An Exploratory Study of Mild Cognitive Impairment of Retired Professional Contact Sport Athletes

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Objective: To test the hypothesis that mild cognitive impairment (MCI) rates are higher among retired professional contact sport athletes than in noncontact athlete controls and compare history of contact sports with other MCI risk factors. **Setting:** University Concussion Management Clinic. **Participants:** Twenty-one retired National Football League and National Hockey League players and 21 aged-matched noncontact athlete controls. **Designs:** Case-control. **Main Measures:** Comprehensive criteria were used to assess MCI based on the following: Wisconsin Card Sorting Test, Delis-Kaplan Executive Function System; Trail Making Parts A and B; Wechsler Adult Intelligence Scale–Third Edition subtests; Neuropsychological Assessment Battery Memory Module List Learning, Story Learning, and Naming subtests; and Controlled Oral Word Association Test. The Wide Range Achievement Test was used as a proxy measure for IQ. Atherosclerotic cardiovascular disease risk factors were self-reported and blood cholesterol was measured. Depression was measured by the Beck Depression Inventory-II (BDI). **Results:** Eight contact sport athletes (38%) and 3 noncontact athletes (14%) met MCI criteria ($P = .083$). Contact sport athletes' scores were significantly worse on Letter Fluency and List B Immediate Recall. Contact athletes were more obese, had more vascular risk factors, and had higher scores on the BDI than controls. **Conclusion:** Athletes with a history of playing professional contact sports had more vascular risk factors and higher depression scores. MCI rates were somewhat higher, though not significant. **Key words:** *athletics*, *cerebral concussion*, *cognitive reserve*, *mild cognitive impairment*, *neuropsychology tests*, *risk factors*

MUCH ATTENTION has been given to chronic traumatic encephalopathy (CTE) as a cause of behavioral, mood, and cognitive changes among retired professional contact sport athletes. Other competing hypotheses for these changes have received less attention. Vascular, mood, and other disease etiologies leading to mild cognitive impairment (MCI) may explain some of the cognitive changes among aging professional athletes. A study using postmortem analysis shows that up to 99% of retired National Football League (NFL) players had CTE, with 71% having severe CTE, and it is suggested that MCI is present in CTE.[1] The definition of MCI has changed since its inception more than 20 years ago.[2] It is distinguishable from normal aging and may be a precursor to dementia.[3] A patient with MCI may be aware of cognitive difficulties and able to function independently.[4] The *DSM-V* (*Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition*) diagnostic criteria for mild neurocognitive disorder (a broader term that includes MCI) state that it includes a modest impairment in cognitive performance, preferably documented by standardized neuropsychological testing.[5]

Some studies of retired NFL players have not found evidence for cognitive, mood, and behavioral changes that would be consistent with CTE. Randolph et al[6] studied a subsample of 513 retired football players older than 50 years whose spouse completed a screening interview for MCI. They identified players with probable MCI and compared this group with age-matched

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healthy controls and a sample diagnosed with MCI. The cognitive profile of the NFL MCI group was milder, although similar to the profile of the clinical MCI group. There was no association between years of play and cognitive scores. They concluded that their results supported diminished cognitive reserve (process of adapting to deterioration by using cognitive processing resources to compensate for deficits) rather than CTE as an explanation for MCI.

Alosco et al[7] studied 25 professional football players (mean age at death = 65 years) with autopsy-confirmed stage III or IV CTE using next-of-kin interviews. They found that all 25 had cognitive symptoms and their age of cognitive decline was inversely related to their cognitive reserve. Unfortunately, this study did not compare the football players with a control population. Hart et al[8] studied 34 retired football players, aged 41 to 79 years (mean = 61.8 years), and found that 14 of 34 (41%) demonstrated cognitive deficits. Eight of 34 players were identified with MCI, which the authors note is slightly higher than the proportion in the general population but not significant. McMillan et al[9] studied mental health and cognitive functioning in 52 retired professional rugby players aged 53.5 years (range, 26-79 years) and compared them with age-matched healthy controls. Despite a high number of concussions in the rugby players, no differences in mental health or cognitive functioning were found later in life.

