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Investigating the Incidence of Cerebral Microhemorrhage in Active Professional Football Players Through Susceptibility-Weighted Imaging Cerebral Microhemorrhages in Professional Football Players

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ABSTRACT

Introduction: This study assesses the effectiveness of susceptibility weighted imaging (SWI) in detecting microbleeds from repetitive head trauma in active professional football players. The investigation aims to contribute to the ongoing discussion about the long-term neurological effects of professional football and the efficacy of advanced imaging techniques in detecting subtle brain changes.

Methods: We collected data from 60 cases, including 30 professional footballers from the top football league and 30 healthy volunteers. Players' age, average playing time, total number of matches, average matches per player, and total number of traumatic concussions were calculated. SWI was conducted using a 3T magnetic resonance imaging device, and two experienced neuroradiologists independently evaluated the SWI. Group microbleeding rates were compared using the Fisher's exact test.

Results: The average duration of a football career among the participants was 7.14 years, and a total of 5647 matches were held, with an average of 38.4 games per footballer, and 15 traumatic concussions in total. No microhemorrhage was found in SWI of either the footballer or the control group. The evaluations of the two radiologists are in harmony, strengthening the validity of the study's findings.

Conclusion: The study shows no additional micro bleeding in football players compared to the control group, indicating the potential of SWI in detecting traumatic brain injuries. However, this does not necessarily mean that professional football does not cause microbleeds. Further research with larger sample sizes and longitudinal designs is recommended to validate these findings and explore other potential neurological effects of repetitive head trauma in football.

Keywords: Footballers, microbleeding, susceptibility weighted imaging

Introduction

Brain damage as a result of trauma has emerged as one of the most urgent public health concerns in recent years, particularly affecting the young and mobile population. This issue, which can lead to severe disability and even death, is a result of various causes: traffic and work accidents, sports traumas, falling from heights, and physical violence (1). The resulting disorders are categorized into primary and secondary pathologies. Primary pathologies include hemorrhage during trauma, vascular injuries, calvarial fractures, and diffuse axonal injury. Secondary pathologies include biochemical, physiological, and vascular damage caused by disrupting homeostasis within minutes and days after trauma, and by mixing harmful chemicals such as amino acids, neurotransmitters, proinflammatory cytokines, and free radicals into the environment (2).

In American football, rugby, boxing, kickboxing, football, and many other such sports, where close contact is frequent, the risk of concussion due to blows and collisions is prevalent. The increase in the number of athletes participating in these sports has led to a rise in head traumas (3). In football competitions, repetitive head trauma due to collision and excessive exposure to the soccer ball can cause acute and chronic brain damage in the athlete. Acute brain injuries encompass a variety of conditions, including concussion and bleeding, injury to cerebral white matter axons, and even death. Most athletes have reported that memory problems occur in their daily lives long after the match. Studies report that many clinical pictures of behavioral, motor, and cognitive disorders may occur in older adults (4).

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Brain computed tomography (CT) and conventional magnetic resonance imaging (MRI) are the most commonly used radiological methods in the diagnosis of mild brain injury caused by trauma during sports. Normal or nonspecific brain imaging findings are primarily seen in certain radiological methods. Therefore, it is not always possible to diagnose mild traumatic brain injury (TBI) with radiological methods. Although CT and MRI findings were not abnormal, cases with clinical and examination findings consistent with TBI have been published in the literature (5). Studies are being carried out on advanced radiological imaging methods to reveal TBI mechanisms and detect cerebral changes before clinical and examination symptoms appear. As a result, by detecting TBI early, it will be possible to prevent the progression of damage by taking necessary precautions before severe and permanent damage occurs.

MRI is the most commonly used, effective radiological method for the detailed explanation of the anatomy of the brain and the diagnosis of many related pathologies. Thanks to the rapidly developing technological advancements, the modality ranks first in central nervous system imaging with advantages such as multiplanar imaging and being radiation-free. The susceptibility weighted imaging (SWI) technique, developed by Haacke et al. (6) is one of the advanced MRI sequences that display changes in blood oxygen levels, and has emerged with technological developments in recent years. The basis of the SWI technique is the magnetic sensitivity of blood products such as deoxyhemoglobin, intracellular hemoglobin, and hemosiderin, and minerals such as iron and calcium, which results in the acquisition of gradient-weighted images consisting of three-dimensional, high-resolution magnified and phase images and their combinations. This allows the detection of microhemorrhages containing blood products.

