

Possible Correlation Between Football Heading and Neurodegenerative Disease

Tianyi Liu*

Shenzhen College of International Education, Shenzhen, 518043, China

*Corresponding Author. Email: 1602887258@qq.com

ABSTRACT

Based on the similar study conducted by Lipton et al., Lisa Silbert and Dr William Stewart, this proposed study will address the correlation between football heading and neurodegenerative diseases like dementia. The experiment devised and mentioned in the passage utilizes the scientific method MRI and image analysis software REGION with strict screening in order to prove the possible relationship between football headings and dementia by focusing on white matter hyperintensity and ventricular cerebrospinal fluid.

Keywords: *Dementia, White matter hyperintensity, Ventricular cerebrospinal fluid, Football heading, Magnetic Resonance Imaging*

1. INTRODUCTION

There is growing fear that collisions when doing sports can in some extent damage people's brains. One circumstance that has incurred growing concern is from soccer headings. Headings is a major and indispensable component of soccer. It simply refers to the deliberate collision between players' heads and the ball either offensively or defensively. According to the Premier League official, in 2020-2021 season, some players performed high frequency headings like Tomas Souček, Harry Maguire and Chris Wood. Approximately, a professional player can have headings for over 1000 times a year including both matches and trainings, with the speed of the ball over 100 km/h under some circumstances. So theoretically, just like having powerful punches on their heads, frequent headings should greatly damage the brain of players.

Consistently, in reality more examples can be found. The prestigious English footballer Sir Bobby Charlton and his brother Jack Charlton, both legends in the English history, were diagnosed as dementia while Jack Charlton even passed away because of this disease. Portugal football icon Cristiano Ronaldo once suffered from severe concussion after a heading goal against AS Roma. In total, there are numerable similar cases, and many of the scientists doubt the coincidence of these upsetting news. More people are beginning to believe that headings can have some negative influences on people's cognitive abilities.

It's now widely viewed by people that the large number of headings occurred in matches and trainings endangers players' health, while this phenomenon, in most cases a degeneration of memory with dementia in severe cases, becomes increasingly common. An increasing number of former professional players have been diagnosed as a variety of dementia. Dementia is actually a rather general term describing the impaired ability to think, recognize, remember or make decisions that interferes with daily routines and activities. In fact, there are varied types of dementia that may have distinct causes and conditions. Alzheimer's disease is the most commonly seen dementia disease among the older generation. It is usually due to some kind of alteration in brain, which includes abnormality in proteins. Lewy body dementia is a form of dementia caused by abnormal deposits of the protein alpha-synuclein. Resulted from blood vessel injury in brain and interruption of blood flow and oxygen to the brain, vascular dementia is another kind of the disease. While frontotemporal dementia is a relatively rare form of dementia that tends to occur in a younger generation. Abnormalities in tau protein and TDP-43 may relate to it. Definitely, there can also be some random combination of dementia which is named mixed dementia [1]. This is the identical category with the one Dennis Law, the well-known Manchester United legend, was diagnosed as recently [2].

To act against the negative consequences resulted from frequent headings and to protect players, there have already been guidelines in some professional league and

clear restrictions as well. For example, the Premier League has announced a heading guidance which will be virtually applied to the clubs from 2021-2022 season [3]. In the guidance, there has included some strict rules about the number of strong headers players can experience. What's more, it is suggested that clubs develop player profiles that include some detailed information about the players' health. These profiles can be used to ensure that all heading training demands reflect the type and quantity of headers that a player could expect to undertake within a match. To make sure that they have suitable and appropriate time to recover from their heading exposure, it is suggested that club workers should work with players after games.

Led by the discoveries, scientists also became gradually more interested in the area of football headings and dementia. An increasing number of experiments have been designed and conducted by scientists to figure it out, as it has been proved to be somehow controversial [4]. Nadav Amitay stated that football was a low-risk sport, with the cognitive symptoms possibly associated with low adaptability or deficient heading technique [5]. While conversely, scientists like Michael Lipton reached a discrete conclusion about the correlation between frequent headings and lower fractional anisotropy (FA) at specific locations in temporo-occipital white matter by the help of diffusion tensor MRI [6]. Tysvaer and Løchen has found out that a great percentage of the football players had a variety of deficits in tests of cognitive abilities (attention, concentration, memory, and judgment), compared to a relatively smaller proportion of the controls with a mild degree of impairment [7].

Nevertheless, considering the controversial statements and fluctuating opinions, no empirical evidence has managed to prove that there is a solid link between headings and dementia. After viewing and as well being inspired by the experiment of William Stewart, there appears to be some potential weakness or omissions considering the sampling and the technique used [8]. Consequently, this experiment aims to improve that to get a clearer perspective of this issue.