Other hypotheses for MCI in retired contact sport athletes have received less attention. Willeumier et al[10] studied 38 overweight and 38 healthy weight retired NFL players (mean age = 57 years; range, 25-82 years) and showed that players with higher body mass had significantly worse neuropsychological test scores than the healthy weight players. Hart et al[8] showed that differences in regional blood flow using arterial spin labeling in retired NFL players corresponded to regions associated with impaired cognitive performance. Other etiologies, such as depression, have been associated with MCI in the nonathlete population and may explain some of the cognitive changes among aging former professional athletes.[11,12] Because of the controversy present in the literature, we wanted to study a sample of retired professional contact sport athletes and compare them with noncontact sport athlete controls on rates of MCI, cognitive scores, and other etiologies of MCI such as vascular disease and depression. We hypothesized that the contact sport athletes would have higher rates of MCI, lower neurocognitive scores, and more vascular and depression risk factors.

METHODS

The current case-control study was completed as part of a larger study of retired athletes (see Willer et al[13]) at the University at Buffalo. Approval was obtained prior to the study from the University at Buffalo institutional review board committee.

Study participants

The contact sport athlete group was composed of former NFL and National Hockey League (NHL) players who were contacted and ultimately recruited through their respective local alumni associations ($N = 21$; mean age = 56.7 years). The noncontact athlete control group was composed of people who participated in noncontact sports ($N = 21$; mean age = 55.4 years) and were contacted through associations of athletic clubs that included older athletes on their roster. Detailed inclusion and exclusion criteria are presented in the *overview paper*.[13]

Measures

Neurocognitive measures

Executive function was assessed with the Wisconsin Card Sorting Test (WCST)[14] and the Delis-Kaplan Executive Function System (D-KEFS).[15] Five subtests for the WCST (perseverative, nonperseverative, and conceptual level responses, perseverative and total errors) and 2 subtests for the D-KEFS (inhibit and switch) were selected on the basis of their relevance to the long-term effects of multiple concussions. Attention was assessed with the Wechsler Adult Intelligence Scale–Third Edition (WAIS-III) using the Standardization Sample norms for Scaled Scores for the subtest of Digit Span[16] and the Trail Making Part A.[17] Memory was assessed with the Neuropsychological Assessment Battery (NAB) Memory Module including the 4 primary scores for immediate and delayed recall from the List Learning test and immediate and delayed recall for phrases for the Story Learning test, using the same parallel form across participants.[18] Language was assessed using the Controlled Oral Word Association Test (COWAT) and the NAB Naming test.[19–21] For the COWAT, the FAS form was used for phonemic fluency and the Animal Naming task was used to measure category or semantic fluency.

Finally, the domain of perceptual motor skills was assessed with the WAIS-III Scaled Scores for the Digit Symbol subtest[16] and Trail Making Part B.[17] IQ was estimated using standard scores from a proxy measure for IQ, the Wide Range Achievement Test 4 (WRAT-4) Word Reading achievement test.[22] Each of the scores for the tests noted earlier was converted to T-scores in order to provide a common metric for the subtests of each of the measures. All of the tests were performed under the supervision of the same experienced neuropsychologist.

Criteria for MCI

To define MCI, we used the Jak et al[23] publication, which provided several approaches to quantifying cognitive impairment that use test scores in multiple cognitive domains. The cognitive domains are based on norm-referenced neuropsychological test scores in attention, memory, executive function, language, and visuospatial domains. They recommend the Comprehensive criteria to classify individuals as having MCI or normal. The criteria include (1) 2 test scores below 1 standard deviation (SD) in 1 domain or (2) at least 1 test score below 1 SD in 3 domains. Subtypes of MCI have been based on test scores below 1 or 1.5 SDs in 1 domain versus multiple domains and in memory versus nonmemory domains. The 4 currently recognized subtypes include memory, 1 domain; memory, multiple domains; nonmemory, 1 domain; and nonmemory, multiple domains.[24,25] At least 2 neuropsychology tests were included for each domain. For tests with more than 1 score per test, we included 2 to 5 primary scores for that test.

