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Prevalence of Concussions and Chronic Headaches in Female Collegiate Athletes

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BACKGROUND: This study assesses concussion rates and current headaches in female soccer versus non-contact sport athletes who have progressed to higher levels of competition in college.
METHODS: Soccer and non-contact sport female athletes from four universities completed questionnaires on concussion history and current headaches.
RESULTS: Soccer athletes had a significantly higher rate of concussions compared to non-contact athletes (50% versus 9%, $p<0.0001$), but there was not a significant difference in current headaches between the two groups (20% soccer; 32% non-contact). Among soccer athletes, 56% of goalkeepers, defenders, and forwards collectively reported a concussion, while only 23% of midfielders reported a concussion ($p=0.03$). Rates of reported headaches were significantly higher in soccer athletes with <15 years of experience (38% versus 11%, $p=0.009$).
CONCLUSION: Collegiate female soccer athletes had a higher rate of concussions versus non-contact-sport athletes, but no difference in rate of current headaches existed. Soccer athletes with <15 years of experience reported higher rates of headaches.

INTRODUCTION

Women's collegiate soccer has significantly grown over the years to include over 1000 different programs in the United States.[1] Studies have looked into the safety of the sport, showing a trend of higher concussion rates in female soccer athletes when compared to male soccer athletes and female athletes in other sports. [2-7]

While concussions are not the only injury experienced during soccer, they do garner attention due to their association with neurocognitive functioning.[8,9] Symptoms experienced after a concussion have been linked to cognitive dysfunction. In particular, headaches as a post-concussion symptom have been associated with overall cognitive, memory, and attention/processing speed impairment.[10] The literature suggests that collegiate athletes experience headaches at higher rates than the general population and female athletes report headaches at a higher percentage when compared to males in the same sport.[11,12] Concussions have also been suspected to exacerbate pre-existing headaches[12]. Though headaches are an established acute symptom of concussions, headaches as a long-term consequence of concussions are not well-studied.

A survey of athletes from 100 high schools found concussion rates to be the greatest among female soccer athletes at 40.5%.[2] As female soccer athletes progress to higher levels of competition, heading becomes more of an essential skill, which may increase the risk for concussions even further. In an article on collegiate female soccer athletes, concussions were the third most common injury during competition.[13] Furthermore, studies have found athletes ≥18 years of age have twice the risk of sustaining a concussion compared to younger athletes[14]. The purpose of this study is to assess rates of past concussions and current headaches in this particular population of collegiate female soccer athletes and compare it to those in non-

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contact collegiate sports. We hypothesized that female collegiate soccer athletes would have a higher prevalence of concussions and headaches than non-contact athletes.

METHODS

Institutional review board approvals from each of the four participating universities (University of Hawaii, Hawaii Pacific University, Occidental College, University of Idaho) were obtained to distribute a questionnaire to female collegiate athletes ≥18 years of age regarding concussion and headache history. Due to existing literature describing the higher rate of concussions in female athletes, this study chose to focus on this population. Teams surveyed consisted of soccer and non-contact sports teams including tennis, cross country, track & field, golf, swimming, and volleyball. Participants included athletes from NCAA Division I, II, and III teams. Both soccer and non-contact sports teams were asked about participation in other sports, diagnosed concussions, year of sustained concussion(s), days of missed practice due to concussion(s), current headaches, duration and frequency of headaches, pain scale of headaches on a 0-10 numeric pain intensity scale, medication taken for headaches, diagnosed migraine from a physician, and any neuroimaging done for headaches. Reported concussion was counted if athletes were diagnosed by a trained medical professional. Headaches were counted if athletes were currently experiencing headaches and were able to characterize their headaches by duration, frequency, and/or pain scale. Refer to **Appendix** for full questionnaires. Soccer athlete questionnaires also asked about position (e.g., goalkeeper, defender, midfielder, forward), number of years playing soccer, participation in heading drills during practice/games, and pain/headaches experienced after heading drills.

Consents and questionnaires were distributed in person (two schools) or a secured online manner (two schools). Athletes were given the option not to participate in the study. Contact information of the research team was provided if clarification of questions was needed.

Athletes who were <18 years of age and those who participated in other sports that involved contact (i.e., boxing, diving, softball) were excluded from the study. AcaStat (Winter Garden, FL) was used for basic statistical analysis including the use of a Student *t*-test to compare continuous measures and chi-square to compare categorical variables between groups. Values were considered statistically significant when $p \leq 0.05$. Descriptive statistics were also used to summarize data (means, ranges, frequencies).

