THE IMPACT OF SPORTS ON WORKING AND LONG-TERM MEMORY

by

BRADLEY BUCHBINDER

A THESIS

Presented to the Department of Psychology
and the Robert D. Clark Honors College
in partial fulfillment of the requirements for the degree of
Bachelor of Arts

March 2025

An Abstract of the Thesis of

Bradley Buchbinder for the degree of Bachelor of Arts
in the Department of Psychology to be taken March 2025

Title: The Impact of Sports on Working and Long-Term Memory

Approved: *Nash Unsworth, Ph.D.*
Primary Thesis Advisor

This paper explores how playing a sport affects someone's working and/or long-term memory. Overall, athletes outperformed non-athletes in both working and long-term memory, but the results were only significant for working memory. Specifically, when looking at individual tasks that participants completed, the athletes had a stronger visuospatial working memory. This study found that non-contact athletes outperformed contact athletes in long term memory to a significant degree. However, it found no differences between team and individual sports in regards to working or long term memory. Gender and length of time playing a sport were two other categories this study viewed to see if they impacted memory, but no significant results were found in either category. The overall strength of athletes in both long-term and working memory, though only significant in working memory, suggests that athletes may have a memory advantage as a result of playing sports. While this study had a large sample size of 599 participants, it lacked equal groups when drawing comparisons. Future studies should aim to recruit a specific amount of athletes per each sport and group into high-level collegiate athletes, amateur athletes, and non-athletes. Equal categories will help to draw more concrete conclusions and further determine whether there is an advantage for athletes and what could be causing that.

Table of Contents

List of Figures

List of Tables

Introduction

Growing up playing many sports, I was always engaging my memory in one way or another. Whether it was remembering technique in Taekwondo, remembering plays in basketball, or remembering positional rotations in volleyball, my working and long-term memory were among key contributing factors to my success or failure in playing sports. Not only have I enjoyed playing sports my whole life, but also closely follow many professional sports. While watching pre- and post-game interviews with players and coaches, I noticed how well many of them were able to remember specific games or plays in intense detail. Specifically, the first time I started to explore the idea of this topic was when I came across a video of Sean McVay, the current coach of the Los Angeles Rams, remembering exact plays from years ago in extraordinary detail when quizzed on them. Sean McVay played football for many years before entering the coaching realm, including as a wide receiver in college at Miami Ohio (Pro Football Reference). His involvement in football as both a player and coach seemed to strengthen his memory of plays and games. As a result of watching this, I began to question if there was a relation between playing sports and memory, whether that be working or long-term memory.

This question helped sculpt my initial research into this topic and helped me formulate my thesis that I researched in Dr. Unsworth's "Memory, Attention, and Individual Differences" Lab. My research will aim to build off Derek Graham's honors thesis that similarly looked at working memory in athletes versus nonathletes (Graham, 2023). This was an initial study in Dr. Unsworth's lab, and I will be extending this research with more participants and will be additionally looking at long term memory. My thesis will explore the intersectionality between sport and an individual's memory, both working and long term. I will begin with a literature review exploring previous research in the field on how working memory and long-term memory differ in athletes versus nonathletes. Next, I will build on prior research on working memory in sports and open new doors in long term memory research by gathering differences between athletes and nonathletes' performance on various tasks within Dr. Unsworth's lab. Not only will I explore performance differences between student participants who played sports and those who didn't but will also investigate subcategories within sports such as differences in memory between contact and noncontact sports as well as differences across genders. Findings from my research on this topic will be important in distinguishing whether athletes have a competitive advantage over nonathletes due to a strengthened working and/or long-term memory. Additionally, potential differences across contact sports will help investigate whether memory is negatively affected because of contact. If memory differences are discovered from my data, future research can explore whether this competitive advantage of improved memory is a result of playing a sport or something that athletes are naturally "blessed" with.

Research Questions:

Is there a statistically significant difference in the working and/or long-term memory of athletes versus that of nonathletes?

- **Specific subcategory questions:**
    - Do contact sports affect memory differently than non-contact sports?
    - Is an athlete's memory capacity impacted by their gender?
    - Does the length of time someone has spent playing a sport impact their memory?
    - Do team sports and individual sports impact memory differently?

Literature Review

When delving into prior research, it was clear that working memory in sports is a well-researched topic. However, there was significantly less research on the role of long-term memory in sports, with a large focus being solely on concussions. To contextualize much of the literature on working memory that will follow, a helpful definition of working memory is, "a brain system that provides temporary storage and manipulation of the information necessary for such complex cognitive tasks as language comprehension, learning, and reasoning" (Baddeley, 1992, p. 1). This temporary storage is crucial for an athlete, whether it involves quickly learning a play or making a decision in a high stress situation. A helpful definition of long-term memory is "a relatively permanent information storage system that enables one to retain, retrieve, and make use of skills and knowledge hours, weeks, or even years after they were originally learned (American Psychological Association, 2018). This is critical for an athlete for something like remembering a play previously practiced during a game.

Exercise has, for many years, been believed to be good for one's health. Not only can it be good for a person's physical and mental health, but research suggests it also can improve memory. In a study involving older adults who were grouped into an aerobic exercise group and a stretching control group, researchers discovered exercise could reverse an aging effect of the hippocampus. The exercising group effectively increased their hippocampal volume by 2%, reversing the aging effect of the hippocampus which normally decreases in volume by 1-2% yearly as we age. The increased hippocampal volume led to an improved spatial working memory (Erickson et al., 2011). While this research is focused on older adults and aging, unlike the scope of my research with college students, it is interesting to consider that if hippocampal volume is prevented from decreasing in volume by exercising, it could be doing the same in exercising young adults. With this theory that athletics could be increasing our memory capacity, it is interesting to consider how memory could be both a beneficial outcome of playing sports and a competitive advantage if one's memory capacity is stronger to begin with.

Working Memory in Sports

The effective management of working memory is an integral part of playing sports and can even be said to separate a choker from a non-choker, essentially whether the athlete fails when the moment matters most (Bijleveld & Veling, 2014). Under high pressure situations, athletes rely on their working memory to navigate the situation. Illustrated by this study involving tennis players, players who began with a higher working memory capacity were more successful in dealing with the distracting thoughts that emerged in pressure situations than those who began with a lower capacity (Bijleveld & Veling, 2014). Clearly, optimal performance in an athlete's sport was guided by their working memory capacity.

Role of Gender

External factors also appear to play a role in working memory for an athlete, such as one's gender. In a previous study with college athletes and non-athletes, it was discovered that auditory and visual working memory were both affected by exercise or participation in athletics, but this was only applicable for male participants (Lineweaver et al., 2020). By concluding some memory components are only affected in males, this literature suggests that future research on the impact of working memory in sports performance should investigate the role of gender when viewing these interactions. Similarly, in another experiment involving college athletes, researchers tested their neurocognitive functions and concussion symptoms. Significant differences were discovered amongst the sexes in both these neuropsychological test scores and their description of concussion symptoms. Male athletes scored significantly better on baseline visual memory test scores, and females reported significantly higher mean symptom scores than men for the same concussion symptoms (Covassin et al., 2006). With differences in how each sex reports concussion symptoms and how they perform overall on cognitive tests, it appears that whether someone is male or female is an important factor when discussing this research.

Role of Concussions

In addition to a factor like gender, a concussion sustained from playing a sport could also play a role in one's working memory capacity. However, results of the impact of concussions on memory are not conclusive across all studies. An example is a study that investigated working memory differences between student athletes who had concussions and those who didn't. While this literature did not investigate contact sports' impact on long term memory, they did draw a conclusion on its role on working memory capacity. They found that working memory capacity was not, in fact, impaired in the student athletes who competed in "head-contact-prone" sports (Mayers et al., 2011). This conclusion opens the possibility that working memory capacity may be positively impacted by playing sports, independent of whether that sport is a contact sport. Another study similarly looked at athletes who participated in high-contact sports and tested their memory and auditory comprehension after they suffered a sports-related concussion. This situation did not compare athletes to non-athletes but compared differences across the specific contact sports. They determined verbal memory and auditory comprehension were not statistically different across the three main contact sports (football, basketball, and ice hockey) following sports-related concussions (Yoo & Taylor, 2022). However, the football players did score lower on verbal memory. While the findings were minimal in terms of the role of contact sports, the fact that the high concussion sport of football lowered verbal memory leaves open the idea that concussions can impact this component of working memory.

Role of Sport Played

Not only does playing a sport appear to play a part in one's working memory, but the impact is also theorized to differ from sport to sport. One experiment categorized athletes into groups of static, interpretive, or strategic sports. They found that visuospatial working memory could play a role in determining athletic performance in strategic sports and is also a benefit of participating in sports (Sato et al., 2022).

Long Term Memory in Sports

The benefit of exercise is seen not only impacting working memory, but also long-term memory. One example is a study that had college students listen to a paragraph story and participate in brief exercises. They were later quizzed (delayed recall) on this story. The group that exercised prior to the story and the group that exercised after the story were both able to recall significantly more of the story, showing that exercise can help boost long term memory (Labban, 2011). With exercise being an integral part of sport, it can be assumed that sports would help boost long term memory too.

A consistent theme seen with previously mentioned studies on working memory, it appears that an improved long-term memory is not just a possible result of playing sports but also a competitive advantage while playing sports. A study that investigated the role of long-term memory in tennis players determined that long term memory structures were crucial for how well the athlete performed basic movements, specifically within their tennis serve. They found that the basic action concepts, a network of long-term memory, were likely accessible for athletes to use for anticipatory control (Schack, 2006).