2. PROPOSED STUDY: HOW DO FOOTBALL HEADING (FREQUENCY) CORRELATE WITH PLAYERS' POSSIBILITY OF DEMENTIA?

The proposed study will mainly focus on the possible relationship between football heading and dementia. Frequency of heading will act as the independent variable while the possibility of dementia will be the dependent variable. The hypothesis for this study is that players with more heading frequencies tend to have greater chance of getting involved in dementia.

To explore the correlation between football heading and possibilities of neurodegenerative disease

(dementia), participants will be required to complete two written forms, one to rate the frequency of heading of participants, one to act as an additional/supplementary method to assess the extent of dementia. For the investigating the frequency of heading, a written questionnaire will be provided to the participants. In terms of the dementia indicator, the globally used Minimal State Examination (MMSE) will be used. Additionally, Magnetic Resonance Imaging (MRI) will also be a crucial aspect of this experiment in order to explore the possibility of dementia by focusing on cerebral white matter [9].

Stage 1 of the experiment aims to investigate the potential linking or the correlational relationship between the independent variable and dependent variable, which are the frequency of heading and the possibility of having dementia. Then, stage 2 is also proposed, which on the other hand focuses on a stronger and clear view of the variables. Participants will be arranged into different groups according to distinct independent variable levels and look for the solid conclusion.

With the ethical requirements of an experiment, it is necessary to obtain potential participants' informed consent. Since this study may cause panic and anxiety among participants due to the use of MRI, they will be provided with enough information about the experiment which enables them to decide whether or not to participate. In addition to that, the whole purpose of this research will be explained to the participants after the experiment, making sure that the experiment won't lead to any mental or physical harm to them.

3. METHOD

3.1 Participants

In this experiment, 250 participants in total, all aged 45 and over. The Player group contains 200 participants that have previously played in the professional leagues in England or Scotland. Players should at least participate for 5 years in the first team of the club and should have the aggregate training age for at least 20 years. On the other hand, 50 people without any experience of playing football will be recruited to act as the Nonplayer (control) group.

3.2 Screening

In order to include subjects who were more representative of the general population as well as improving the experiment's validity and generalizability, a genetic test should be carried out to make sure there's no hereditary source of dementia in the family since genetics play a major role in the diagnosis of dementia. In other words, there should be no patients of dementia within the three generations of participants. Participants

will also complete a medical history test and underwent the Mini-International Neuropsychiatric Interview to exclude subjects with psychiatric disorders. Participants will take a test called Mini-mental State Examination (MMSE). It contains 30 questions and acts as a professional and authoritative role in assessing cognitive impairment and neurodegenerative disease (dysfunction in thinking, communication, understanding and memory) [10]. The MMSE test contains a number of questions about cognition and memory. They are scored on a 30-point scale, with above 25 as normal and below as abnormal (have mental impairment). Participants who score under 25 will be filtered out.

4. STAGE 1

4.1 Procedure

Since this experiment focuses on the cognitive abnormalities of the participants, it is necessary to find a way to determine the disease or the symptoms. Fortunately, Lisa Silbert has already proposed a way for the study. She investigated the relationship between the acceleration of white matter hyperintensity (WMH) and ventricular cerebrospinal fluid (vCSF) volumes burden and cognitive impairment (MCI). In her words [9], the sheer increase in WMH and vCSF burden, a common indicator of cerebrovascular disease in the elderly, is a pathologic change that emerges early in the presymptomatic phase leading to MCI.

Thus, participants will take a brain Magnetic Resonance Imaging (MRI) test. It is a test that uses strong magnets, radio waves and a computer to form a digital graph of the structure of people’s brains. In this experiment, I will specifically aim to find out the differences of participants in cerebral white matter. Grey matter and white matter together comprise the main section of the human brain. Performing the role of a signal transmitter from one region of the cerebrum to another and between the cerebrum and lower brain centers, white matter is largely made up of glial cells and myelinated axons. The participants will then be taken part into a follow-up study to test the acceleration of WMH and vCSF.

5. STAGE 2

5.1 Procedure

For the second experiment, all participants were divided into three groups by their frequency of heading. They firstly need to fill up a form or a questionnaire about the frequency of games they participated in throughout the year and the frequency of headings. Possible questions include: “How many months did you play soccer during the previous 12 months?” and “How many times do you hit the ball during a typical

competitive game?” (See Figure 1). This form was also carried out by Michael Lipton which largely proves the validity of the method [6]. Moreover, according to existing data, defenders and strikers have a relatively higher frequency of heading compared to midfielders, with goalkeepers having the least possibility of getting involved in the heading. Consequently, the total population of participants in Experiment 1 would be divided into three groups, one (High) consists of defenders and strikers, one (Medium) consists of midfielders, and one (Low) consists of goalkeepers. These are the two main aspects of arranging the participants.

