

Supplementary Table 4: Detailed data on neurocognitive assessment extracted from the included papers

Reference	Type of neurocognitive test	Domain	Results
McMillan et al. 2018 (32)	Montreal Cognitive Assessment (MOCA)	General cognitive function	Mean 27.4 for retired international rugby players (RIRP) vs 28.0 for comparison group (p=0.806)
	Symbol Digit Test	Processing speed	- 50.9 mean for Scottish International rugby players (RIRP) vs 53.0 for comparison group (p=0.490)
	Trail Making Test B	Executive Function	- 56.1 mean for RIRP vs 51.9 for comparison group (p=0.434)
	Rey Auditory Verbal Learning Test (RAVLT)	Memory & Learning	- Immediate recall 50.2 for RIRP vs 56.1 for comparison group (p=0.022) - Delayed recall 10.5 for RIRP vs 11.6 for comparison group (p=0.165)
	Sustained Attention to Response Task (SART)	Sustained Attention	- Sustained attention in response task (SART) commission errors 10.3 for RIRP vs 10.0 for comparison group (p=0.860) - SART reaction time 336 for RIRP vs 313 for comparison group (p=0.618)
	Judgement Line Orientation Task	Visual perception	- Mean of 28.2 for RIRP vs 28.1 for comparison group (p=0.442)
	Lafayette Grooved Pegboard	Fine hand coordination	- Dominant hand 74.9 mean for RIRP vs 68.7 for comparison group (p=0.038) - Non-dominant hand 85.4 mean for RIRP vs 80.1 for comparison group (p=0.126)
Hume et al., 2017 (31)	CNS-Vital Signs (VS) Test battery	Composite memory	- The community-rugby group performed worse than the US norms on composite memory (-0.31, -0.48 to -0.14)
		Psychomotor speed	- No significant difference between the groups
		Reaction time	- All three former-player groups performed worse than the US norms on reaction time (elite rugby: -0.50, -0.69 to -0.30; community rugby: -0.61, -0.78 to -0.45; non-contact sport: -0.73, -0.98 to -0.48)
		Complex attention	- Elite-rugby group performed worse on tests of complex attention (effect size -0.67, 95 % confidence interval [CI] -1.07 to -0.26) than the non-contact-sport group and the community-rugby group (-0.38, -0.71 to -0.05) - Community-rugby group and the non-contact- sport group performed slightly better than the US norms on complex attention (community rugby: 0.22, 0.08–0.35; non-contact sport: 0.40, 0.20–0.60)
		Cognitive flexibility	- The elite-rugby group performed worse on tests of cognitive flexibility (-0.37, -0.74 to 0.00) than the non-contact-sport group - The community-rugby group performed worse than the non-contact group on cognitive flexibility (-0.39, -0.69 to -0.08) - Rugby groups performed worse on cognitive flexibility (elite rugby: -0.26, -0.47 to -0.05; community rugby: -0.27, -0.41 to -0.13) than the US norms

		Processing speed	- Rugby groups performed worse on processing speed (elite rugby: -0.51, -0.75 to -0.26; community rugby: -0.32, -0.48 to -0.17), than the non-contact-sport group
		Executive functioning	- The elite-rugby group performed worse on tests of executive functioning (-0.41, -0.80 to -0.02) than the non-contact-sport group - The community-rugby group performed worse than the non-contact group on executive functioning (-0.51, -0.89 to -0.12) - Rugby groups performed worse on executive functioning (elite rugby: -0.24, -0.45 to -0.03; community rugby: -0.23, -0.37 to -0.10) than the US norms
		Verbal memory	- All three former-player groups performed worse than the US norms on verbal memory (elite rugby: -0.36, -0.60 to -0.12; community rugby: -0.54, -0.72 to -0.36; non-contact sport: -0.39, -0.69 to -0.08)
		Visual memory	- No significant difference between the groups