However, the role of long-term memory in sports is not consistent across all studies. In one case, athletes, people who hardly exercise, and people who exercise were placed in three different groups. Researchers concluded there was not a statistically significant difference in long term memory across the three groups; it did not matter how physically active the person was (Nyberg, 2008). Clearly, with mixed findings on the role of exercise/sports on long term memory, more research is needed to make further conclusions.

Conclusions

Overall, various prior literature seems to indicate a relation between both working and long-term memory and playing a sport. It generally seems as though working memory is better in athletes than nonathletes, with important elements to also factor in such as gender or concussion history. However, surprisingly, a lot of this previous literature suggests concussions do not severely impact memory, as many believe. I hypothesize that working memory and long-term memory will both be stronger in athletes versus non-athletes but do think the scope of my research will illustrate differences in the impact of contact sports.

Method

Participants

A total of 599 participants (272 athletes) were recruited from the subject-pool at the University of Oregon, a comprehensive state university. Participants received course credit for their participation. Each participant was tested individually in a laboratory session lasting approximately two hours.

Materials and Procedure

Participants completed a demographics form with an additional question asking them if they have played any sports. If they answered yes, they were asked what sport they played and how long (in years). After signing informed consent, all participants completed a paired associate's task, delayed free recall, picture source recognition, operation span, and lastly, the change detection – colored squares task. Participants also completed other various tasks looking at reaction time, but these will not be explored in this current study.

Long-term Memory (LTM) tasks

Paired associates task. Participants were administered 3 lists of 30 word-pairs each. Word pairs were presented horizontally for 3 s each, and every word pair was preceded by a mask of five plus signs replacing each word that had previously been on screen (2 s duration). All word pairs were associatively and semantically unrelated. Participants were told that the cue would always be on the left and the target would be on the right. After the presentation of the last word, participants saw the cue word and ??? in place of the target word. Participants were instructed to type in the target word from the current list that matched the cue. Cues for the corresponding target words were presented in the same order at recall as they were presented during the encoding phase. Participants had 5 s to type in the corresponding word. A participant's score was the proportion of items recalled correctly.

Delayed Free Recall. Participants were administered a delayed free recall task consisting of 3-word lists containing 10 words each. Word lists were initially composed of randomized nouns selected from the Toronto word pool (Friendly, Franklin, Hoffman, & Rubin, 1982). All participants received the same lists of words and were instructed to recall as many words as possible from each list. Words were presented onscreen for 1 s, with each word preceded and followed by a 500 ms blank screen. Following presentation of the last word within each list, a 16 s distractor task began that required participants to write down a series of 8 three-digit numbers in descending order (adapted from Rohrer & Wixted, 1994). For example, participants might see "548" and have to report "854." Each 3-digit string was presented onscreen for 2 s. After the distractor task, 3 question marks appeared in the center of the screen to prompt participants to recall as many words as possible within a 45 s window. Participants typed their responses in any order they wished and pressed “enter” after each word, thereby clearing the screen. A participant’s score was the proportion of items recalled correctly.

Picture Source Recognition. During the encoding phase, participants were presented with a picture (30 total pictures) in one of four different quadrants on screen for 1 s. Participants were explicitly instructed to pay attention to both the picture (item) as well as the quadrant it was located in (source). At test, participants were presented with 30 old and 30 new pictures in the center of the screen. Participants were required to indicate if the picture was new or if it was old. If the picture was deemed old, they also had to specify what quadrant the picture was presented in via key press. Thus, on each test trial participants pressed one of five keys indicating new, old-top left, old-top right, old-bottom left, or old-bottom right. Participants had 5 s to press the appropriate key to enter their response. A participant’s score was the proportion of correct responses.

Working memory capacity tasks

Operation span. Participants solved a series of math operations while trying to remember a set of unrelated letters (see Unsworth et al., 2005; Redick et al., 2012). Participants were required to solve a math operation, and after solving the operation, they were presented with a letter for 1 s. Immediately after the letter was presented the next operation was presented. At recall participants were asked to recall letters from the current set in the correct order by clicking on the appropriate letters. For all of the span measures, items were scored correct if the item was recalled correctly from the current list. Participants were given practice on the operations and letter recall tasks only, as well as two practice lists of the complex, combined task. List length varied randomly from three to seven items, and there were two lists of each list length for a maximum possible score of 50. The score was the total number of correctly recalled items in the correct serial position.

Change Detection – Colored Squares (CD-color). In this task, participants were required to remember the colors of squares in various spatial locations (Luck & Vogel, 1997). Each trial began with a two second fixation screen upon which a black fixation cross was centered on a light gray background. This fixation screen was followed by a 750-ms blank delay, then the stimuli appeared for 250 ms. The stimuli consisted of an array of six colored squares (each 20 x 20 pixels; 1◦ visual angle) that appeared within a 540 x 402 pixel region centered on the screen for 250 ms. The spatial location of items was random, with the requirement that no item appear within a 100-pixel distance of any other item (measured from each item's upper-leftmost point). The colors of the items were sampled from a list of seven possible colors (red, blue, violet, green, yellow, black, or white). Colors did not repeat within a trial. The appearance of the stimuli was followed by a four second delay before the test array. On the test screens, the stimuli reappeared with one of the squares surrounded by a black circle. The participant's task was to decide whether that square was the same color or a different color as it had been during the first presentation of the array. Participants pressed a key marked "S" to indicate the same or a key marked "D" to indicate different (the F and J keys on the keyboard, respectively). For this task and the letter change detection task, we obtained a single accuracy estimate for the task which was then used as the dependent variable in all analyses. Participants first completed five practice trials and 42 experimental trials.

Results

After the conclusion of my data collection, I used the software Jamovi to analyze my results. First, I made a descriptive table that lists each individual sport that every athlete played and how many people played that sport, in order from the largest sample size to the smallest sample size. The list includes 47 different sports. Next, I ran independent sample t-tests, a one-way ANOVA, and correlation tests to analyze my data. T-tests are used to measure the mean difference between two groups, ANOVAs are used to measure mean differences for three or more groups, and correlation tests are used to measure the relationship between two continuous variables. From the subgroup containing contact and non-contact sports, I defined contact sports as sports with frequent intentional contact, such as a sport like football, while sports with infrequent incidental contact, like a baserunner running into a second basemen in baseball, were left off the list. My group of contact sports included the following sports: football, basketball, soccer, wrestling, boxing, lacrosse, water polo, ice hockey, martial arts, and rugby. My group of non-contact sports included the following sports: baseball, softball, tennis, dance, volleyball, track & field, cross country, cheer, golf, swimming, skiing, snowboarding, weightlifting, bowling, table tennis, running, ice skating, climbing/bouldering, gymnastics, rowing, equestrian, color guard, ultimate frisbee, flag football, surfing, biking, skateboard, archery, paddling, tumbling, kayaking, field hockey, racquetball, horseback, cross fit, pickleball, and ballet. For the subgroup with team and individual sports, sports were classified based on whether they were more frequently played as a part of a team or individually. Some were not straightforward and could have gone either way, like wrestling for example. I classified it as an individual sport because of the individual skillset needed in head-to-head competition, even though its scoring system tallies total points scored by all the wrestlers on the team. The team sports category included: football, basketball, soccer, lacrosse, water polo, ice hockey, rugby, baseball, softball, volleyball, cheer, rowing, color guard, ultimate frisbee, flag football, field hockey, and equestrian. The individual sports category included: wrestling, boxing, track & field, tennis, dance, cross country, golf, swimming, skiing, snowboarding, weightlifting, bowling, table tennis, running, ice skating, climbing/bouldering, gymnastics, archery, paddling, surfing, biking, skateboard, racquetball, horseback, cross fit, pickleball, ballet, martial arts, tumbling, and kayaking.

Table 1

List of Sports Played by Athletes

Descriptives

Descriptives

	N	SD	Minimum	Maximum
Soccer	76	4.586	1	20
Basketball	64	4.265	1	18
Volleyball	44	3.306	1	19
Track&Field	34	2.694	1	12
Swimming	26	4.131	1	13
Dance	25	4.319	2	18
Tennis	22	3.477	1	12
CrossCountry	20	2.130	2	10
Football	17	5.361	2	19
Baseball	16	4.946	3	20
Skiing	15	5.480	1	18
Lacrosse	15	3.674	1	13
Waterpolo	13	2.332	3	11
Golf	12	4.793	1	17
Climbing/Bouldering	11	4.338	1	14
Softball	11	4.167	1	15
Cheer	9	2.819	1	11
MartialArts	8	3.021	4	12
Gymnastics	8	3.370	3	11
Rugby	6	1.835	1	5
Wrestling	5	3.362	1	10
Snowboard	5	4.637	1	13
UltimateFrisbee	5	1.673	2	6
FlagFootball	5	0.548	1	2
Biking	4	2.160	1	6
Running	4	1.155	2	4
Weightlifting	3	0.577	3	4
Rowing	3	0.000	3	3
Ballet	2	5.657	5	13
FieldHockey	2	3.536	1	6
Skateboarding	2	2.121	5	8
Equestrian	2	4.243	4	10
TableTennis	2	0.707	1	2
IceHockey	2	4.243	12.0	18.0
Boxing	2	0.000	4	4
Surfing	2	1.414	2	4
Archery	1	NaN	1	1
Paddling	1	NaN	2	2
Tumbling	1	NaN	1	1
Racquetball	1	NaN	2	2
Horseback	1	NaN	7	7
Crossfit	1	NaN	1	1
Pickleball	1	NaN	3	3
Colorguard	1	NaN	3	3
IceSkating	1	NaN	9	9
Kayaking	1	NaN	10.0	10.0
Bowling	1	NaN	2	2

The first test I ran was an independent samples t-test, comparing athletes' long term memory scores to nonathletes' long term memory scores. Non-athletes were scored as "0", while athletes were scored as "1" in the data. The LTMz (participants' compiled long term memory score) results indicated that athletes (*M* = 0.0321, *SD* = 0.780) scored higher than non-athletes (*M* = -0.0206, *SD* = 0.769), *t* (462) = -0.731, *p* = 0.233. Although athletes did outperform non-athletes, the p value is not statistically significant and the Cohen's D effect size of -0.0682 is very small, suggesting negligible practical significance. The next independent sample t test compared athletes' working memory scores to non-athletes' working memory scores. The WMz (participants' compiled working memory score) results indicated that, once again, athletes (*M* = 0.0914, *SD* = 0.773) scored higher than non-athletes (*M* = -0.0518, *SD* = 0.859), *t* (414) = -1.768, *p* = 0.039. In this case, the results are statistically significant ($p < 0.05$). Cohen's D of -0.1742 suggests a small negative effect size between the two groups.