Depression

Beck Depression Inventory-II (BDI-II) was used to assess depression in both groups. It is a validated 21-item instrument that rates depression in the following categories: none, mild, moderate, and severe.[26]

Vascular risk factors

Participants reported on vascular risk factors, including a history of high blood pressure, diabetes, smoking, elevated cholesterol level, and obesity. One or more vascular risk factors were compared with no vascular risk factors. Serum cholesterol levels and supine blood pressures were obtained. The Framingham Heart Study atherosclerotic cardiovascular disease (ASCVD) risk calculator was used to estimate the 10-year primary risk of ASCVD for people aged 40 to 79 years.[27] Patients are considered to be at "elevated" risk if the Pooled Cohort Equations predicted risk is 7.5% or more.[28] The factors used in calculating risk include age, gender, race, total cholesterol, high-density lipoproteins (HDLs), systolic blood pressure, diastolic blood pressure, history of high blood pressure, history of diabetes, and smoking.

Statistical analysis

According to the systematic review and meta-analysis by Karr et al,[29] an estimated effect size of 0.80 was used for the power analysis. On the basis of the computed power analysis, the results indicated that to achieve a power of 0.80 with a 1-sided test at level .05, a total of 20 participants in each group were required. Independent 2-samples t tests were used to compare neuropsychology test scores in each of 5 domains between the contact sport athletes and noncontact sport athletes, with statistics, P value, Cohen's d effect size, and 95% confidence interval, are reported. Most of the normative reference scores for the neuropsychology tests included adjustment for education, with the exception of one measure in each of the attention, executive function, and visuospatial domains. Since IQ and education (and therefore cognitive reserve) were significantly different between contact sport athletes and noncontact sport athletes, we compare neuropsychology test scores in each of the 5 domains in a full model containing IQ and group as explanatory variables and a reduced model-only containing group as the explanatory variable with test score as response. The full model and the reduced model were compared using a partial F-test. Similarly, 2-samples t tests (unequal variation) were conducted to examine vascular risk factors, BDI scores, and MCI in athletes and controls. All analyses were performed using the R programming language.[30]

RESULTS

The neurocognitive test results are summarized in Table 1. Using a proxy measure of IQ, the WRAT-4 Word Reading achievement test standard score, the contact sport athletes scored significantly lower on this measure of estimated IQ ($P < .001$). Contact sport athletes did not significantly differ from noncontact sport athletes on most of the primary scores in the 5 domains. Only the Letter Fluency, NAB Naming, and List B Immediate Recall scores were significant, but after adjusting for IQ, only Letter Fluency ($P = .01$) and List B Immediate Recall ($P = .03$) were significant.

Table 2 presents contact sport athletes and noncontact athletes who qualified as having MCI along with self-reported vascular risk factors, BDI categories, and number of years played (only for the contact sport athlete group). Eight contact sport athletes (38%) versus 3 noncontact controls (14%) met the criteria for MCI ($P = .083$). Although close, this did not reach significance. Of the 8 contact sport athletes who met the Comprehensive criteria for MCI, 7 were considered as having memory MCI, multiple domains, and 1 was considered as having memory MCI, 1 domain. Of the 3 noncontact sport athletes who met the criteria, 2 were considered as having memory MCI, multiple domains, and 1 was considered as having nonmemory MCI, 1 domain. In a subanalysis of contact athletes, the number of playing years was not associated with meeting the MCI criteria ($P = .66$).