RESULTS

We surveyed 165 female athletes across four universities: 62 from the University of Hawaii, 43 from Hawaii Pacific University, 30 from Occidental College, and 30 from the University of Idaho. Among the 165 athletes that responded to the surveys, 62 (37.6%) were from the University of Hawaii, 43 (26.0%) from Hawaii Pacific University, 30 (18.2%) from Occidental College, and 30 (18.2%) from the University of Idaho. The response rates for the University of Hawaii, Hawaii Pacific University, Occidental College, and the University of Idaho were 84.9% (62/73), 82.7% (43/52), 31.6% (30/95), and 36.1% (30/83) respectively. Surveys given to the University of Hawaii and Hawaii Pacific University were done fully in-person with a response rate of 84.0% (105/125). Surveys given to Occidental College and the University of Idaho were all completed online with a response rate of 28.6% (60/210). Refer to **Table S1** for a breakdown by sports team and response rates. We identified 132 athletes who met the inclusion criteria. Their demographics are summarized in **Table 1**.

Soccer athletes had a significantly higher rate of reported concussions than non-contact athletes ($p<0.0001$). Of those with concussions, the frequency of multiple concussions was not significantly different between the two groups. Average years since athletes' last concussion was similar between the two groups 3.0 years for soccer athletes and 2.9 years for non-contact sport athletes. Some athletes were not able to recall the number of days of missed practice due to their concussion or gave vague responses (e.g. "at least a few months"), so this value could not be reported. Current headache frequencies were also not significantly different between the soccer and non-contact sport athletes (**Table 2**). Additionally, frequencies of current headaches did not differ between athletes that had a history of at least one concussion and those without a history of concussion.

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Table 1. Demographics of soccer versus non-contact sport athletes

	Soccer	Non-Contact Sport
Number of Athletes	66	66
Number of Athletes by University	University of Hawaii: 25 Hawaii Pacific University: 27 Occidental College: 0 University of Idaho: 14	University of Hawaii: 10 Hawaii Pacific University: 13 Occidental College: 28 University of Idaho: 15
Athletes by NCAA Division	Division I: 39 Division II: 27 Division III: 0	Division I: 25 Division II: 13 Division III:28
Soccer Position/Main Sport	Goalkeeper = 6 Defender = 26 Midfielder = 13 Forward = 20	Swimming = 29 Track & Field (TF) = 12 Cross-Country (CC) = 11 Tennis = 9 Volleyball = 3 Golf = 1 TF + CC = 1
Average Age (mean, range)	19.5 (18-24)	20.0 (18-25)
Average Years Participated in Soccer (mean, range)	14.5 (10-20)	-

Table 2. Reported past concussions and current headaches

	Soccer	Non-Contact Sport	p-value
Reported Concussion (%)	33/66 (50%)	6/66 (9%)	<0.0001
Number of Repeated Concussion (%)	8/33 (24%)	1/6 (17%)	NS
Average Years Since Last Concussion (mean, range)	3.0 (0.5-7)	2.9 (0.5-5)	NS
Reported Current Headache (%)	14/66 (21%)	21/66 (32%)	NS
Duration of Headache			
> 1 hour	7/11 (64%)	8/17 (47%)	NS
< 1 hour	4/11 (36%)	9/17 (53%)	NS
Frequency of Headache			
Daily	1/13 (8%)	3/19 (16%)	NS
Several times per week	5/13 (38%)	7/19 (37%)	NS
Once a week	3/13 (23%)	5/19 (26%)	NS
Rarely	4/13 (31%)	4/19 (21%)	NS
Use of Medications (%)	7/14 (50%)	17/21 (81%)	NS
Over-the-counter (%)	7/7 (100%)	14/17 (82%)	NS
Prescription (%)	-	3/17 (18%)	NS
Seen by MD for Headaches (%)	2/14 (14%)	5/17 (29%)	NS
Formally Diagnosed with Migraine Headache	2/14 (14%)	2/17 (12%)	NS
Imaging (CT/MRI) for Headaches (%)	1/14 (7%)	2/21(10%)	NS
Average Pain Scale Rating (0-10 Numeric Pain Intensity Scale) (mean, range)	3.9 (1-6)	4.3 (1-9)	NS

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When soccer athletes were stratified based on soccer experience (<15 years of experience versus ≥15 years of experience), rates of concussions were the same in both groups, but the current headache frequency was greater in athletes with <15 years of soccer playing experience (**Table 3**). Of note, 3 athletes did not report their years of soccer experience. The age range of the cohort is narrow and thus, age stratification (>20 years versus ≥20 years) did not demonstrate any differences in headache or concussion rates.