Table 2

LTM and WM Test Scores – Athletes vs. Non-athletes

Independent Samples T-Test

Independent Samples T-Test

		Statistic	df	p		Effect Size
LTMz	Student's t	–0.731	462	0.233	Cohen's d	–0.0682
WMz	Student's t	–1.768	414	0.039	Cohen's d	–0.1742

Note. H_a $\mu_0 < \mu_1$

Group Descriptives

	Group	N	Mean	Median	SD	SE
LTMz	0	255	–0.0206	–0.0298	0.769	0.0481
	1	209	0.0321	0.0801	0.780	0.0539
WMz	0	229	–0.0518	0.1076	0.859	0.0568
	1	187	0.0914	0.2088	0.773	0.0565

Figure 1

LTM Scores Bar Plot (Athletes vs. Non-athletes)

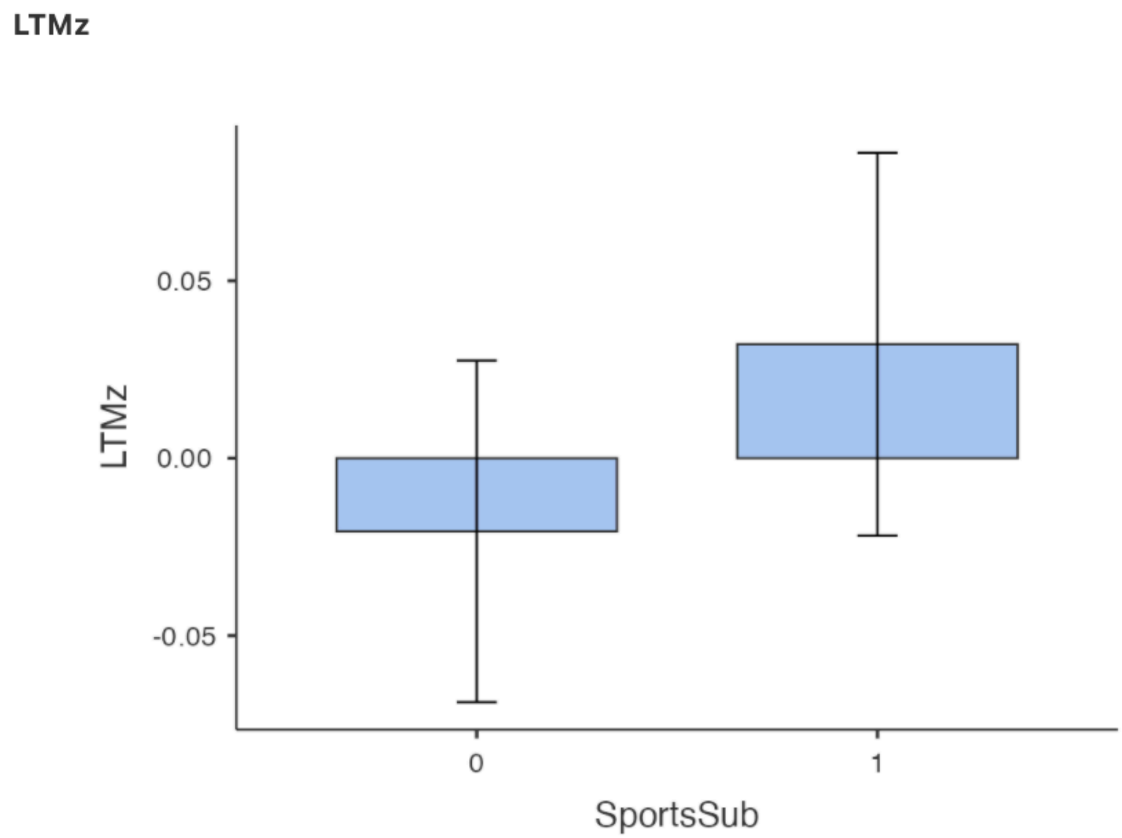
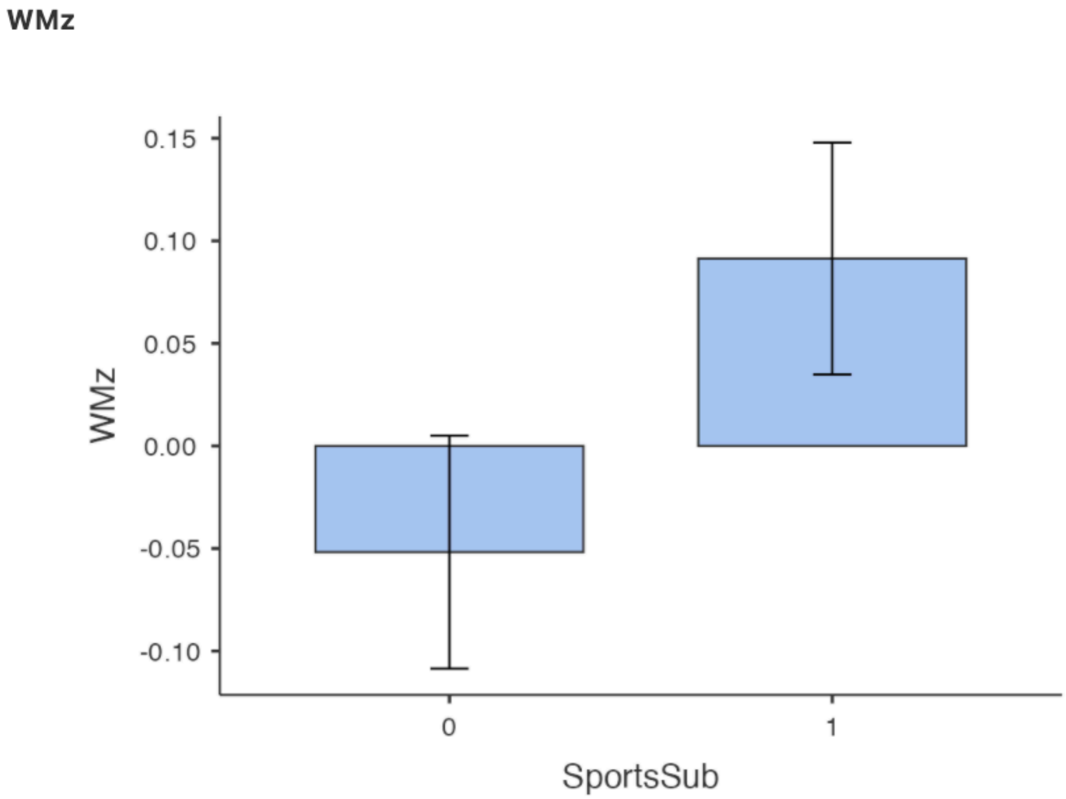


Figure 2

WM Scores Bar Plot (Athlete vs. Non-athlete)



After the completion of comparing athlete's compiled memory scores to non-athletes' compiled memory scores, I compared performance on the individual memory tasks. Of the tasks completed, the working memory CD (colored squares change detection) task, was the only one with a statistically significant difference to report. The results indicated that athletes (M = 0.811, SD = 0.106) outperformed non-athletes (M = 0.788, SD = 0.124), t (435) = -2.026, p = 0.022. Despite a statistically significant p value of 0.022, the effect size was small (d = -0.1946), suggesting a modest difference in performance. Additionally, the results from the picture source recognition were marginally significant, t (465) = -1.586, p = 0.057, with athletes (M = 0.758, SD = 0.174) scoring slightly higher than non-athletes (M = 0.731, SD = 0.192). The effect size was small, *d* = -0.1476, indicating a negligible difference. The results from the remainder of individual tasks are listed below in “Table 3”.

