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A Preliminary Study of Early Onset Dementia of Former Professional Football and Hockey Players

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Abstract

Objective—To provide an overview of three studies of the same population of retired professional contact sport athletes compared with age-matched non-contact sport athlete controls on cognition, executive function, behavior and advanced brain imaging.

Setting—University Concussion Management Clinic

Participants—Twenty two retired professional hockey and football athletes (average age 56) and 21 age-matched non-contact sport athlete controls.

Design—Case-control

Main measures—Participants were assessed on a broad range of neuropsychological measures that are associated with identification of Mild Cognitive Impairment (MCI) and executive function. Athletes were also assessed using self-report measures of executive function and personality. Advanced structural and functional imaging techniques were utilized as well.

Results—The former NFL and NHL athletes perceived themselves to have impaired executive function but this was not confirmed by objective neurocognitive assessment. No significant differences were found when comparing contact-sport athletes to controls on the presence of MCI or brain structural and functional tissue injury. Contact sport athletes were more anxious and more likely to report unusual beliefs and experiences.

Conflict of interest:
Robert Zivadinov received personal compensation from EMD Serono, Novartis, Celgene, Genentech, Claret Medical and Sanofi-Genzyme for speaking and consultant fees. R. Zivadinov received financial support for research activities from Biogen Idec, Teva Pharmaceuticals, Sanofi-Genzyme, Novartis, Claret Medical and Coherus-Intekrin. Other investigators report no conflicts.

Conclusion—None of the retired contact sport athletes qualified as having early onset dementia consistent with Chronic Traumatic Encephalopathy (CTE). There were no remarkable differences in imaging, cognition, behavior or executive function from non-contact sport athletes. The results underscore an apparent disconnect between public perceptions and evidence-based conclusions about the inevitability of CTE and the potential neurodegenerative effect on former athletes from contact sports.

INTRODUCTION

Chronic Traumatic Encephalopathy (CTE) is a neurodegenerative disorder characterized by abnormal accumulation of hyperphosphorylated tau protein within the brain.[1] It is suspected that CTE is linked to a history of concussive or sub-concussive blows that occurs with athletes who play sports with a high level of physical contact (e.g., American football and ice hockey) and members of the military who experienced multiple blast injuries.[2] Omalu et al. [3–5] is credited with bringing recent attention to this disease by publishing in 2005 the first case report of a fifty year-old former National Football League (NFL) athlete who suffered from deficits in memory and judgement. Subsequently, McKee et al. [6] in 2009 described CTE in three more cases of former athletes. Later, McKee et al. [7] described post mortem analysis of 85 former NFL and National Hockey League (NHL) athletes with a history of repetitive mild traumatic brain injury (mTBI) ranging in age from 17 to 98 and found 65 (76.5%) had CTE.

Although it is agreed that post-mortem analysis is currently the only way to definitely diagnose CTE[8], there are varying opinions regarding the degree to which the presence of tau protein represents trauma-induced CTE versus normal deposits as a result of age and other life factors.[9] Gardner et al.[10] reviewed the 85 cases described earlier by McKee et al. [7] and found only 15 cases, instead of 65, met a more stringent criteria of CTE. The National Institutes of Health held a consensus meeting in 2016 with the aim of defining the neuropathological criteria for the diagnosis of CTE.[11] Seven neuropathologists blindly evaluated 25 cases of various tau proteinopathies including CTE and a number of dementing brain diseases that are characterized by excessive tau. The results demonstrated reasonably good agreement among the neuropathologists; and, the group was able to add greater specificity to the description and, therefore, the diagnosis of CTE.