Today, with the increase in competitions in football, recognized as the most watched and played sport worldwide, the incidence of TBI is rising due to collisions and repeated heading of the ball. In football players, rapid acceleration, decelerations, contusions, tension, and ruptures in neural and vascular structures may occur due to severe collisions or hard blows to the head by the soccer ball during the match. In TBI, contusion and diffuse axonal injury accompanied by microhemorrhages are observed. As far as we know, an article investigating microhemorrhages in the brain using the SWI method in active football players has yet to be published.

This study marks a significant leap in TBI research. It is a pioneering investigation into the potential of the SWI technique in detecting microhemorrhages resulting from repetitive head trauma in active professional footballers playing in the top football league.

Methods

Informed consent forms were obtained from the participants and the procedure was carried out. The study was approved by the Local Ethics Committee of Selçuk University Faculty of Medicine (approval number: 2020/102, date: 04.03.2020). Our university's Scientific Research Projects unit received financial project support to cover the study's MRI expenses. A total of 60 cases were included in the study, 30 of whom were active professional football players and 30 healthy volunteers of similar age. The age of the players, the average time they played, the total number of matches, the average number of matches per footballer, and the total number of traumatic concussions were recorded. Individuals with neurological or other diseases, including head trauma, epilepsy, metabolic disorders, perinatal asphyxia, active or previous diseases related to the central nervous system, a history of drug and similar substance use, and hypertension were excluded from the study. This exclusion applied to both active professional football players and healthy volunteers. All participants underwent a Mini-Mental Status Examination to assess the possible presence of chronic traumatic encephalopathy, and neurological examinations to rule out diseases such as dementia, depression, tremor, nystagmus, speech disorders, or forgetfulness. Data on the cases included in the study were collected between October 2021 and November 2022.

The MRI examination was conducted meticulously, using an MRI device with a 3T magnetic field strength (Magnetom Aera, Siemens Healthcare, ErlangenGermany) and a head coil. Localizer images were first created in the sagittal plane. For the SWI sequence, the following detailed acquisition parameters were utilized: repetition time, 49 ms, echo time, 40 ms, voxel dimensions, 0.9×0.9×3.0 mm, slice gap overlay, 1, slice thickness, 1.6 mm, base resolution, 320, flip angle, 15°, field of view phase, 75%, and image matrix, 247×320. These optimized parameters were selected to maximize sensitivity for detecting susceptibility effects associated with microhemorrhages while maintaining adequate spatial resolution and signal-to-noise ratio. Since no artifact was detected on SWI, no case was excluded from the study.

All images were evaluated independently by two academic radiologists with 10 and 12 years of neuroradiology experience, regardless of their groups, and the radiologists did not know each other. Corrected phase and magnitude images created using post-imaging software were used for SWI evaluation. The presence of microhemorrhage was investigated using the images. A semi-quantitative analysis method was used to evaluate the sensitivity effects, and was evaluated according to the amount of hypointense foci present in the magnitude images (Figure 1 a-d).

Statistical Analysis

All statistical calculations were performed using IBM SPSS Statistics for Windows version 23, ensuring the objectivity and reliability of the study's conclusions. Microbleeds group rates were compared using the Fisher's exact probability test, and the significance level was set at $p<0.05$.

Results

To investigate the effectiveness of the SWI technique in detecting micro bleeding due to repetitive head trauma in active professional football players, axial plane SWI sequence images of the brains of 60 patients, 30 of whom were from the football player group, and 30 from the healthy control group, were obtained with a 3T MRI device.

SWI of 60 cases were independently evaluated by two academic radiologists with 10 and 12 years of neuroradiology experience, regardless of their groups, unaware of each other's evaluations.

All of the patients participating in the study were male, and the age range was 19-27 years (median 22 years). The average duration of a football career among the participants was 7.14 years, and a total of 5647 matches were played, with an average of 38.4 games, and 15 traumatic concussions per footballer.

Notably, microhemorrhage was not found in the SWI of either the footballer or the control group. There was no statistically significant difference between the groups. Compliance among radiologists was 100%. The fact that the evaluations of the two radiologists are in harmony further strengthens the validity of the study's findings.