Table 3

Individual Task Performance Athletes vs. Non-athletes

Independent Samples T-Test

Independent Samples T-Test

		Statistic	df	p		Effect Size
CD	Student's t	–2.026	435	0.022	Cohen's d	–0.1946
PA	Student's t	0.128	476	0.551	Cohen's d	0.0118
DFR	Student's t	–0.221	479	0.413	Cohen's d	–0.0202
PicSource	Student's t	–1.586	465	0.057	Cohen's d	–0.1476
Ospan	Student's t	–0.402	433	0.344	Cohen's d	–0.0387

Note. H_a $\mu_0 < \mu_1$

Group Descriptives

	Group	N	Mean	Median	SD	SE
CD	0	238	0.788	0.825	0.124	0.00806
	1	199	0.811	0.830	0.106	0.00751
PA	0	259	0.481	0.467	0.257	0.01594
	1	219	0.478	0.467	0.265	0.01790
DFR	0	261	13.552	13.000	4.807	0.29756
	1	220	13.650	13.000	4.930	0.33236
PicSource	0	257	0.731	0.780	0.192	0.01200
	1	210	0.758	0.820	0.174	0.01203
Ospan	0	237	36.211	38.000	10.121	0.65741
	1	198	36.616	39.000	10.878	0.77309

Figure 3

CD Performance of Athletes vs. Non-athletes

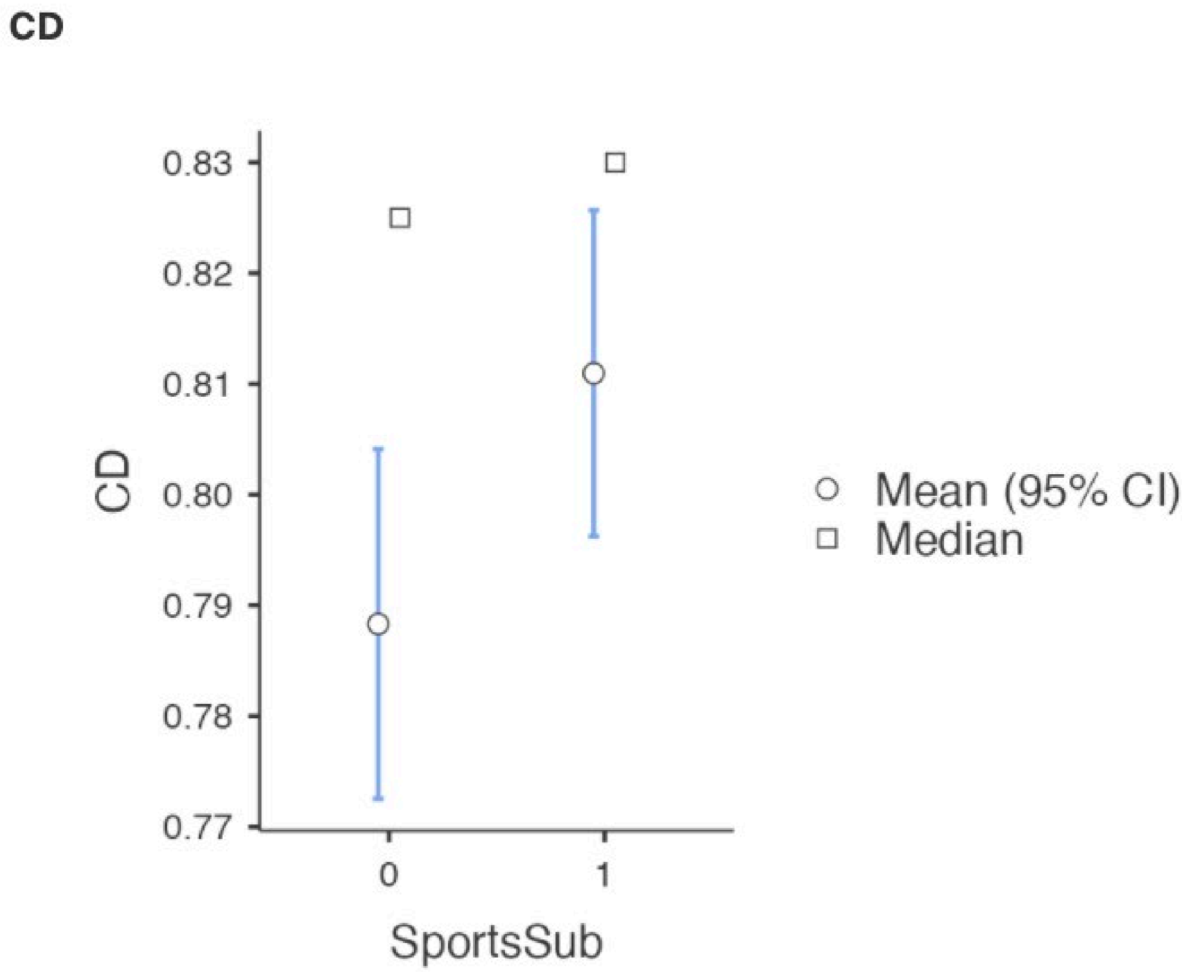


Figure 4

PA Performance of Athletes vs Non-athletes

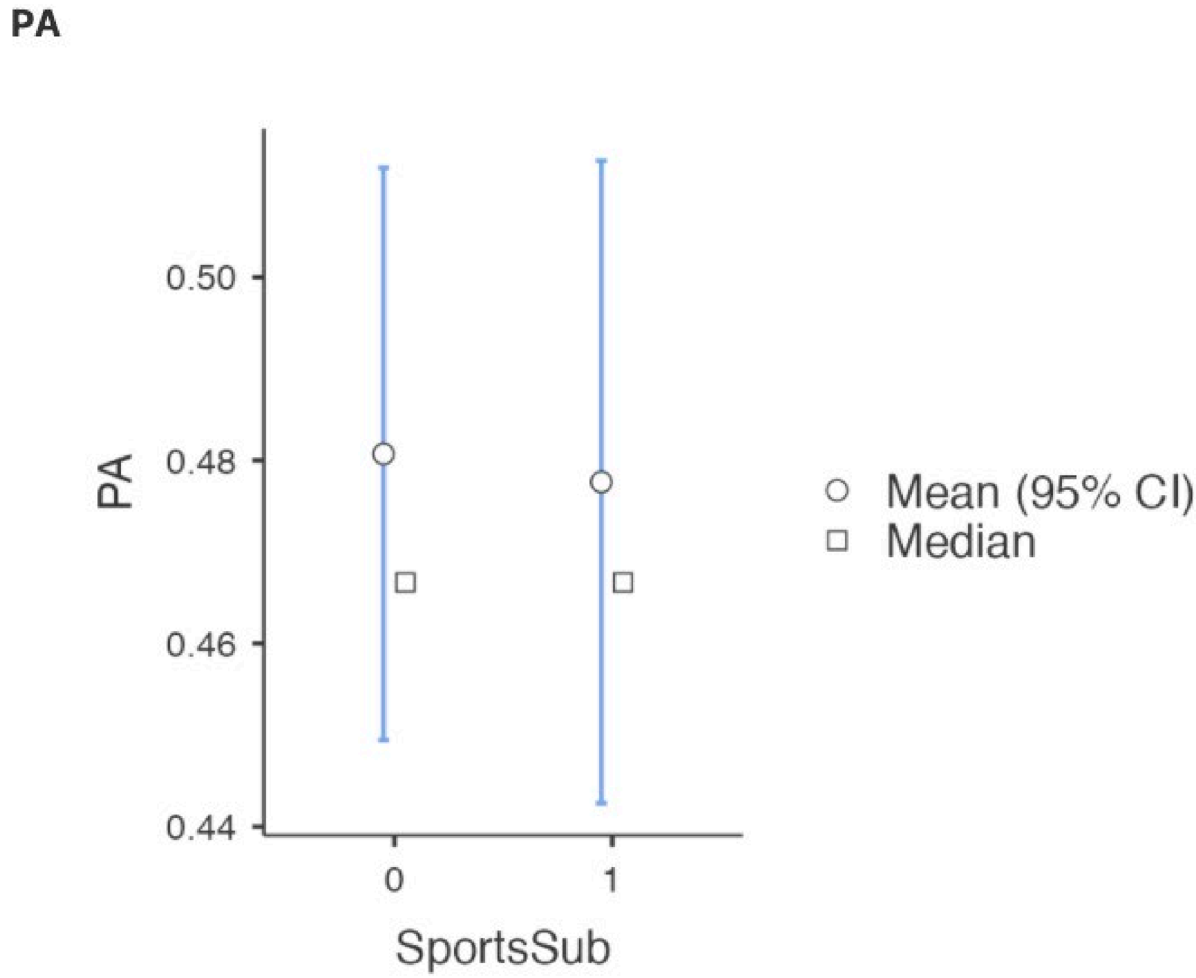


Figure 5

DFR Performance of Athletes vs. Non-athletes

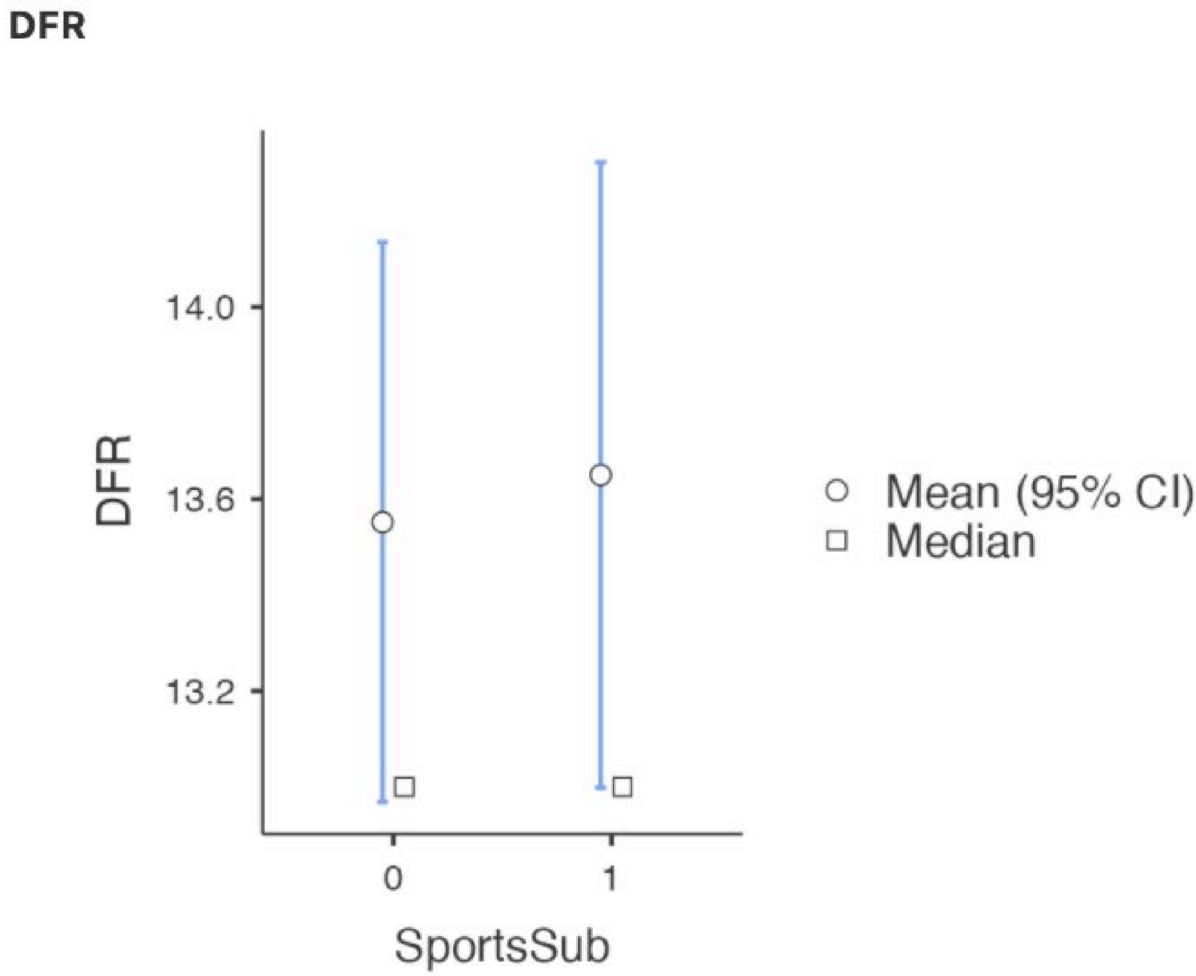


Figure 6

PicSource Performance of Athletes vs. Non-athletes

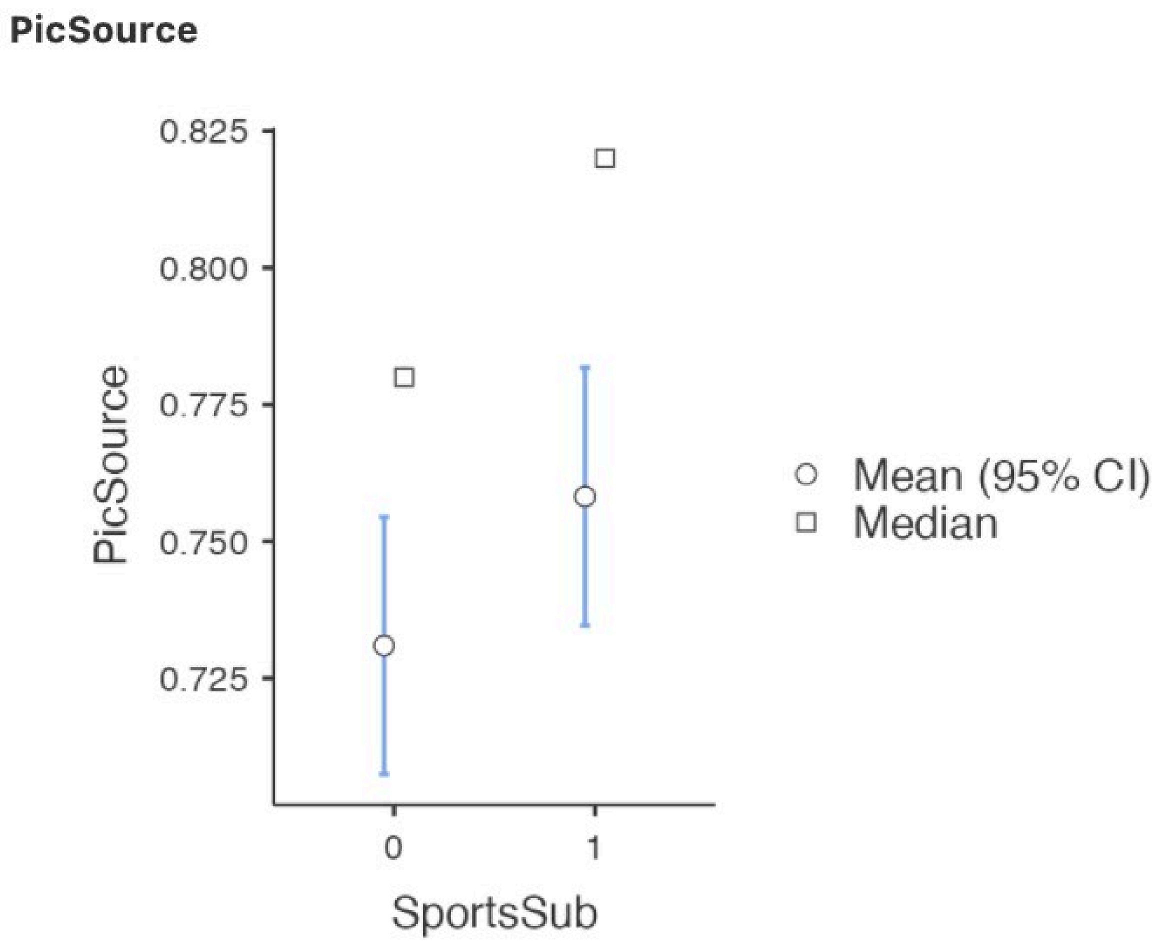
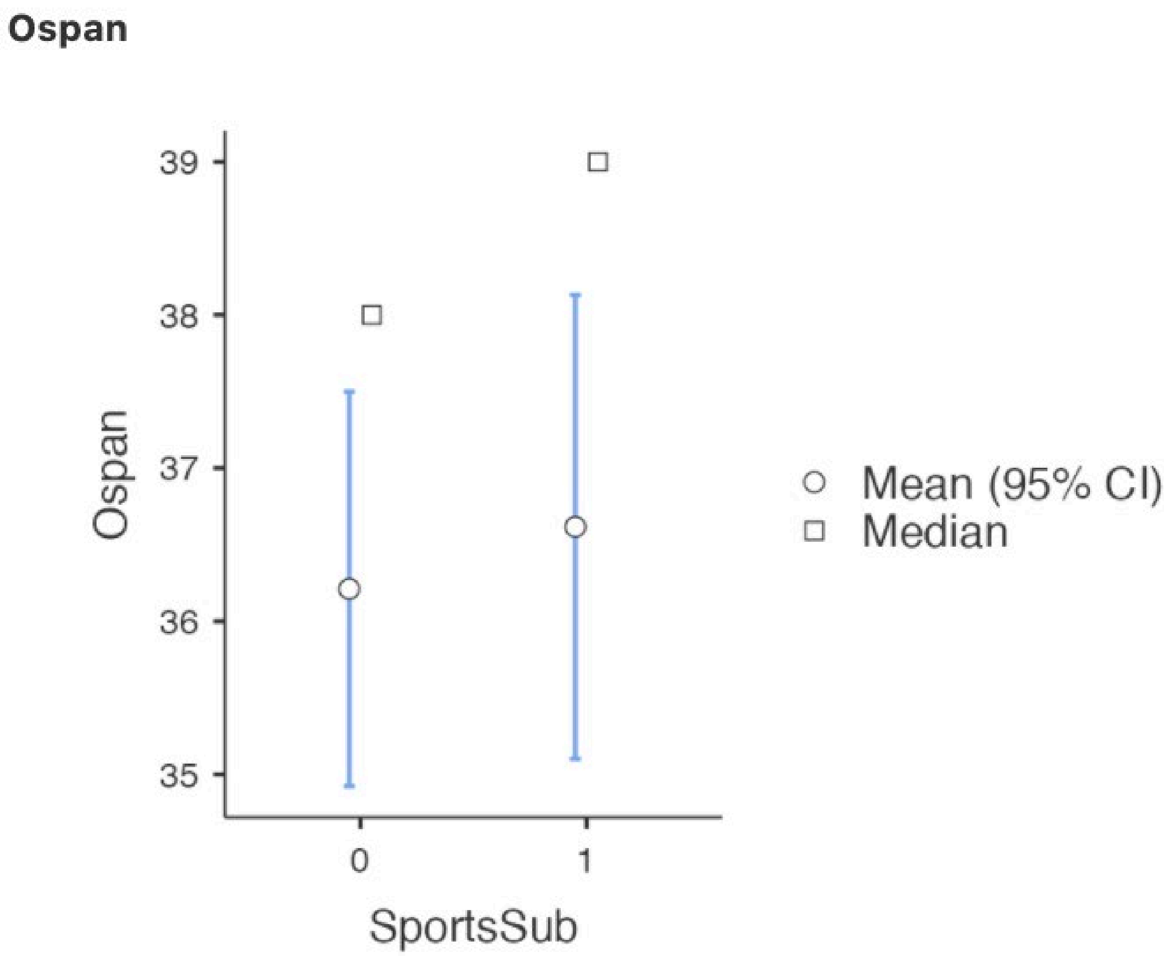


Figure 7

Operation Span Performance of Athletes vs. Non-athletes



Next, I looked deeper at how some sports impact memory differently than others. In order to do so, I compared the impact of contact versus non-contact sports on both working and long-term memory. I ran a one-way ANOVA to compare three different group's memory scores. People who played only a contact sport were scored as "1", people who played both contact and non-contact sports were scored as "1.5", and people who played only non-contact sports were scored as "2". This one-way ANOVA revealed a statistically significant effect of whether the sport played was contact on long term memory, F (2, 107.1) = 4.35, p = 0.015. Post hoc tests using the Games-Howell test indicated that those who played only contact sports scored significantly lower than those who played both contact and non-contact sports (mean difference = -0.438, $p = 0.018$) and significantly lower than those who played only non-contact sports (mean difference = -0.403, $p = 0.024$). There was not a significant difference between the group who played both contact and non-contact sports and those who played only non-contact sports (mean difference = 0.035, $p = 0.951$). The results of the differences in working memory scores were not statistically significant, F (2, 96.2) = 1.39, $p = 0.253$, which indicate no evidence of differences in working memory across non-contact and contact athletes. Although not statistically significant, the trend of the mean plot in “Figure 8” does suggest that those who played only non-contact sports tended to score better than those who either played only contact sports or both contact and non-contact sports.