Table 3 presents the vascular risk factors and depression scores for contact sport athletes and noncontact sport athletes. The ASCVD risk for 1 contact sport athlete could not be calculated because he was 36 years old. Body mass index (BMI) ($P < .001$) and 1 or more reported vascular risk factors ($P = .005$) were significantly

TABLE 1 *Subdomains of neurocognitive measures associated with mild cognitive impairment using T-scores*

Domain	Primary variable	Contact sport athletes T-score, mean (SD)	Noncontact sport athletes T-score, mean (SD)	T-test score	*P*	Cohen effect (95% CI)	Intercept shift in contact athletes relative to controls	*P*[a]
Proxy IQ	WRAT Word Reading achievement test	49.29 (6.76)	57.57 (8.82)	3.44	.01	1.06 (3.43-13.2)		
Language	Letter Fluency (FAS Total Score)[b]	52.95 (10.98)	47.43 (6.83)	1.96	.06	0.6 (−0.03 to 1.24)	8.9742	.01
	Animal Naming Total[b]	49.95 (11.59)	49.14 (10.39)	0.24	.81	0.07 (−0.55 to 0.70)	− 2.3015	.55
	NAB Naming[c]	49.33 (8.49)	53.33 (1.68)	− 2.12	.05	− 0.65 (−1.29 to −0.01)	− 2.7477	.21
Visual-spatial	WAIS-III Digit Symbol[d]	55 (9.98)	53.38 (8.38)	0.57	.57	0.18 (−0.45 to 0.80)	2.6053	.43
	Trails B[e]	48.52 (23.06)	53.38 (9.95)	− 0.89	.38	− 0.27 (−0.9 to 0.35)	− 5.2625	.41
Attention	WAIS-III Digit Span[d]	54.9 (11.67)	57.33 (9.65)	− 0.73	.47	− 0.23 (−0.85 to 0.40)	0.5543	.88
	Trails A[e]	55.52 (13.12)	54.9 (10.2)	0.17	.87	0.05 (−0.57 to 0.68)	2.8804	.49
Executive function	D-KEFS Color-Word Interference Inhibitioh[d]	57.67 (4.64)	57.19 (8.29)	0.23	.82	0.07 (−0.55 to 0.69)	2.5044	.28
	D-KEFS Color-Word Interference Inhibition/Switching[d]	59.14 (5.86)	56.48 (8.1)	1.22	.23	0.38 (−0.25 to 1.01)	4.6449	.06
	WCST Total Errors[d]	49.43 (9.89)	52.45 (6.3)	− 1.17	.25	− 0.36 (−1 to 0.27)	− 2.9522	.33
	WCST Perseverative Responses[e]	49.95 (9.46)	51.3 (6.06)	− 0.55	.59	− 0.17 (−0.8,0.46)	− 1.2879	.66
	WCST Perseverative Errors[e]	49.95 (9.82)	51.75 (6.25)	− 0.70	.49	− 0.22 (−0.85 to 0.42)	− 1.5971	.59
	WCST Non-Perseverative Errors[e]	48.29 (9.74)	51.65 (6.76)	− 1.29	.21	− 0.4 (−1.04 to 0.24)	− 4.1909	.17
	WCST Conceptual Level Responses[e]	49.71 (10.35)	52.7 (6.33)	− 1.12	.27	− 0.35 (−0.98 to 0.29)	− 3.1447	.32
Memory	List A Immediate Recall[c]	54.48 (10.21)	56.71 (8.99)	− 0.75	.46	− 0.23 (−0.86 to 0.39)	− 2.6561	.44
	List B Immediate Recall[c]	50.9 (9.93)	57.24 (10.44)	− 2.01	.05	− 0.62 (−1.26 to 0.02)	− 8.2536	.03
	List A Short Delay[c]	53.48 (10.85)	57.33 (8.3)	− 1.29	.2	− 0.4 (−1.03 to 0.23)	− 4.2227	.23
	List A Long Delay[c]	56.1 (11.48)	59.38 (8.12)	− 1.07	.29	− 0.33 (−0.96 to 0.30)	− 2.2336	.53
	STL Phrase Immediate Recall[c]	41.71 (9.72)	45.57 (9.66)	− 1.29	.2	− 0.4 (−1.03 to 0.23)	− 3.9058	.26
	STL Phrase Delayed Recall[c]	45.1 (8.81)	48.19 (8.43)	− 1.16	.25	− 0.36 (−0.99 to 0.27)	− 2.2176	.47