Question Identifier	Question
A	How many months did you play soccer during the previous 12 months?
B	How many times per week do you practice?
C	How many times do you head the ball during a typical practice session?
D	How many times per week do you play a competitive game?
E	How many times do you head the ball during a typical competitive game?

Figure 1 Questionnaire about the frequency of heading.

The procedure of stage 2 will be exactly the same as the one of stage 1. The participants will be asked to carry out an MRI test that specifically focuses on WMH and vCSF.

5.2 Application of MRI

Briefly, I will apply the same MRI conditions as the one Lisa (2012) [9] did. A 1.5 Tesla magnet will be used for the scans. The protocol consists of slice thickness of 4 mm (no gap), 24 cm field of view with a 256 × 256 matrix (0.86 mm × 0.86 mm pixel size) and 0.5 repetitions per sequence. The brain will be visualized in 2 planes using the following pulse sequences: 1) T1-weighted sagittal images centered in the midsagittal plane with the pituitary profile (including the infundibulum) and cerebellar vermis clearly delineated: repetition time (TR) = 600 msec, echo time (TE) = 20 msec images; 2) multiecho sequence T2-weighted (TR = 2,800 msec, TE = 80 msec) and proton density (TR = 2,800 msec, TE = 32 msec) coronal images perpendicular to the sagittal plane.

5.3 Analysis of data

Professional image analysts will assess the images of participants completely without any awareness of the outcome of cognitive testing. Image analysis software REGION is used to quantitatively assess regional brain volumes of interest. Pixel areas will be added up for all slices and turned into volumetric measures by multiplying by the slice thickness for regions of interest including total WMH, vCSF, and hippocampal volumes. To quantify the data, this work will use the same method Lisa did, which is the results of the Player group and Nonplayer group will be compared and analyzed. NLMIXED will be used to determine the location of the change point with respect to the timing of MCI conversion. The percentage of increase of WMH and vCSF before and after the change point will be calculated by Lisa's method and the acceleration will be presented clearly then.

6. Prediction

In this study, the participants will be assessed for the MRI image focusing on the white matter hyperintensity and ventricular cerebrospinal fluid. As shown in Figure 2, the participants of the Nonplayers group would probably have a smaller acceleration of WMH and vCSF than that for the Players group. For stage 2, the acceleration for the High group will be possibly higher than the value for the Medium group and likewise for the Low group (See Figure 3). Since the acceleration of WMH and vCSF can act as a trustful indicator of MCI, the ones with a higher value tend to possess a greater likelihood of dementia. Consequently, participants with a higher frequency of heading may have a higher possibility of having dementia from the perspective of white matter.

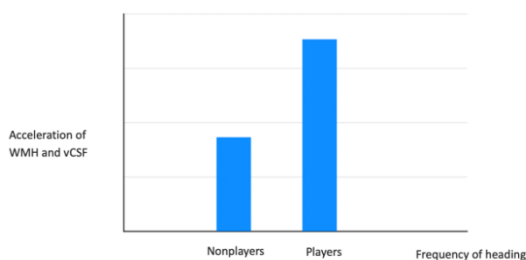


Figure 2 Prediction of the study (1)

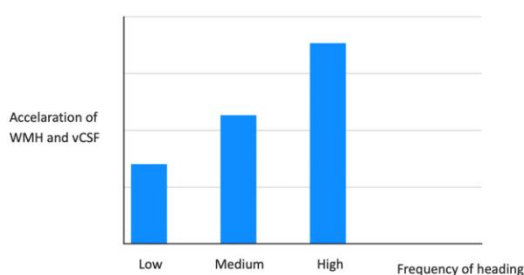


Figure 3 Prediction of the study (2)

7. CONCLUSION

If the results of the study support the experimental prediction, then I can reach a conclusion with a positive correlation between the frequency of heading and the possibility of neurodegenerative disease, that the more frequent a player experiences football heading, the larger possibility for him/her to get dementia.

Alternatively, if the results don't support the prediction, that the frequency of heading doesn't clearly affect players' chance of getting dementia, I will have to conclude that there's no correlation between the independent variable and dependent variable in this experiment. Also, if there appears to be an opposite outcome as I hypothesized, I will conclude a negative correlation between the frequency and the cognitive impairment.

From other perspectives, scientists like Vann Jones SA have raised some novel and promising ideas like that the cognitive impairments are actually reversible or that heading may be less deleterious as people thought [11]. This could be a possible explanation that may account for this topic.

For further investigation in this field, I'd like to raise the idea that this issue may differ by gender or age. Males and females may have different possibilities in having dementia due to the different intensity of the game and resilience to heading. Ages may also be a determining factor [12]. This may be a path that scientists need to work on in the next few decades.

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