Table 3. Reported concussions & headaches by years of soccer experience

	< 15 Years of Experience	**≥ 15 Years of Experience**	***p*-value**
Reported Concussion (%)	14/26 (54%)	17/37 (46%)	NS
Reported Current Headache (%)	10/26 (38%)	4/37 (11%)	0.009

Among the 65 soccer athletes who reported both position and concussion history, 6 were goalkeepers (9%), 26 defenders (40%), 13 midfielders (20%), and 20 forwards (31%). 83% of goalkeepers, 54% of defenders, 23% of midfielders, and 50% of forwards reported a history of concussions. Collectively, goalkeepers, defenders, and forwards combined reported a significantly higher rate of concussion compared to midfielders (56% versus 23%; p=0.03) (**Table 4**).

Table 4. Reported concussions in soccer athletes by position

Soccer Position	**Number of Athletes (n=65)**	**Reported Concussion**
Defenders	26 (40%)	14/26 (54%)
Forwards	20 (31%)	10/20 (50%)
Goalkeepers	6 (9%)	5/6 (83%)
Midfielders	13 (20%)	3/13 (23%)

DISCUSSION

Consistent with previous studies, our results showed female collegiate soccer athletes had a significantly higher rate of concussions compared to other non-contact female athletes.[2-7,15] Although female soccer athletes in this study reported a higher rate of concussions than non-contact athletes, they did not differ significantly in rates of current headaches. In general, headaches are not uncommon among female athletes and have been reported at higher rates than their male counterparts.[12] Headaches have also been described as an acute symptom of concussions; however, several studies examining post-traumatic headaches in children found that the majority resolved by three months and only a small percentage of children complained of persistent headaches one year later (2%).[16,17] This may explain why there was no significant difference in the rate of current headaches experienced between the female college soccer athletes and non-contact athletes. This may also explain why there was no measured difference in current headaches between athletes with or without a concussion history. Notably, none of the participants who completed the survey reported a concussion within the last three months. Thus, our results seem to support previous studies that headaches are not a long-term consequence of concussions.

However, due to the small sample size of this study an association or lack thereof between concussions and long-term headaches cannot be made. Additionally, this does not suggest that other long-term consequences do not exist. Studies have pointed to overall cognitive, memory, attention, processing speed impairment as well as depression and behavioral dysregulation linked to prior concussions.[10,18] Our study was also not able to determine the reason for the greater headache frequency in those with less than 15 years of soccer experience despite no difference in concussion rates between the two groups. Future studies are needed to better assess this.

Within the group of soccer athletes, midfielders had a significantly lower rate of concussions compared to the collective rate of concussions among goalkeepers, defenders, and forwards. There is no consensus among studies on which position sustains the most concussions; however, a study by Weber et al.[19] found that forwards had the most concussions in a cohort of NCAA Division I women's soccer athletes. Other studies suggest goalkeepers are at the highest risk of sustaining a concussion.[20-22] Among the athletes surveyed in our study, goalkeepers had the highest incidence of concussions with 5 out of 6 athletes reporting a history of concussions.

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These results may be explained by the type of head impact sustained rather than the number of impacts. With the correct technique employed, intentional headers usually do not lead to concussions.[23,24] A study by Lamond et al.[25] measured linear head accelerations of collegiate women's soccer athletes and found higher mean accelerations during head-to-head impacts and unintentional deflections compared to intentional heading (e.g., shots, passes, clears). Their study also found that peak linear head acceleration was the same among each position in their cohort, but all recorded head impacts in their goalkeepers were unintentional.[25] This can help to explain why goalkeepers may be at a higher risk; however, this conclusion cannot be drawn from this study due to the small sample size (n=6). A more robust sample size is needed to fully elucidate these findings.

Limitations

In addition to a small sample size, another limitation of the study was that the etiology of current headaches could not be elucidated by self-reported answers and could not be validated by secondary search in an EMR. Patients described onset, frequency, duration, and severity of headaches and if they have ever been diagnosed with a migraine; however, we were unable to conclude if the current headache was directly related to traumatic brain injury (TBI). However, by including a control group, if headaches were non-TBI related, we would expect the rate of headaches to be similar between the two groups.