Abbreviations: D-KEFS, Delis-Kaplan Executive Function System; NAB, Neuropsychological Assessment Battery; STL, Story Learning Trial; WAIS-III, Wechsler Adult Intelligence Scale–Third Edition; WCST, Wisconsin Card Sorting Test; WRAT, Wide Range Achievement Test-4.

[a]Adjustment for estimated IQ.

[b]Age, education, and ethnicity normative T-scores.

[c]Age, education, and gender normative T-scores.

[d]Age normative T-scores.

[e]Age and education normative T-scores.

TABLE 2 *MCI classification, reported VRFs, and AHA risk in contact sport athletes and noncontact sport controls*

Case no.	Contact sport athletes ($n = 21$)						Noncontact athletes ($n = 21$)				
	Sport	Age, y	MCI[a]	VRF[b]	BDI[c]	Years played	Sport	Age, y	MCI	VRF	BDI
1	Football	62	X	X	...	2	Running	72	X	X	...
2	Hockey	64	X	X	...	13	Running	49	X	...	...
3	Football	64	X	X	1	9	Cycling	61	X	...	...
4	Hockey	71	X	X	...	6	Running	57	...	X	...
5	Hockey	58	X	X	2	2	Running	42	...	...	...
6	Hockey	52	X	...	3	18	T & F	72	...	...	...
7	Hockey	36	X	...	...	2	Running	64	...	X	...
8	Football	69	X	X	...	2	Running	59	...	...	...
9	Hockey	45	...	X	...	19	Cycling	47	...	...	...
10	Football	72	...	...	...	5	Cycling	61	...	X	...
11	Hockey	45	...	...	...	16	Running	67	...	X	...
12	Football	71	...	X	...	2	Running	65	...	X	...
13	Hockey	50	...	X	...	9	Cycling	62	...	...	...
14	Hockey	66	...	X	...	15	Running	61	...	X	...
15	Hockey	59	...	...	...	13	Triathlete	61	...	...	...
16	Football	57	...	X	1	5	Running	59	...	X	...
17	Football	57	...	X	...	6	Running	55	...	X	1
18	Hockey	52	...	X	...	18	Cycling	45	...	...	...
19	Football	51	...	X	...	4	Cycling	45	...	...	...
20	Hockey	41	...	X	2	4	Triathlete	44	...	...	...
21	Hockey	40	...	...	...	12	Running	43	...	...	...

Abbreviations: AHA, American Heart Association; BDI, Beck Depression Inventory; BMI, body mass index; MCI, mild cognitive impairment; VRF, vascular risk factor.
[a]Comprehensive criteria: at least 2 test scores in 1 cognitive domain or 1 test score in 3 domains fall 1 SD below normative reference values, X = Yes, ... = No.
[b]Presence of 1 or more of BMI ≥ 30 (criteria for obesity), history of high blood pressure, diabetes, smoking, or high cholesterol, X = Yes, ... = No.
[c]... = minimal; 1 = mild; 2 = moderate; 3 = severe.

higher in contact sport athletes, and HDL cholesterol ($P = .017$) was significantly higher in noncontact sport controls. No other vascular risk factors were significantly different. Table 3 also presents the depression scores of the contact athlete and noncontact control groups as assessed by the BDI. The contact sport athlete group scored significantly higher ($P = .04$) than the noncontact control group in the BDI raw scores but were not significantly different ($P = .078$) when comparing minimal risk for depression (13 or below on the BDI) with mild depression or higher (14 or above on the BDI).