Discussion

The SWI sequence, a novel addition to clinical practice, contrasts using the magnetic susceptibility differences of tissues and differs from T1, T2, T2*, and proton density. This unique approach, sensitive to relaxation changes and phase changes caused by the difference in sensitivity between oxygen and deoxygenated hemoglobin, results in more pronounced signal loss in venous blood. The method creates filtered phase images by applying high- and low-pass filters to the initial raw photos, enhancing the contrast in the original magnified images. These images are duplicated and combined with the original magnified images to create enlarged SWI. This technique has been shown to provide valuable data in the radiological diagnosis of many brain pathologies, making it a compelling area of research for medical professionals. In the past, SWI has been used in the diagnosis of many diseases other than trauma-related brain injury (6). İkizceli and Mutlu Değer (7), a series of SWI studies conducted on 70 patients aged 1-87 years on a 1.5 T MRI device, investigated its sensitivity in detecting lesions such as ischemic cerebral infarction, traumatic and non-traumatic hemorrhage, vascular malformation, intracranial mass, and neurodegenerative disease. As a result, it has been stated that SWI sequences improve visibility and facilitate detection by showing micro- and macrohemorrhages, venous malformations, and mineral accumulation better than conventional MRI sequences (8). In a study of 180 patients with traumatic-non-traumatic hemorrhage, masses, foci of microbleeding, vascular malformation, ischemic cerebral infarction, cerebral mineral accumulation due to systemic or neurodegenerative disease, multiple sclerosis, and non-specific findings, without loss of detail in anatomical formations, the SWI sequence detected slow-flow vascular lesions, large and small hemorrhage foci, mineral accumulation in cerebral strokes, the internal structure of cerebral masses, and hemorrhagic. It has been noted that a new MRI sequence is highly effective and sensitive in detecting transformation (8).

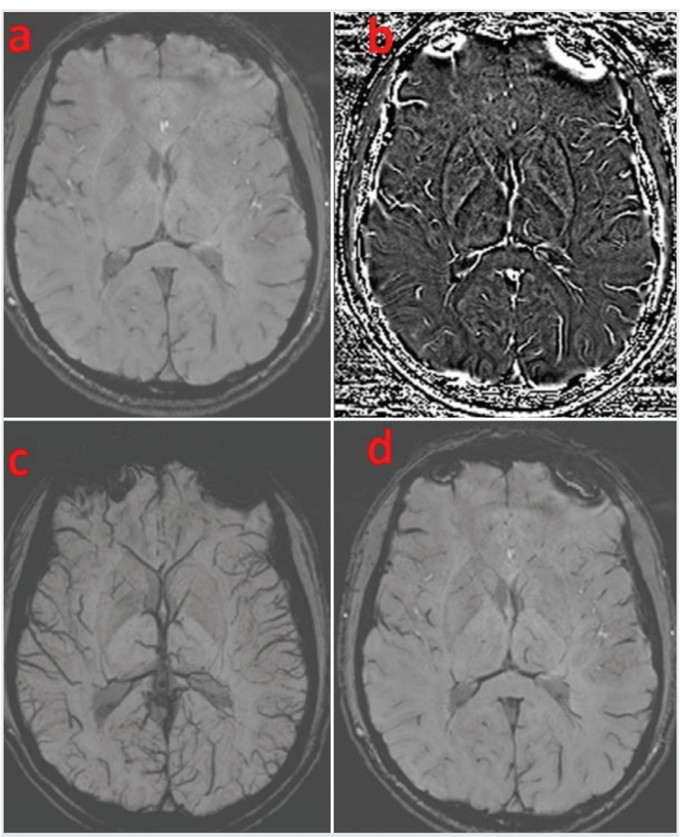

Figure 1. SWI a) magnitude image b) filtered phase image c) minIP image d) processed SWI

SWI: Susceptibility weighted imaging, minIP: Minimum intensity projection

In recent years, studies on sports-related TBI were primarily conducted in boxers. One of these studies was performed with CT and evaluated 388 active professional boxers; 93% had normal brain CT findings, and 6% had borderline atrophy (9). In another study conducted with MRI and attended by 12 active and 40 retired boxers, mild cerebral atrophy was described in 8 cases, and mammillary bodies and optic chiasm were described as small in 30 cases (10). In a 1992 study using MRI, no brain abnormalities or brain microhemorrhages were detected in the systematic study of 13 amateur boxers, despite the technical limitations of the early days of MRI. This study obtained images using a 10 mm thick 0.5 T MRI device (11). Unlike these studies, the introduction of SWI, a more sensitive and up-to-date technique, was a significant advancement. This study used this method for the first time to detect microbleeding in active professional football players, marking a crucial step forward in the field. In addition, factors affecting the severity and recurrence of trauma, such as match severity, previous severe trauma, and encephalopathy, were also taken into account.