Table 4

The Effect of Contact vs. Non-contact Sports on Memory

One-Way ANOVA

One-Way ANOVA (Welch's)

	F	df1	df2	p
LTMz	4.35	2	107.1	0.015
WMz	1.39	2	96.2	0.253

Table 5

Descriptive Statistics of Contact vs. Non-contact Athletes

Group Descriptives

	ConVSNon	N	Mean	SD	SE
LTMz	1.0	45	–0.296	0.871	0.1299
	1.5	69	0.142	0.728	0.0876
	2.0	95	0.107	0.736	0.0755
WMz	1.0	41	–0.111	0.948	0.1481
	1.5	66	0.117	0.660	0.0813
	2.0	80	0.174	0.751	0.0840

Figure 8

LTM Mean Plot Contact vs. Non-contact

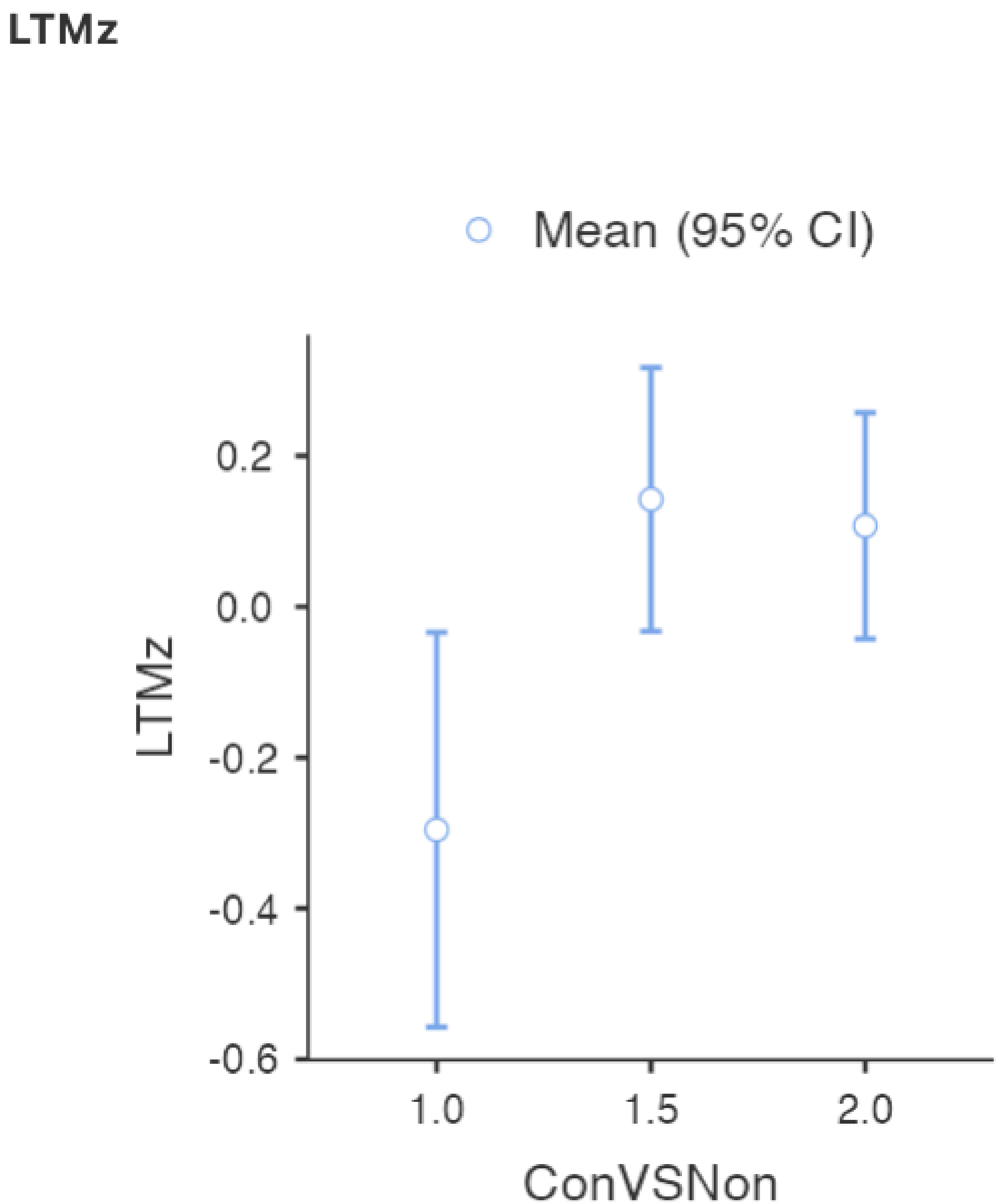
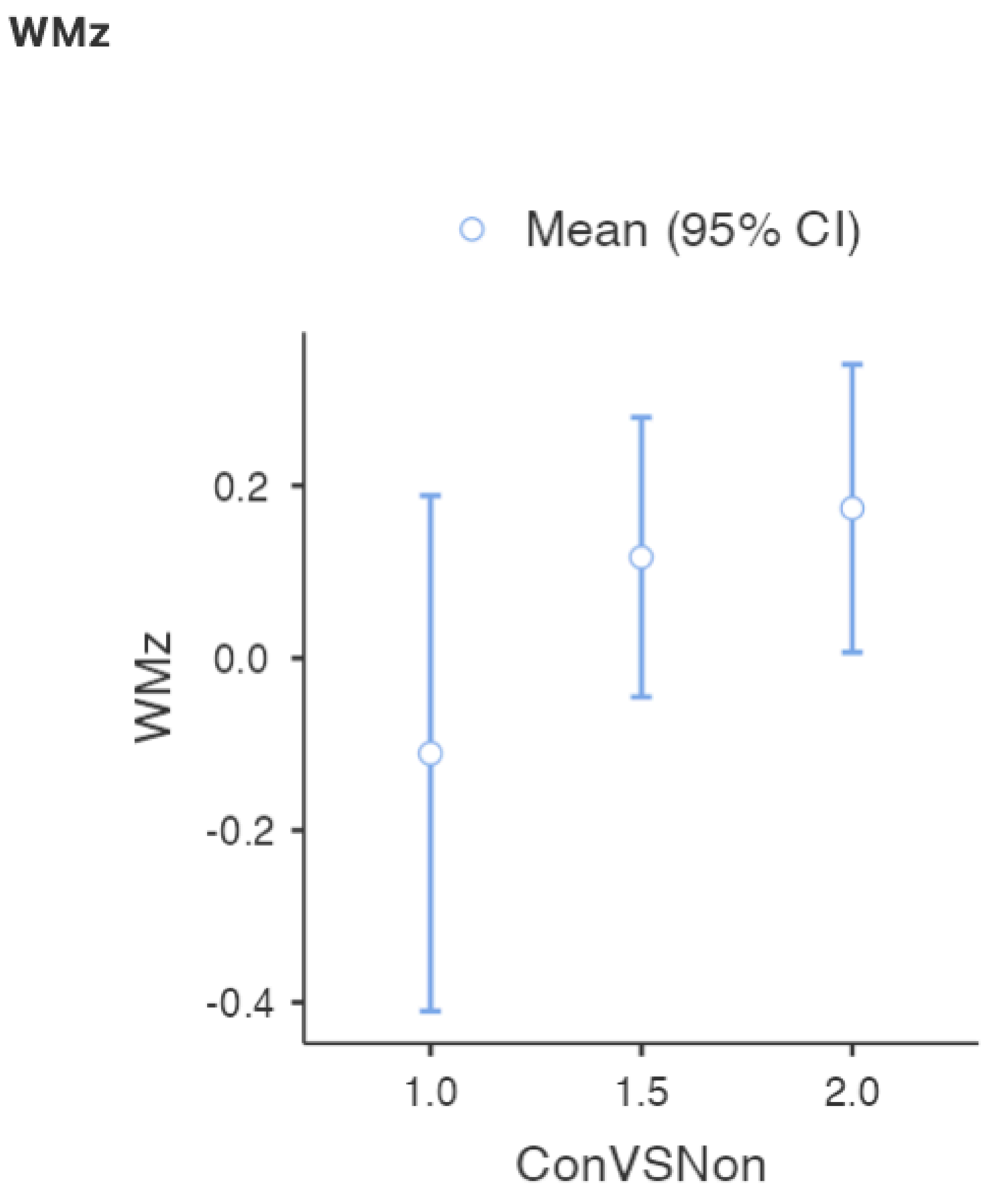


Figure 9

WM Mean Plot Contact vs. Non-contact



The next category that I chose to look at was whether team sports impact memory differently than individual sports. I ran a one-way ANOVA, with 1.0 coded as team sports, 1.5 as individual sports and team sports, and 2.0 as individual sports. Across the overall long term memory scores, overall working memory scores, and individual task scores there were no statistically significant results. However, the individual DFR long term memory task approached significance, $F\ (2, 131) = 2.83$, 0.063. This long-term memory result indicates a trend that may warrant further investigation with a larger sample size.