The most recent research publication by Mez et al. [12] on the association of CTE and football reported that of 111 NFL players, 110 (99.1%) showed evidence of CTE upon post mortem examination. In the total sample of 202 high school, college, and professional football players, various degrees of CTE were diagnosed in 177 of these players (87.6%). All of the athletes represented in the study had their brains donated to the brain bank at Boston University. The authors also provide a discussion of ascertainment bias; simply stated, families of individuals with cognitive deficits are far more likely to donate the brain of their deceased family member for study. Thus, the results may not be representative of the entire population. Still, research to date on CTE based on pathological studies has been interpreted to imply that all athletes who played contact sports professionally have a high probability of eventually experiencing CTE. The subject of CTE has received major public

attention,[9] including a movie about Dr. Omalu and the resistance of the NFL to accept that concussions could have long-term deleterious effects.

Nevertheless, controversy continues to surround the clinical manifestations of CTE, i.e., what are the patterns of behavior and cognitive deficits experienced by the living individual affected by CTE? The study by Mez et al. [12] included detailed, blinded retrospective evaluations of the 111 subjects for whom standardized informant reports had been collected. The results indicated a progressive clinical course was common in 85% of mild cases of CTE and 100% of severe cases. Gavett et al.[13] conducted interviews of friends and family members of people who had documented CTE. They described a consistent pattern of impairment in cognition, executive function, mood, behavior (impulsivity) and signs of motor neuron disease. Stern et al.[14] conducted a similar retrospective analysis of 36 deceased athletes—average age of death 56.8 years—with confirmed CTE (mostly former NFL athletes and a few former NHL athletes). Three of these athletes were asymptomatic, 11 had cognitive dysfunction, 13 had behavior alterations that gradually became mood changes, and 10 were diagnosed with dementia. Using next-of-kin interviews, Alosco et al. [15] studied 25 professional football players (mean age at death = 65 years) with autopsy confirmed stage III or IV CTE. They found that all 25 of 25 had cognitive symptoms and their age of cognitive decline was inversely related to their cognitive reserve. However, this study did not compare athletes with a control population.

Two studies published in 2017 found very limited evidence of abnormalities consistent with dementia among contact sport athletes. Esopenko et al.[16] studied 33 former professional ice hockey players, average age 54, and compared them with 18 age-matched controls. They found very few differences on a full range of cognitive measures and no differences on critical cognitive factors like memory. Interestingly, they found the athletes performed much better on all of the measures of cognition than the athletes expected they would perform. McMillan et al.[17] examined a sample of 52 former international rugby athletes, average age 53, and 29 age-matched controls. They also found minimal differences, the primary exception being that the athletes did poorly on one test of verbal learning. Importantly, the mean scores for both groups on almost every measure of cognition were in the average range for age and there were no differences in mental health or daily functioning between the retired athletes and the control group.

Since previous post-mortem pathological studies have been interpreted by the public as implying that almost all contact sport athletes have, or will have, some form of CTE, the purpose of the current study was to examine a cohort of living former professional athletes from high contact sports and compare them to a control group of high level athletes who did not play contact sports. It was important to our goals to provide a comprehensive assessment of cognitive function, executive function, mental health, physical health and advanced imaging in search of objective biomarkers for the development of CTE. We also studied their diets, lifestyles, drug and alcohol history, and cardiovascular risk factors to assess possible confounders.

The extensive nature of the assessments conducted on our participants dictated the need for at least three papers to present the three primary facets of the study: (1) cognitive

impairment and rates of Mild Cognitive Impairment (MCI) and the risk factors, (2) executive dysfunction and mental health, and (3) advanced brain imaging findings. Based on an initial round of review, a fourth paper (the current article) was proposed to provide an overview of the study and address details of the study participants. The reviewers stated that an overview paper should describe the participants in greater detail and confront what they outlined as a critical concern, namely the possibility of selection bias in our recruitment of contact sport athletes. The purpose of the current paper is to provide a detailed description of the participants and a general summary of findings and conclusions.

METHODS

Participants

We approached the local NHL and NFL alumni associations with the purpose of recruitment. The athletes voiced a number of concerns, not the least of which was the fact that it was researchers who were quoted regularly in the media describing CTE with little apparent concern for the athletes who are still alive. We tried to assure local NHL and NFL alumni association representatives that we would be objective and would have regular contact to allay their fears and benefit from their wisdom. We attended a number of their fund-raising and social events. We had two representatives of the alumni associations attend our planning committee meetings and they regularly offered suggestions for other issues to consider. Alumni members were then contacted by newsletters and emails from their leadership and urged to participate in the study.