DISCUSSION

The purpose of our study of retired athletes was to extensively evaluate the cognitive and behavioral characteristics of athletes who had professional careers playing contact sports that may have left them vulnerable to CTE.[31–39] The research on CTE and extensive media attention have given the impression that most former contact sport athletes will experience early-onset dementia marked by cognitive impairment, although the high rate of findings of CTE occurred in a very selected population of athletes involved in contact sports. The former NFL and NHL athletes we recruited and evaluated in this study were convinced that early signs of dementia had already happened or was about to happen, which was their primary reason for participating in our study.

Contrary to expectations, our results provide little evidence of early-onset dementia. The control group, with whom the contact sport athletes were compared, were healthier due, in part, to their continued athletic activities, had better education level, had a higher estimated IQ, and had a reduced likelihood of dementia.[40,41] Despite the substantial advantage, we did not find many differences in cognitive abilities (except those that could easily be explained by the differences in education and IQ).

The rates of MCI were higher in the contact sport athlete group, but this did not reach significance. We found that 38% of our contact sport athletes had MCI versus 14% of our noncontact sport controls, which is similar to earlier studies[6,8,9] but lower than studies with similar sample sizes. Tremblay et al[42] found reduced

TABLE 3 *Contact sport athletes and noncontact sport athletes versus vascular risk factors and depression*

	Contact athletes ($n = 21$)	Noncontact athletes ($n = 21$)	P	Cohen effect (95% CI)
AHA/ACC risk				
Mean (SD)	14.11 (10.60)	10.36 (8.44)	.223	0.39 (−9.89 to 2.37)
Elevated risk[a]	70% ($n = 14/20$[b])	62% ($n = 13/21$)	.747	0.10 (−0.35 to 0.26)
Body mass index				
Mean (SD)	29.67 (3.64)	24.52 (2.55)	<.001	1.63 (−7.10 to −3.19)
Obese (BMI > 30)	42.8% ($n = 9$)	0% ($n = 0$)	<.001	1.19 (−0.65 to −0.21)
One or more reported VRFs	71.4% ($n = 15$)	42.9% ($n = 9$)	.005	0.57 (−0.59 to 0.017)
History of high blood pressure	38.0% ($n = 8$)	19.0% ($n = 4$)	.18	0.41 (−0.47 to 0.092)
History of diabetes	...	...	...	...
History of high cholesterol	9.5% ($n = 2$)	19.0% ($n = 4$)	.39	0.25 (−0.13 to 0.32)
History of smoking	33.3% ($n = 7$)	23.8% ($n = 5$)	.506	0.19 (−0.38 to 0.19)
Total cholesterol, mean (SD)	189.4 (30)	182.8 (25)	.44	0.24 (−23.8 to 10.5)
LDL cholesterol, mean (SD)	106.9 (39)	103.3 (33)	.753	0.09 (−26.0 to 19.0)
HDL cholesterol, mean (SD)	42.6 (8)	49.8 (11)	.017	0.76 (1.37 to 13.1)
Beck Depression Inventory				
Mean score (SD)	10.2 (8.1)	3.9 (5.3)	.004	0.92 (−10.6 to −2.09)
Mild depression or higher[c]	23.8% ($n = 5$)	4.8% ($n = 1$)	.078	0.59 (−0.78 to 0.025)

Abbreviations: AHA/ACC, American Heart Association/American College of Cardiology; BMI, body mass index; HDL, high-density lipoprotein; LDL, low-density lipoprotein; VRF, vascular risk factor.
[a]AHA/ACC risk 7.5 or more.
[b]One participant younger than 40 years.
[c]Fourteen or higher on the Beck Depression Inventory.