		Simple attention	- No significant difference between the groups
		Motor speed	- The elite-rugby group performed slightly better than the US norms in relation to motor speed (0.38, 0.19–0.57)
Decq et al., 2016 (27)	F-TICS-m MCI score	Mild cognitive disorders (TICS-m score ≤ 30 was considered to be compatible with mild cognitive disorder)	- Median (IQR) TICS-m score in former rugby player 30 (28-32), in other sports 31 (29-34) ($p=0.07$) - Mean (SD) TICS-m score in former rugby player, 30.2 (3.5) in other sports 31.3 (3.6) - Mild cognitive disorder (TICS-m ≤ 30) 57% of former rugby player and 40% of other sports ($p=.005$) - TICS-m score did not vary across the number of reported concussions - In multivariate analysis, number of concussions were not associated with TICS-m score (only education, smoking, and perceived health were positively associated with good cognitive function, playing rugby and age were negatively associated with good cognitive function)
Esopenko et al. 2017 (28)	Rey-Osterrieth Complex Figure Test (RCFT); Wechsler Abbreviated Scale of Intelligence (WASI); Brief Visual Memory Test Revised (BVM-T-R); Wechsler Abbreviated Scale of Intelligence (WASI) Matrix reasoning; Symbol Digit Modalities Test (SDMT); Judgement of Line Orientation (JLO); Rey Auditory Verbal Learning Test (RAVLT); Brief Visual	Intellectual functioning, speeded attention, memory, visuospatial processing and executive functioning	- Lower performance on the executive/intellectual function, $t(49)=5.53$, $p<0.001$, in alumni athletes vs comparison group - Group effect was evident on the WCST, $t(43.41)=6.08$, $p<0.001$; and WASI vocabulary, $t(49)=4.43$, $p<0.001$ and similarities, $t(49)=2.17$, $p=0.035$, but not matrix reasoning $t(49)=1.95$, $p=0.057$. - No significant differences for the other factors (visuospatial, $t(49)=1.18$, $p=0.25$; verbal memory, $t(49)=1.16$, $p=0.25$; speeded attention, $t(49)=0.16$, $p=0.87$). - No significant effects or interactions involving Group detected on the computerised cognitive test battery.

	Memory Test-Revised (BVM-T-R); Self-Ordered Pointing Task (SOPT); Paced Auditory Serial Addition Task (PASAT); Phonemic Word List Generation (FAS); Paced Auditory Serial Addition Task (PASAT); Trail Making Test (TMT) (Version B and A); Wisconsin Card Sorting Task; and computerized cognitive tests including Switching Stroop/Colour Word Remapping		
Baker et al. 2018 (24)	Wisconsin Card Sorting Test (WCST) & Delis-Kaplan Executive Function System (D-KEFS)	Executive function	- D-KEFS Colour-Word Interference Inhibition: 57.67 mean score for contact sport athletes and 57.19 in non-contact sport athletes, t-test 0.23 (p=0.82) - WCST Total Errors: mean of 49.43 for contact sport and 52.45 in non-contact sport athletes, t-test -1.17 (p=0.25)
	WASI-III Digit Span	Attention	- 54.9 mean score for contact sport athletes and 57.33 in non-contact sport athletes, t-test -0.73 (p=0.47)
	Neuropsychological Assessment Battery (NAB) (list learning and story learning test)	Memory (immediate and delayed recall)	- List B Immediate Recall: 50.9 in contact sport athletes and 57.24 in non-contact sport athletes, t-test -0.62 (p=0.05) - List A Short Delay: 53.48 in contact sport and 57.33 in non-contact sport athletes, t-test -1.29(p=0.2)
	Controlled Oral Word Association Test (COWAT) & NAB Naming test	Language	- Letter Fluency (FAS Total score) mean of 52.95 in contact sport athletes and 47.43 in non-contact sport athletes, T-test score 1.96 (p=0.06) - NAB Naming score 49.33 in contact sport athletes and 53.33 in non-contact sport athletes, T-test -2.12 (p=)