The alumni associations were interested in our study because they had been reading research and stories in the press regarding the incidence of CTE; and; while they generally wanted us to assess the former players for cognitive and behavioral issues, they were also quite anxious about the impact of the findings on their members. In response to these concerns, once all assessments were completed on an individual we gave participants the option to receive individual feedback on the state of their physical and mental health along with suggestions from our clinical team regarding treatment. In the end we had 27 former NHL/NFL volunteers agree to participate.

Of the 27 former professional athletes 22 were included in the studies. There were 20 participants that completed every questionnaire, every neuropsychological examination, the physical examination and the advanced imaging. There was one former NHL athlete that did not complete the MRI (due to claustrophobia) and one former NFL athlete that completed the MRI but did not complete all of the questionnaires. Thus the imaging study had 21 former contact sport athletes (8 NFL and 13 NHL) and the executive function and Mild Cognitive Impairment studies had 21 former contact sport athletes (7 NFL and 14 NHL).

We were concerned that those who participated in the study be as representative as possible of the alumni members as a whole. We discussed this issue with the alumni representatives and there appeared to be two groups of alumni members that did not participate. One was a small group of alumni who were physically unable because of health conditions such as cardiovascular ill health, kidney disease or stroke. The second group of non-participants was

those that have significant public presence. This included athletes currently associated with a professional team as a coach, manager or team representative.

One important issue for our study was determining the characteristics of the most appropriate comparison group. The lack of a control group has been a common criticism of prior research.[18] Hence, after considerable discussion we decided to compare our professional contact sport athletes with athletes who did not play contact sports. Athletes have been described as extroverted, tough minded, and (sometimes overly) aggressive.[19] We thought that by having a comparison group of athletes who did not play contact sports it would control for some of the personality traits that may make athletes, as a group, different from the general population.

The non-contact sport athletes were contacted through associations of athletes such as running and swimming clubs that included older athletes on their roster. These master athletes were involved in individual, non-contact sports since their youth and at the time of enrollment. It was not a deliberate choice to recruit control group participants who were currently active in sport, but we did not know how to systematically contact athletes who were no longer participating in sport. Thus, the health status of the control group may have benefitted from their current state of physical fitness.

Inclusion and Exclusion criteria

Inclusion criteria for contact sport group (Athletes) were players who (1) played professional contact sport (NFL, NHL) for two or more seasons; (2) currently retired; and (3) aged 36 to 72 years. Exclusion criteria included (1) medically unsafe to receive an MRI, with implants or medical devices contraindicated for MRI; (2) history of concussion in the past two years; (3) history of moderate to severe brain injury from any cause; (4) history of cerebrovascular event that could lead to hypoxia; and (5) history of learning disability. The control group inclusion criteria were (1) master athletes who participated in individual non-contact sports such as running, cycling, or swimming since their youth; (2) aged 36 to 72 years; and (3) no history of self-reported or documented concussions. Exclusion criteria were the same as contact-sport athletes.

Procedure

A multi-disciplinary team of researchers volunteered to participate in the design of the study. The faculty were divided into six teams: (1) Lifestyle (nutrition, smoking, drug and alcohol history, activity); (2) Physical Health, (development of a physical exam; measures of important aspects of physical health such as sleep and pain); (3) Psychological Assessment (depression, anxiety, mental health, executive function, aggressiveness); (4) Cognition (various aspects of memory and attention, visual spatial orientation, intelligence, verbal skills); (5) Imaging (determining the neural structures, hemodynamic and neuro-metabolite concentrations in the brain of prime concern and the methodology to best assess for dementia); and finally (6) Research Methods (determining how the assessment procedures will be carried out and how to reduce redundancy). An Executive Committee was made up of the principal investigators and leaders of each team.