Table 6

The Effect of Team vs. Individual Sports on Memory

One-Way ANOVA

One-Way ANOVA (Welch's)

	F	df1	df2	p
LTMz	2.391	2	134	0.095
WMz	0.296	2	116	0.744
PA	1.951	2	139	0.146
DFR	2.428	2	131	0.092
PicSource	1.028	2	137	0.361
CD	1.535	2	123	0.220
Ospan	1.282	2	127	0.281

Group Descriptives

	TeamVSIndivid2	N	Mean	SD	SE
LTMz	1.0	79	−0.1167	0.787	0.0886
	1.5	69	0.1458	0.751	0.0904
	2.0	61	0.0962	0.784	0.1004
WMz	1.0	74	0.1172	0.826	0.0960
	1.5	65	0.0333	0.754	0.0935
	2.0	48	0.1302	0.724	0.1045
PA	1.0	85	0.4333	0.264	0.0286
	1.5	72	0.5060	0.271	0.0320
	2.0	62	0.5054	0.254	0.0322
DFR	1.0	85	12.9294	4.029	0.4370
	1.5	73	14.6164	5.351	0.6262
	2.0	62	13.5000	5.407	0.6867
PicSource	1.0	79	0.7357	0.189	0.0213
	1.5	70	0.7681	0.168	0.0201
	2.0	61	0.7759	0.161	0.0206
CD	1.0	79	0.8141	0.104	0.0118
	1.5	67	0.7940	0.109	0.0133
	2.0	53	0.8277	0.104	0.0142
Ospan	1.0	74	37.3919	11.448	1.3308
	1.5	68	37.3529	10.605	1.2861
	2.0	56	34.6964	10.376	1.3866

Another group I was interested in was gender and whether it had an impact on either working or long-term memory performance. I ran an independent samples t-test to investigate. While neither long term nor working memory compiled scores revealed any statistically significant differences, one individual task was close to statistical significance. The paired associates' long term memory task results indicated that female students (M = 0.4904, SD = 0.251) outperformed male students (M = 0.4490, SD = 0.251), t (475) = -1.564, p = 0.059. These results are considered marginally significant, just outside the statistically significant threshold of $p < 0.05$.

Table 7

Differences in Scores Across Male and Female Participants

Independent Samples T-Test

Independent Samples T-Test

		Statistic	df	p
LTMz	Student's t	−0.981 [a]	461	0.164
PA	Student's t	−1.564	475	0.059
DFR	Student's t	−0.108 [a]	478	0.457
PicSource	Student's t	−0.604	464	0.273
WMz	Student's t	1.678	413	0.953
Ospan	Student's t	3.324	432	1.000
CD	Student's t	−0.294	434	0.385

Note. H_a $\mu_M < \mu_F$

[a] Levene's test is significant (p < .05), suggesting a violation of the assumption of equal variances

Group Descriptives

	Group	N	Mean	Median	SD	SE
LTMz	M	128	−0.0537	−0.0712	0.878	0.0776
	F	335	0.0253	0.0434	0.731	0.03992
PA	M	134	0.4490	0.4167	0.281	0.0243
	F	343	0.4904	0.5000	0.251	0.01355
DFR	M	136	13.5515	12.0000	5.601	0.4803
	F	344	13.6047	13.0000	4.545	0.24503
PicSource	M	130	0.7358	0.7800	0.187	0.0164
	F	336	0.7473	0.8000	0.183	0.00998
WMz	M	115	0.1219	0.2367	0.802	0.0748
	F	300	−0.0295	0.1287	0.831	0.04795
Ospan	M	120	39.0667	41.0000	9.138	0.8342
	F	314	35.3726	38.0000	10.781	0.60842
CD	M	122	0.7960	0.8300	0.123	0.0111
	F	314	0.7996	0.8250	0.115	0.00647

Lastly, I ran a correlation matrix to determine whether the number of years someone played a sport impacted their overall memory. There was a weak, negative correlation between average years of sport participation and long-term memory scores, $r = -0.057$, $p = 0.412$. This result is not statistically significant, indicating no evidence of a linear relationship between length of participation in sport and long-term memory performance. Similarly, there was a weak, negative correlation between average years of sport participation and working memory scores, $r = -0.025$, $p = 0.738$. This result is also not statistically significant, indicating no evidence of a relationship between length of participation in sport and working memory performance.

Discussion

Overall, these results were helpful in answering some questions about the relationship between memory and athletics, but not all. This study found a statistically significant difference ($p = 0.039$) between working memory in athletes to that of non-athletes, with athletes outperforming those who did not play sports on the working memory tasks. While athletes also outperformed non-athletes on long term memory tasks, the result was not statistically significant. These findings help to highlight the role of working memory in athletic performance. The statistically significant advantage displayed by athletes aligns with previous research highlighting how working memory helps athletes manage high-pressure situations. The ability to effectively utilize working memory can separate successful athletes from those who struggle in pressure situations, as seen in the previous study on tennis players (Bijleveld & Veling, 2014). This suggests that athletes' stronger working memory could be providing a competitive edge in their sport, as their higher working memory capacity aids in resisting distracting thoughts and maintaining strong performance in high-stakes conditions. In terms of long-term memory, athletes did outperform nonathletes with a mean score of 0.0321 compared to -0.0206. While not statistically significant, the outperformance suggests that there could be a real difference there with a larger sample size. In future studies, it would be helpful to recruit a set number of non-athletes compared to athletes because, in the case of long-term memory results, there were 255 non-athletes to 209 athletes.

The one statistically significant result from the individual task performance is interesting when considering visuospatial working memory. The results from our experiment revealed that athletes outperformed non-athletes in the change detection-colored squares task, with a statistically significant *p* value of 0.022. This task tested visuospatial working memory as participants had to remember the colors of squares in spatial locations, then decide whether a circled colored square had changed colors or not from the first presentation. Visuospatial working memory, specifically, is the ability to temporarily store and manipulate visual and spatial information for skills like remembering shapes, colors, movements, and locations. These skills all involve a level of visualization (Kulman, 2016). Something to consider are the responsibilities that come with playing a sport such as tracking moving objects, anticipating a play, or making a quick spatial judgment. Athletes rely on their visuospatial working memory to successfully accomplish these tasks and are constantly visualizing scenarios, like a basketball player visualizing the ball going through the hoop before shooting a free throw or a quarterback anticipating a blitz before it happens in order to throw the ball away fast. Repeatedly engaging their visuospatial working memory in whatever sport they’re playing helps give athletes a competitive advantage in game and could be the cause of them outperforming non-athletes in this specific task.

While athletes did outperform non-athletes in long-term memory tasks, there was clearly an asterisk on whether that athlete played a contact or non-contact sport. With a moderately high

F value of 4.35 and statistically significant p value of 0.015, the difference between athletes who only played contact sports and those who played either contact and non-contact sports or just non-contact sports was telling. While significant, these results are limited by the difference in sample sizes, with 49 people in the only contact group, 69 in the contact and non-contact, and 95 people in the only non-contact group. This was an uncontrollable factor as students were not recruited based on sports and is a common limitation throughout results with discrepancies in sample sizes.

The results from the comparisons across gender did not find any significant differences, unlike prior research. A previous study found that auditory and visual working memory were both affected by exercise or participation in athletics, but only in male participants (Lineweaver et al., 2020) or that male athletes scored significantly better on baseline visual memory test scores (Covassin et al., 2006). The only result that neared statistical significance with a *p* value of 0.059 was the paired associates long term memory task, which indicated that female students outperformed male students. Despite nearing significance, this sample size discrepancy was even worse than others, with 343 females to 134 males. With these groups being so uneven, it is difficult to make any conclusions from this experiment about the role of gender in memory.

The years someone played a sport proved to not be a significant factor. The question on the demographics form was placed there because I theorized that playing a sport for longer (ten years versus one) could impact memory differently, but that proved to not be the case.

Lastly, the results found no significant differences between those who played team sports and those who played individual sports. Prior research separated athletes into static, interpretive, or strategic sports with similar criteria to my team versus individual sports categories. This research did find that strategic sport athletes, soccer, outperformed non-athletes and static athletes, tennis and kendo players in visuospatial working memory (Sato et al., 2022). The similarly grouped team versus individual groups in this experiment did not find that same effect with either working or long-term memory.

The main limitation of my study is how athletes versus non-athletes were defined, with participants self-reporting sport participation. To have a stronger test of the hypothesis, it would be helpful to have athletes who play sports at a collegiate level versus athletes who play sports but not at a collegiate level, and then non-athletes. This would help to really determine whether high-level athletes differ in their memory abilities. Additionally, by gathering participants exclusively from the University of Oregon's human subject pool, SONA, the sample will be naturally biased toward Western Educated Industrialized Rich and Developed (WEIRD) beliefs. Since this study will not be representative, the results may not be relevant to all cultures. As a result of this pooling, most students participating will be psychology students completing this lab for class credits, so there will not be a complete representation of all students.

Conclusion

This study explored differences between athletes and non-athletes' memory performances. It also looked at how factors like gender or the type of sport played could further impact memory performance. This study found a significant difference between athletes and non-athletes' working memory performances, with no significant difference in long term memory performances. Athletes did outperform non-athletes in both categories, but only to a statistically significant degree in working memory. This stronger working memory aligns with previous findings that found working memory to be a competitive advantage within athletes. Specifically, when analyzing individual tasks, it was determined that athletes have a stronger visuospatial working memory. This is an advantage for athletes in many ways, and further research should aim to discover whether this memory can be trained in athletes and how to do so.