	WASI-III Digit Symbol Subtest and Trail Making Part B	Perceptual motor skills (visuospatial)	- WASI-III Digit Symbol: 55 mean score for contact sport athletes and 53.38, t-test 0.57 (p=0.57) - Trail B: 48.52 mean for contact sport and 53.38 in non-contact sport athletes, t-test -0.89 (p=0.38)
Misquitta et al. 2018 (33)	Rey Auditory Verbal Learning Test (RAVLT)	Verbal learning and memory	- RAVLT short delay mean for retired Canadian Football League players (Ex-CFL) 8.8 vs 9.2 for controls (p=0.497) - RAVLT long delay mean for Ex-CFL 8.1 vs 8.9 for controls (p=0.298)
	Rey Visual Design Learning Test (RVDLT)	Visual learning and memory	- RVDLT long delay mean for Ex-CFL and controls was 9.2 (p=0.977)

Alosco et al. 2017 (22)	Trail Making Test (TMT) Parts A and B; Wechsler Adult Intelligence Scale-Revised (WAIS-R) Digit Span and Digit Symbol Tests; Wisconsin Card Sorting Test; Controlled Oral Word Association Test (COWAT); Delis-Kaplan Executive Function System Colour-Word Interference Test (DKEFS); Boston Qualitative Scoring System for the Rey-Osterrieth Complex Figure (ROCF); Neuropsychological Assessment Battery (NAB) Story Learning Test, List Learning Test, Map Reading Test, and Naming Test; and Animal Fluency.	Attention, executive function, psychomotor speed, visual and verbal episodic memory, language, motor, and visuospatial functions	<ul style="list-style-type: none"> - More impaired factor scores for NFL players vs control group in the psychomotor speed/executive function, t-test 2.61 (p=0.012) but not for the verbal (p=0.209) or visual (p=0.102) memory domains. - NFL players performed worse across most of the cognitive measures compared to the comparison group - Trails A Time: T-score, 54.18 (10.37) mean score for comparison group vs 49.01 (11.72) mean for NFL group, p=0.030 - Digit Symbol: scaled score, 11.71 (2.05) mean score for comparison group vs 10.15 (2.03) mean for NFL group, p=0.003 - Trails B Time: T-scores, 52.75 (15.38) mean score for comparison group vs 43.77 (15.86) mean for NFL group, p=0.005 - DKEFS Inhibition/Switching completion time: scaled score, 12.00 (2.68) mean score for comparison group vs 10.60 (2.92) mean for NFL group, p=0.078 - COWAT: T-score, 52.21 (9.80) mean score for comparison group vs 48.96 (11.38) mean for NFL group, p=0.197 - ROCF Immediate Copy, Presence & Accuracy: T-score, 53.39 (7.69) mean score for comparison group vs 47.91 (9.93) mean for NFL group, p=0.021 - ROCF Delayed Presence & Accuracy: T-score, 55.00 (7.88) mean score for comparison group vs 48.43 (11.01) mean for NFL group, p=0.006 - NAB Phrase Unit (1 & 2) Immediate Recall: T-score, 43.00 (10.82) mean score for comparison group vs 39.19 (8.45) mean for NFL group, p=0.045 - NAB Phrase Unit Delayed Recall: T-score, 46.79 (10.12) mean score for comparison group vs 41.75 (7.77) mean for NFL group, p=0.006 - NAB List A Short Delay: T-score, 51.96 (11.99) mean score for comparison group vs 44.55 (13.03) mean for NFL group, p=0.014 - NAB List A Long Delay: T-score, 49.75 (12.88) mean score for comparison group vs 41.55 (13.77) mean for NFL group, p=0.010
Multani et al., 2016 (34)	Rey Visual Design Learning Test (RVDLT)	Visuospatial learning and memory	<ul style="list-style-type: none"> - RVDLT total learning score: 41.39 ± 13.1 in retired players, and 35.59 ± 8.7 in comparison group (p=0.303) - RVDLT long delay total score: 10.11 ± 3.3 in retired players, and 9.76 ± 2.1 in comparison group (p=0.443)