Each team produced a long list of variables of interest and a similarly long list of measures to assess each of the variables. The Cognition team was greatly aided by the Boston University team[12] who shared their entire list of cognitive measures being employed as part of their ongoing investigation of CTE. Although our study did not include all of the cognitive tests of the Boston University team, we were able to select our measures with confidence that we could ultimately compare our results with theirs. The Executive Committee had final say as to which questionnaires would be employed based on the amount of time commitment we thought reasonable for each participant. The final protocol consisted of assessments that would require approximately two days to complete, not including MR imaging.

Executive Function

We compared participants on norm-referenced neuropsychological test scores in attention, memory, executive function, language, and visuospatial domains. At least two neuropsychology tests were included for each domain. For tests with more than one score per test, we included 2 to 5 primary scores for that test. We also used the Behavior Rating Inventory of Executive Function (BRIEF-A) which is a self report measure of aspects of behavior normally considered part of executive function.

Mild Cognitive Impairment

According to Jak. et al.[20], MCI can be diagnosed using several different criteria based on norm-referenced neuropsychological test scores in attention, memory, executive function, language, and visuospatial domains. The most frequently used is the Comprehensive criteria (two test scores below 1 standard deviation (SD) in one domain or one test score below 1 SD in 3 domains). To validate our findings, we also used the Typical criteria (one test score below 1.5 SD in one domain), which is also frequently used.[20, 21] The results for both criteria were similar so only the results from the Comprehensive criteria are presented.

Advanced Imaging

Magnetic Resonance Imaging (MRI) was used to assess the multimodal conventional and non-conventional MRI measures reflective of neural structure, hemodynamic and neuro-metabolite concentration impairment in the brain, on a 3T scanner. The following sequences were acquired: proton density/T2-weighted image; Fluid-Attenuated Inversion-Recovery; 3D high resolution T1-WI using a fast spoiled gradient echo (FSPGR) with magnetization-prepared inversion recovery pulse (3D HIRES), diffusion-weighted imaging, susceptibility-weighted imaging, magnetic resonance spectroscopy (MRS) and perfusion-weighted imaging (PWI).

Image analysts were blinded to the subjects' demographic, clinical characteristics and group status and included: detection of white matter signal abnormalities, calculation of global and regional brain atrophy measures, measurement of diffusion-tensor imaging tract-based-spatial-statistics measures of mean diffusivity and fractional anisotropy, assessment of cerebral microbleeds and quantitative susceptibility mapping values in various brain structures, measurement of neuro-metabolites in the corpus callosum, such as N-acetyle aspartate, glutamate and glutamine, relative to the concentration of creatine and phosphor

creatine on MRS, and calculation of perfusion cerebral blood flow, blood volume and mean transit time within examined brain regions using PWI.

General and Mental Health

To account for possible confounders, we assessed cardiovascular risk factors including history of hypertension, diabetes, and smoking; and drew blood for complete lipid panels. We also assessed their demographics, education, diet, lifestyle, alcohol and drug history, and energy expenditure. Physical activity was assessed using the Yale Physical Activity (Interview) Survey[22] that provides an estimate of the kilocalories expended during the average week. Mental health was assessed using the Beck Depression Inventory-II (BDI) [23] and Beck Anxiety Inventory (BAI)[24] and the Personality Inventory for DSM-V (PID-5)[25]. All are validated self-reported questionnaires.

Concussion History

As part of our data collection we interviewed participants regarding their history of concussion. We were interested in the relationship between the number of concussions endured during their playing career and their current state of cognition and mental health. This part of the assessment process with the former NFL/NHL athletes became lengthy and we faced a dilemma. The athletes often used the question to describe how concussion was perceived during their playing careers. Generally, there was no medical assessment for the player who ‘had my bell rung’ and players often did not report symptoms because it could interfere with playing time. Some athletes then told stories of concussive effects that would last for weeks and how they hid their symptoms from team medical staff and other team members. They also described instances where they were not sure the hit to their head qualified as a concussion or whether the symptoms may have been from something else, like dehydration or a neck injury. While all of the contact sport athletes could be said to have experienced concussive events we concluded that it would be impossible to obtain an accurate and useful assessment of concussion history that was consistent across players. In the end, we decided that retrospective recall of events involving repeated blows to the head that occurred decades ago was so inaccurate that we had no confidence in determining the number of concussions for one athlete versus another. We decided to exclude these data altogether.