semantic verbal fluency and altered episodic memory on both delayed recall and recognition among a sample of 15 retired contact sport athletes aged 51 to 75 years. De Beaumont et al[43] found decreased episodic memory and response inhibition performance that correlated with slowed motor speed and delayed event-related potentials among 19 retired athletes compared with 21 controls. Stern et al[38] conducted a retrospective postmortem analysis of 36 athletes with confirmed CTE (mostly former NFL athletes and a few former NHL athletes). Three were asymptomatic, 11 had recognizable cognitive dysfunction, 13 had behavior alterations that gradually became mood disturbance, and 10 were diagnosed with dementia. Guskiewicz et al[44] found that more than 3 reported concussions resulted in a 5-fold increase in MCI among their sample of retired NFL players. Larger studies from the Boston University group have identified the range of pathologies of CTE. Postmortem analysis of professional NFL players suggest that almost every individual who plays contact sports will have cognitive impairment and develop CTE, but they also provide a cautionary note.[1] Simply stated, one cannot expect that an autopsy-based case series is representative of the total population of athletes who play contact sports since families of individuals with cognitive deficits are far more likely to donate the brain of their deceased family member for study.

When comparing other risk factors for developing MCI, we found that BMI, presence of 1 or more vascular risk factors, and depression score differences approached significance. HDL cholesterol was higher in the noncontact sport athletes. The higher BMI is easily explained by the fact that contact sport athletes were much heavier build,[45] and our noncontact athlete controls were currently active in aerobic activities. Both the contact sport athletes and noncontact sport athletes controls had vascular risk factors (71% vs 43%), but the contact athletes were significantly at a higher risk because of obesity. Although not significantly different, both contact sport athletes and noncontact sport athletes had a high risk of a cardiovascular event according to the Framingham Heart Study risk calculator. This could be due to the older ages of both groups, which is a strong modifier of vascular risk. HDL cholesterol is considered to be the "good" cholesterol and is associated with lower BMI and exercise, which was higher in the noncontact control group.[46]

Our rate of MCI among the athletes using the Comprehensive criteria (8/21 = 38%) was higher than that found in the Hart et al[8] study (8/34 = 24%), which the authors note was slightly higher than the general population.

There are a number of limitations of the current study. Most notable, we were unable to ascertain with confidence the number of concussions experienced by each athlete. The contact sport athlete group studied did play a substantial amount of time in their respective professional leagues, with an average career length of 8.7 years. Several of these athletes are Hall of Fame members. The years played do not account for the number of concussive or subconcussive hits directly, nor do they account for the years of contact and potential head injuries sustained in junior and college playing years. All members of the noncontact athlete group continue to remain physically active in their sports of cycling, running, or swimming. The continued physical activity is important, as physical activity has been shown to reduce the risk of developing dementia.[40,41] They also had higher education levels, which is an indicator of higher cognitive reserve. Also, the impact of head injuries on cognitive reserve is related to education[47] and our noncontact athlete control group had much higher education, on average.

We realize that studies that report no significant differences between groups are often underpowered to make such claims. However, when we began this study, we too were influenced by the media reports and reports of high rates of CTE among former NFL and NHL athletes. We hypothesized that these former contact sport athletes would be significantly impaired cognitively compared with an above-average noncontact group of athletes and concluded that the likelihood of type II error would be reduced. Still, our sample size is small and the study results need to be replicated. Future studies of retired contact sport athletes can continue to examine alternate influences on cognition with aging. Examples could include nutrition, exercise/activity, chronic pain, sleep disturbance, current and previous substance abuse, and a history of performance-enhancing drugs.

CONCLUSION

According to the results of our study, contact sport athletes do not have a significantly higher rate of MCI than age-matched noncontact sport control athletes. Other risk factors for MCI, such as vascular risk factors, depression, and lower cognitive reserve, are present in contact sport athletes and could explain some of the cognitive issues thought to be present in retired athletes due to CTE.

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