Additionally, athlete's stronger long-term memory also suggests promise for future research with a larger sample size that recruits high-level collegiate athletes. However, this stronger long-term memory is essentially thrown out if that athlete is playing a contact sport. Despite uneven groupings, this study found strong evidence of contact sports negatively effecting long term memory relative to non-contact sports or not playing sports. Further research should continue to incorporate the element of concussions and how those could be playing a role in deteriorating long term memory. Overall, athletes seem to have a slight advantage in long term memory, so a logical explanation for why that advantage goes away in contact sports could be concussions/head trauma.

Although this study did not find any differences in how gender impacts memory, the sample sizes were completely uneven, and it would be helpful for future studies to recruit an even number of males and females to be able to better draw conclusions.

The amount of time someone played a sport proved to be non-significant in how that sport impacted the athlete's memory. These results are similar to previous research in this lab done by Derek Graham, who found that there was no significant correlation between average years someone played a sport and their working memory performance (Graham, 2023). The last category looked at, whether someone played a team or an individual sport, proved to not be significant in dictating working or long-term memory performance.

Future direction for this research involves recruiting set numbers of even sample sizes and recruiting specifically by sport. An even number of high-level collegiate athletes, amateur athletes, and non-athletes will be split into three groups and will then further be evenly divided into things like gender or contact versus non-contact sports.

Annotated Bibliography

American Psychological Association. (2018, April 19). *Apa Dictionary of Psychology*. American Psychological Association. https://dictionary.apa.org/long-term-memory

Baddeley, A. (1992). Working Memory. *Science*, *255*(5044), 556–559. http://www.jstor.org/stable/2876819
Alan Baddeley describes working memory and its subcomponents: the central executive which controls attention, the visuospatial sketch pad which handles visual images, and the phonological loop which stores and rehearses information obtained from speech. Unlike earlier studies, he differentiates working memory from short-term memory and explains the role of working memory in predicting individual differences between people's cognitive skills. He discusses that more research has been done on the “slave systems” of working memory (the visuospatial sketch pad and the phonological loop) than the central executive. A key focus is on the extensive research done on the phonological loop, including its main jobs as well as phenomena related to this system that have been discovered in labs.

Bijleveld, E., & Veling, H. (2014). Separating Chokers From Nonchokers: Predicting Real-Life Tennis Performance Under Pressure From Behavioral Tasks That Tap Into Working Memory Functioning. *Journal of Sport and Exercise Psychology*, *36*(4), 347– 356. https://doi.org/10.1123/jsep.2013-0051
This study took 45 competitive tennis players who had a mean age of 24.9 and had them take an automated operation span task (AOSPAN) to measure their working memory capacity as well as the Balloon Analogue Risk Task (BART) to measure how often they took risks. A main finding was that people who start with a higher working memory capacity do not have as much trouble handling the load of distracting thoughts that emerge under pressure than those who start with a lower working memory capacity.

Covassin, T., Swanik, C. B., Sachs, M., Kendrick, Z., Schatz, P., Zillmer, E., & Kaminaris, C. (2006). Sex differences in baseline neuropsychological function and concussion symptoms of collegiate athletes. *British journal of sports medicine*, *40*(11), 923-927
This study took American collegiate athletes from various northeastern universities and tested them using the computer system, “ImPACT”, which tested their neurocognitive functions and concussion symptoms. The study concluded that female athletes outperform male athletes when their baseline verbal memory was tested, but male athletes outperformed females on baseline visual memory.

Erickson, K. I., Voss, M. W., Prakash, R. S., Basak, C., Szabo, A., Chaddock, L., Kim, J. S., Heo, S., Alves, H., White, S. M., Wojcicki, T. R., Mailey, E., Vieira, V. J., Martin, S. A., Pence, B. D., Woods, J. A., McAuley, E., & Kramer, A. F. (2011). Exercise training increases size of hippocampus and improves memory. *Proceedings of the National Academy of Sciences*, *108*(7), 3017–3022. https://doi.org/10.1073/pnas.1015950108

This study took 120 older adults and randomly assigned them to an aerobic exercise group or a stretching control group. Hippocampal volume typically shrinks around one to two percent in older adults, but this study found that aerobic exercise could reverse this aging effect and increase hippocampal volume by two percent. This increase in hippocampal volume led to improved spatial memory.

Graham, D. (2023). *University of Oregon Libraries*. Sports' Relationship with Reaction Time and Working Memory Capacity. https://scholarsbank.uoregon.edu/xmlui/handle/1794/28674

Killiam, C., Cautin, R., & Santucci, A. (2005). Assessing the enduring residual neuropsychological effects of head trauma in college athletes who participate in Contact Sports. *Archives of Clinical Neuropsychology*, *20*(5), 599–611. https://doi.org/10.1016/j.acn.2005.02.001

This study had college athlete participants who were either not concussed, not recently concussed, or recently concussed; plus, a fourth control group of non-athletes who were not concussed. These participants took the Repeatable Battery for the Assessment of Neuropsychological Status, the post-concussion syndrome checklist, and did the Stroop task. They drew various conclusions like the fact that athletes who had a recent concussion performed poorer than the controlled subjects in immediate and delayed memory tasks. A more surprising finding was that there were noticeable memory impairments in athletes who claimed to have never been diagnosed with a concussion.

Kulman, Dr. R. (2016, April 15). *What is visual spatial working memory.* South County Child & Family Consultants. https://southcountychildandfamily.com/2015/10/14/what-is-visual-spatial-working-memory/

Labban, J. (2011). Effects of acute exercise on long-term memory. *Research Quarterly for Exercise and Sport*, *82*(4). https://doi.org/10.5641/027013611x13275192111943

This study had college students participate in brief exercises with delayed recalls of paragraph stories. One group worked out prior to exposure to the story, one group worked out after exposure, and the other was a control group that did not work out. They discovered that both exercise groups recalled more items than the control group, but only the exercise-prior group was able to recall a "significant" amount of story items compared to the control group.

Lineweaver, T. T., Kercood, S., Morgan, E. B., Rampone, S. L., Frank, C. C., McLuckie, S. A., & Reed, M. F. (2019). Working memory in collegiate athletes and non-athletes: A comparison of team-sports athletes, solo-sports athletes, frequent exercisers and infrequent exercisers. *OBM Integrative and Complementary Medicine*, *5*(1), 1–1. https://doi.org/10.21926/obm.icm.2001002

This cross-sectional, correlational study compared working memory in men and women college students across four different categories: "team-sports athletes, solo-sports athletes, frequent exercisers, and infrequent exercisers". After running the participants through five different working memory tasks, they determined that male sports athletes had an advantage in auditory working memory, and males who exercised infrequently had the best visual working memory. Additionally, it was determined that relationships between athletics/exercise and working memory was dependent on gender, with males outperforming females in visual and auditory working memory tasks.

Mayers, L. B., Redick, T. S., Chiffriller, S. H., Simone, A. N., & Terraforte, K. R. (2011). Working memory capacity among collegiate student athletes: Effects of sport-related head contacts, concussions, and working memory demands. *Journal of Clinical and Experimental Neuropsychology*, *33*(5), 532–537. https://doi.org/10.1080/13803395.2010.535506

This study took student athletes who played contact sports, athletes who played noncontact sports, and non-athletes and had them complete the AOSPAN test to measure their working memory capacity. The students who played contact sports were young but had played their respective sport for an average of 10 years. They found no significant differences in capacity between contact and non-contact athletes. An interesting finding was that scores varied depending on the specific working memory demands of that person's sport, opening different possibilities that either strong working memory helps athletes succeed or years of training improves working memory capacity.

Nyberg, S., & Pirmoradi, A. (2008). A Study of Verbal and Action Memory among Athletes and Non-Athletes. 1-20.

This research took (high school graduate) athletes, people who exercise, and people who hardly ever exercised and placed them in three different groups. They were tested on long-term memory, working memory, and vocabulary. Overall, the study concluded that there was not a statistically significant difference in the long-term memory or working memory across the three groups, regardless of how physically active the person was.

Sato, T., Kosaki, K., Choi, Y., Tochigi, Y., Shindo-Hamasaki, A., Momma, R., & Maeda, S. (2022). Association between sport types and visuospatial working memory in athletes. *The Journal of Physical Fitness and Sports Medicine*, *11*(4), 247–253. https://doi.org/10.7600/jpfsm.11.247

These researchers compared the visuospatial working memory of athletes in different sports (static, interceptive, or strategic) to that of non-athletes. The study discovered that visuospatial working memory was stronger in strategic athletes than static athletes or non-athletes. These findings indicated that visuospatial working memory could determine athletic performance in strategic sports and could also be a benefit of participating in sports.

Schack, T., & Mechsner, F. (2006). Representation of motor skills in human long-term memory. *Neuroscience Letters*, *391*(3), 77–81. https://doi.org/10.1016/j.neulet.2005.10.009

This study looked at novice and expert tennis players and what role long term memory played in their basic action movements within their serve. The researchers determined that long term memory structures were crucial for the performance of the athlete's movements. The BAC (basic action concept) networks in long-term memory are likely used as structures that can be referenced for anticipatory control.

Sean McVay record, Statistics, and category ranks. Pro. (n.d.). https://www.pro-football-reference.com/coaches/McVaSe0.htm

Yoo, H., & Taylor, B.-S. (2023). The impact of high-contact sports on memory and auditory comprehension in young athletes following sports-related concussions. *Clinical Archives of Communication Disorders*, *8*(2), 76–80. https://doi.org/10.21849/cacd.2022.00640

This research took athletes who participated in high-contact sports (defined as football, basketball, and ice hockey) and tested their memory and auditory comprehension after they suffered a sports-related concussion. These young athletes took two different common post-concussion tests to evaluate their performance in verbal and visual memory. After they were tested, the results were compared across each sport. The researchers concluded that, at a sentence level, verbal memory and auditory comprehension were not statistically different across these contact sports following sports-related concussions, although the football players did score lower on verbal memory.