Statistical Analysis

According to the systematic review and meta-analysis by Karr et al.[26], an estimated effect size of 0.80 was used for the power analysis for the studies. Based on that analysis and an expectation that athletes will perform worse than controls, in order to achieve a power of 0.80 with a one-sided two-sample t-test at level 0.05, a total of 20 participants in each group was required. Ultimately, to ensure that we would discover an unexpected result (that is, contact sport athletes performing better than the non-contact sport athletes), all statistical tests were two-sided tests and in the case of t-tests an assumption of unequal variances was employed.

In this overview paper, we compare the demographic and clinical characteristics between the contact sport athletes and non-contact controls using two sample two-sided t-tests with

unequal variance (level 0.05) for continuous variables, Fisher's exact test for 2×2 tables (level 0.05) and Chi-squared tests for larger contingency tables (level 0.05). When possible, significant confounding variables such as IQ in the MCI paper are accounted for in each paper. In addition, each of the three papers contain its own statistical analysis section detailing the data analysis for the corresponding variables in that paper. In these papers, upon the advice of the statistical reviewers, we did not control for multiple comparisons (MC) because differences between the groups may be lost due to the conservative nature of MC adjustments. Thus, by not adjusting for MC we increased the likelihood of finding significant differences between the groups. We also present estimated confidence intervals and effect sizes whenever appropriate so that the readers could evaluate whether a finding or non-finding was sufficient to draw a conclusion.

RESULTS

Demographics and clinical characteristics

Table 1 presents demographic and clinical characteristics of the study groups. A total of 27 former NFL and NHL players volunteered and provided informed consent. From the pool of 27 volunteers, five participants were excluded because of difficulty completing the testing process and 1 participant was excluded because he had a serious brain injury from a motor vehicle crash that was only revealed during testing. Hence 22 male professional contact sport athletes (8 NFL, 14 NHL) comprised the contact sport athlete group. Twenty-one contact sport athletes participated in the imaging study (8 NFL, 13 NHL) and 21 contact sport athletes participated in the study of executive function and Mild Cognitive Impairment. The average playing career was 8.5 years and all played for at least two professional seasons at the highest level (NHL or NFL). Twenty-four non-contact sport athletes volunteered to participate but 3 did not complete all questionnaires and were therefore considered drop-outs. Hence 21 male non-contact sport athletes comprised the non-contact control group. There were no significant differences between contact athletes and non-contact controls for age and ethnicity. However, contact athletes had significantly higher body-mass-index compared to non-contact controls (30.1 vs. 24.5, $p<.0001$). There was also higher education in non-contact controls vs. contact athletes ($p=.024$). No significant differences between the study groups were found for current or past smoking, alcohol or drug abuse, although frequencies were somewhat higher in the contact athletes. There was a trend for more frequent current smoking in contact athletes compared to non-contact controls (4 vs 0, $p=.025$).

The physical exam results revealed important differences between the two groups. Eighteen of 22 contact athletes had significant sleep disturbance. Sixteen of the 22 contact athletes had surgery due to injuries sustained while playing sport. Four contact athletes had replacement body parts like knees, hips or shoulder. Nineteen contact athletes reported chronic pain that was confirmed during the physical examination. In contrast, only one of the non-contact controls complained of chronic pain and one complained of moderate, periodic pain. One of the non-contact control participants described sleep difficulties. The non-contact sport athletes were almost twice as likely to participate in exercise and expended significantly more kilocalories per week compared to the contact sport athletes. It should be

noted that all differences found between the groups would tend to bias toward lower cognitive functioning in the group of contact athletes.