To elucidate the pathologies in the boxing population using up-to-date MRI techniques, studies have been initiated to detect recent and minor bleeding. Although the survey evaluated images including transverse dual spin echo, rapid gradient echo acquisition prepared by 3D sagittal magnetization, and axial flight-time MR angiography sequences in coronal T2* and 3T devices, as well as fight and knockout numbers, weight distribution, and duration of boxing, and found a statistically higher frequency of cerebral microbleeding than in non-boxers, this difference was not statistically significant (12). The study investigated the differences between conventional MRI, T2 FSE, T2* GE, and 1.5T MRI devices (including SWI). Microbleeding was detected in 2 of 21 boxers. Although more micro-bleeding was detected in amateur boxers than in the control group, the difference was not considered statistically significant (13). One of the technical differences in this study is using a 3T MRI device. This has led to greater sensitivity in detecting microbleeding. The fact that experienced neuroradiologists perform the evaluation without being aware of each other, and that the results are compatible, are among the factors that increase the reliability of the SWI sequence. In addition, the absence of micro bleeding in the group of football players in our study can be explained by the football players being younger, and the number of severe trauma and encephalopathy was low. In addition, the fact that the traumas experienced during football were not directed to the head, as is common in boxing, may have affected the results.

In the SWI study conducted to determine the changes due to concussion in a total of 45 male and female ice hockey players in Canada, at the beginning and end of the season, it was reported that the SWI sequence helped determine the severity of cerebral microhemorrhage foci and follow-up. In addition, it was found that the cerebral microhemorrhage burden of boys was higher than that of girls, especially in the first two weeks following concussion (14). In the case report of IM Asif et al. (2), the presence of cerebral microhemorrhages was demonstrated by SWI sequence in a university football player who suffered a concussion, and the risks and clinical significance associated with cerebral microhemorrhages in the young athletic population were not determined. It has been emphasized that the findings of current neuroradiological imaging in the management of sports-related concussions have potential benefits for the return to play. However, the importance of further research is urgent and cannot be underestimated. There are not enough SWI studies in the literature on TBI resulting from head traumas seen in football. In a comprehensive randomized prospective study involving four European countries, which examined head and neck injuries in children aged 7-12 years, it was reported that 39 of the total 791 injuries were head injuries and one was a neck injury. Head injuries were seen in the form of concussion, contusion, laceration, or abrasion, nasal fracture, and dental injury (15). Radiological imaging findings were not included because no imaging modality was used in this study. In the future, studies with SWI can show microhemorrhages in the brain that may occur in child athletes, leading to the implementation the necessary treatments in a timely manner. Our study is critical in terms of providing insight into this subject.

Study Limitations

Due to its unique focus on active professional football players, our study faced several challenges. First, the limited number of players in the top football league made it challenging to conduct MRIs. Second, we could only record official matches, despite the players' history of training and unofficial matches. Lastly, while SWI is a sensitive imaging technique, chronic bleeding may not always appear in the SWI sequence due to resorption over time, potentially leading to missed data. Another limitation of our study is the inability to evaluate the relationship between factors such as players' field positions, heading dominance, height characteristics, and SWI findings. These factors may be determinative, particularly in terms of the frequency and severity of head trauma, and should be considered in future studies.

Conclusion

SWI, a highly reliable method for detecting cerebral microhemorrhages, which is a severe form of TBI in active professional football players, has the potential to bring about substantial advances in the field. The study did not find increased microbleeding in football players compared to the control group, and this is a promising finding. To gain a deeper understanding of the efficacy of SWI, it is essential to perform imaging in large study groups of professional football players who have a high number of recurrent histories of severe trauma and are at risk of developing chronic traumatic encephalopathy. This could lead to substantial advances in preventing and treating TBIs in football, the most popular sport today, providing hope and progress in sports medicine.

Ethics

Ethics Committee Approval: The study was approved by the Local Ethics Committee of Selçuk University Faculty of Medicine (approval number: 2020/102, date: 04.03.2020).

Informed Consent: Informed consent forms were obtained from the participants and the procedure was carried out.

Footnotes

Authorship Contributions: Concept - M.Ö., K.D.; Design - M.Ö., A.B., K.D.; Data Collection or Processing - M.Ö., A.B., A. Bayr., K.D., H.C.; Analysis or Interpretation - M.Ö., A. Bayr., A.B., H.C.; Writing - M.Ö., A. Bayr.

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