathy and cranial nerve dysfunction, leading to neurological diseases and impairments along with some mental health problems. In addition to the factors related with physical injuries, other psychological factors such as career-related stress, and external factors like difficulties in life can also lead to mental health problems among professional or elite athletes, especially when they have to experience high-intensity training and face fierce competitions. Therefore, for this group, more effective professional services and measures should be provided to help them identify, diagnose, and treat these diseases and problems.

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