All participants were given the opportunity to meet with the clinical team (the physician who completed the physical exam, the neuropsychologist who oversaw the administration of the cognitive testing and a general psychologist who was familiar with the psychiatric screening results). None of the non-contact control group participants chose to meet with the clinical team. The opposite was true for the contact sport athletes who all chose to receive feedback on their results. Most of the athletes were informed about services available for sleep disturbance and pain management. Occasionally there was a different specific disorder for which there was referral to a specialist.

The results of the specific sub-studies are provided in detail in the accompanying articles. The study of executive function and behavior indicated that contact athletes perceived themselves to have issues with working memory and overall rated themselves more poorly on executive function compared to the non-contact controls. However, spousal ratings of both groups were indistinguishable. As well, objective findings of factors associated with executive function revealed no differences between the groups, even for working memory.

The study of cognitive function and MCI also demonstrated relatively few differences between contact athletes and non-contact controls. The contact athletes had less education and lower estimated IQ. Despite a broad range of neurocognitive tests, there were only a few tests that showed that contact athletes were less capable: Letter Fluency and List B Immediate Recall. The study employed a set of comprehensive criteria and neurocognitive tests to classify participants as MCI, generally considered a possible precursor to dementia. The contact athletes were more likely to qualify as MCI (8/21) compared with Controls (3/21). These differences only showed a trend toward significance (p=.08) with the differences appearing to be primarily related to education, IQ, and BMI.

The results of the multimodal imaging study did not find neuro-metabolic, hemodynamic functional or structural differences on brain MRI. An analysis of the contact athletes with MCI also revealed no significant findings. Surprisingly, one of the few differences between the groups was the presence of cerebral microbleeds where more non-contact controls (N=7) than contact athletes (N=2) had at least one micro bleed. This difference only approached significance.

DISCUSSION

Perhaps the most important finding in this study is the fact that after completing extensive evaluation for cognitive function, executive function and mental health none of the former NHL or NFL athletes could be diagnosed with early onset dementia. We began this study assuming some, if not most of the former contact sport athletes would have dementia and we would use advanced imaging to confirm the MRI abnormalities, suggestive of CTE, based on previous literature.[27] Instead, our advanced brain imaging confirmed our findings that these former professional athletes were functioning according to their age in each of the facets being evaluated. Our non-contact sport control group turned out to be better educated

and in much better health than our contact sport athletes but we discovered they were not substantially different in most aspects of functioning except physical activity.

Reviewers for these studies expressed concern about the representativeness of the sample of former NFL and NHL athletes that volunteered to be a part of this study. The authors, Mez et al., of the post mortem study of CTE in former contact sport athletes expressed a similar concern about selection bias.[12] It would appear that former athletes who volunteered for our study worried about their mental state and wanted to know, for themselves, whether playing their sport professionally had left them disadvantaged. In contrast, the family members of those who donated brains to the brain bank at Boston University did so because they were convinced that there was something wrong with their family member. In our study, family members (mostly spouses) rated the function of the contact athletes more positively than the athletes themselves. We believe that our study participants represent former contact sport athletes who are alive and do not have dementia, whereas the athletes with CTE appeared to have dementia before they passed away. The participants in the current study were also a convenience sample; but one for which we would have expected a selection bias for worse functioning—if not when compared to the entire population of retired contact sport athletes, at least when compared to non-contact controls still participating in regular exercise.

In an effort to determine if our sample of participants was comparable to the sample found to have CTE we reviewed all of the publications on CTE and found they provide surprisingly little demographic information that is comparable. For example, they describe the numbers of years their sample played football but do not separate out the years played in professional football. We know the age at death of those who qualified as severe CTE (median age 71) but they do not report the age of death of those who played professional football. We know that our NFL athletes played an average of 4.4 years and the NFL players association reports that the average playing career today is 3.3 years. But the average career length during the era represented by most of our athletes was apparently more than what it is today, by one or two years. A survey of NFL alumni conducted in 2001 had a large sample (N=2552) and the average career length in their sample was 6.7 years.[28] It is our assumption that our sample is reasonably representative of those that played in the NFL in the era they represent. In contrast, the average career length for an NHL player is 5 years (according to the NHL Players Association) and the average career for our sample of former NHL athletes was 11.3 years. We are very confident that our sample of NHL athletes had average to above average exposure based on career length.