	Wechsler Test of Adult Reading (WTAR)	Pre-morbid intellectual functioning, verbal memory	<ul style="list-style-type: none"> - WTAR standard score: 113.87 ± 6.6 in retired players, and 11.94 ± 8.2 in comparison group (p=0.781)
Hart et al., 2013 (30)	Trail Making Test Parts A and B & Digit Span Subtest from the Wechsler Adult Intelligence Scale	Attention and cognitive flexibility	<ul style="list-style-type: none"> - Trail Making Test Part A score: 49.0 (45.8-52.1) for comparison group, 50.2 (44.2-56.2) for unimpaired NFL players, 52.0 (47.8-56.2) for cognitive impaired NFL players (p=0.58)* - Trail Making Test Part B score: 54.1 (50.6-57.5) for comparison group, 51.9 (44.9-58.9) for unimpaired NFL players, 46.8 (40.5-53.1) for cognitive impaired NFL players (p=0.12)*

			- WAIS-IV Digit span SS: 11.0 (10.0-12.0) for comparison group, 9.3 (7.2-11.5) for unimpaired NFL players, 10.3 (8.4-12.2) for cognitive impaired NFL players (p=0.35)*
Randolph et al., 2013 (35)	Wechsler Adult Intelligence Test-III (WAIS-3) and the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS)	Verbal memory, processing speed, visuospatial ability, language, attention	- RBANS Total Scale score mean for the NFL sample was significantly lower than the comparison group, F= 10.4; p= 0.002.
Amen et al. 2011 (23)	MicroCog Assessment of Cognitive Functioning	Attention/mental control, memory, reasoning, spatial processing and reaction time	- Players scored in the bottom half of the percentile placements on all measures except spatial processing and reaction-time, which were both in the top half of the percentile placements.
	Conners' Continuous Performance Test II (CCTP II)	Response inhibition and attention (validated screening tool that assigns a clinical probability of having attention-deficit hyperactivity disorder (ADHD))	- 84% of the players had a 50% greater chance of having ADHD based on CCPT II
Bang et al. 2016 (25)	Mini-Mental State Examination (MMSE)	Visuospatial skills, language, concentration, working memory, memory recall, and orientation	- Mean (SD) MMSE in former boxers 28.6 (1.5) in comparison group 30.0 (0.0) (p=0.212)
	Hopkins Verbal Learning Test (HVL) : verbal memory	Verbal episodic memory	- Mean (SD) Immediate recall in boxers 15.2 (3.0) in comparison group 19.5 (4.4) (p=0.127) - Mean (SD) delayed recall in boxers 4.8 (1.9) in comparison group 6.8 (3.1) (p=0.282) - Mean (SD) recognition in boxers 20.8 (0.8) in comparison group 21.0 (1.9) (p=0.832)
	Rey-Osterrieth Complex Figure test: visuospatial memory	Visuospatial memory	- Mean (SD) Immediate recall in boxers 15.3 (3.4) in comparison group 18.4 (4.7) (p=0.291) - Mean (SD) delayed recall in boxers 14.7 (3.3) in comparison group 20.6 (4.0) (p=0.045) - Mean (SD) recognition in boxers 20.2 (1.8) in comparison group 20.3 (2.1) (p=0.97)
Bernick et al. 2015 (26)	CNS Vital Signs (including verbal memory, symbol digit coding, Stroop and a finger tapping test)	Verbal memory	- No difference detected
		Processing speed	- There was a significant relationship between the number of professional fights and speed of processing (p=0.041), with an estimated 0.19% reduction in processing speed per fight - There was a significant relationship between the Fight Exposure score (FES) and speed of processing (p=0.023), with an estimated 2.1% reduction in processing speed scores for each increase in FES - Processing speed was related to fighter type (adjusting for years of education) with both fighter groups scoring worse than controls, but boxers being overall slower than MMA fighters
		Psychomotor speed	- Not clear
		Reaction time	- Not clear