Our findings support the recent studies by Esopenko et al.[16] of former professional hockey players, and McMillian et al.[17] of elite rugby union players. These two studies, like our study, did not find evidence of dementia in retired contact sport athletes, suggesting that many of these athletes not only escape the horror of CTE but appear to have relatively normal lives. We believe our study had several important advantages over the Esopenko et al.[16] and McMillian et al.[17] studies. We used a clearly defined control group of athletes who did not play contact sport whereas the other studies simply used age-matched controls. We also used advanced imaging to confirm the brain health of the athletes. Finally, we think it was prudent to examine other factors in the lives of the former professional athletes. For

example, physical examinations demonstrated that these athletes had more significant problems with sleep disturbance and pain management than with cognition. The athletes that are experiencing MCI may have more to worry about because of obesity, chronic pain and sleep disturbance than they do with their history of playing a contact sport.

CONCLUSION

News coverage has given the public the impression that CTE is inevitable among professional contact sport athletes.[9] It is a picture that was reinforced by the post mortem analysis of brains of athletes donated to a brain bank. The results of our comprehensive investigation of a relatively small sample of former athletes do not support this notion. However, this study and similar investigations cited earlier do not provide argument against the existence of CTE but do suggest that the risk is not as great as once believed. The next steps in research should be to try to address the factors, genetic or otherwise, that make the risk of CTE for some athletes much greater than others.

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Table 1

Demographic and clinical characteristics of the study subjects. (a) Participants in the MRI study and (b) Participants in the Executive Function and MCI studies.

	Non-Contact Sport Athletes (N=21)	Contact Sport Athletes (n=21)	p-value
Age, mean (SD)	55.4 (9.3)	(a) 56.7 (9.5) (b) 56.2 (10.0)	(a) .654 (b) .881
Height in inches, mean (SD)	69.7 (2.3)	(a) 72.3 (2.0) (b) 72.0 (2.1)	**(a) .001** **(b) .001**
Weight in pounds, mean (SD)	169.9 (24.3)	(a) 218.7 (30.0) (b) 221.9 (29.9)	**(a) .001**
BMI, mean (SD)	24.5 (2.5)	(a) 30.1 (3.5) (b) 29.6 (3.6)	**(a) .001** **(b) .001**
Ethnicity, n (%)			
Caucasians	21 (100)	19 (86.4)	.232
African-American	–	3 (13.6)	
Education, n (%)			**.024**
High school	2 (9.5)	8 (36.4)	
Some college	0 (0)	4 (18.2)	
College degree	9 (42.9)	7 (31.8)	
Associate’s degree	2 (9.5)	2 (9.1)	
Post Graduate Degree	8 (38.1)	1 (4.5)	
Kilocalories per week	51 (15)	26 (19)	**.001**
Current smoker, n (%)	0 (0)	4 (18.2)	**.035**
Past smoker, n (%)	5 (23.8%)	8 (36.4%)	.317
Current alcohol abuse	0 (0%)	1 (4.5%)	.999
Past alcohol abuse	1 (4.8%)	6 (28.6%)	.093
Current drug abuse	1 (4.8%)	1 (4.8%)	.999
Past drug abuse	1 (4.8%)	4 (19.0%)	.343
Sport, n (%)			**<.001**
Football	–	8 (36.4)	
Hockey	–	14 (63.6)	
Running	12 (57.1)	–	
Cycling	6 (28.6)	–	
Triathlete	2 (9.5)	–	
Track & field	1 (4.8)	–	

The differences between the groups were tested using Student's *t*-test, Fisher's exact test or a Chi-squared test. In bold are shown significant p values.