In this study, participants were excluded from the non-contact group if they reported additional participation in a contact sport. However, participants were not specifically asked about previous participation in contact sports, which means that a participant in our non-contact group who may have sustained a concussion from previous participation in a contact sport like soccer would not have been identified and appropriately excluded.

A potential confounding factor of the study was that surveys were administered through two methods: a secure online platform or in-person. Participants' responses were higher when delivered in-person. Therefore, due to a lower response rate from online participants, a complete representation of teams may not have been captured. Additionally, though surveys were sent to schools of varying NCAA division levels to capture the breadth of collegiate athletes, we recognize that concussion reporting protocol, education, and management may differ based on NCAA division level.

CONCLUSION

In this study, female collegiate soccer athletes experienced a significantly higher rate of concussions compared to their non-contact sport counterparts; however, reports of current headaches experienced between the two groups were not significantly different. A larger sample size would be needed to further assess if an association between concussions and long-term headaches exists and if soccer position is related to risk of concussion.

Conflict of Interest Statement

The authors report no conflict of interest with the contents of this manuscript.

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APPENDIX

Table S1. Response Rate by university and sport

University	*Sport*	*Response Rate (%)*
University of Hawaii	Soccer	29/30 (96.7%)
	Softball	23/23 (100%)
	Swimming	10/20 (50.0%)
Hawaii Pacific University	Cross Country (CC)	5/13 (38.5%)
	Soccer	30/30 (100%)
	Tennis	8/9 (88.9%)
Occidental College	Cross Country (CC)	5/29 (26.3%)
	Golf	1/6 (16.7%)
	Swimming	12/25 (48.0%)
	Volleyball	1/14 (7.1%)
	Track & Field (TF)	11/31 (35.5%)
University of Idaho	CC & TF	5/32 (15.6%)
	Soccer	14/32 (43.8%
	Swimming	8/27 (29.6%)
	Tennis	1/7 (14.3%)
	Volleyball	2/17 (11.8%)

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Survey 1. Survey for Soccer Athletes

INTERVIEW QUESTIONS FOR SOCCER PLAYERS

1. List your age:_____ **Today's date**:_____

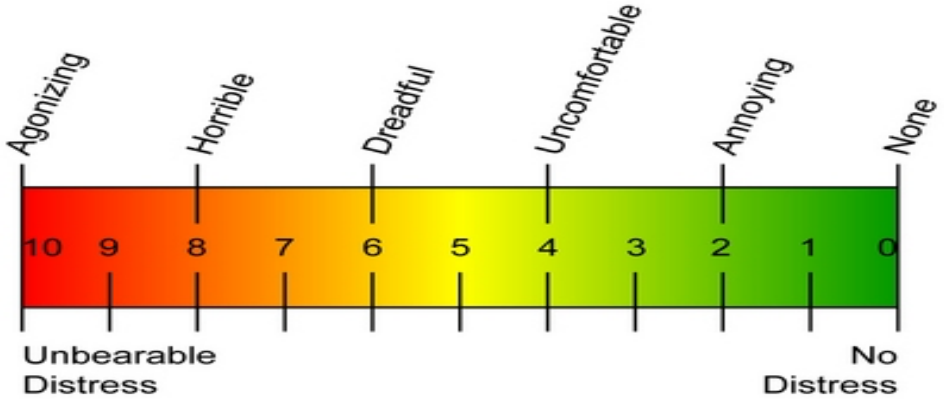
SOCCER PLAYERS
2a. What position do you play? Goalkeeper / Defender / Midfielder / Forward
2b. How many years have you played soccer?

2c. Do you participate in heading drills during practice? YES / NO (If NO, skip to question 3)
2d. If YES, does your head often hurt afterwards? YES / NO
2e. If YES, does the pain continue to the next day? YES / NO
2f. If YES, how many years have you participated in heading drills?

3. Do you participate in any other sports which involve striking your head such as boxing, martial arts, diving, football, rugby, etc? YES / NO (If yes, specify which sports

4. Have you ever been diagnosed or told by a trained medical professional that you have had a concussion? YES / NO
4a. What year were you diagnosed? _____
4b. How many days of practice and/or games did you have to miss because of your concussion? (if multiple concussions, _____ please list the number of days missed for *each* concussion)_____

5. Are you currently experiencing headaches? YES / NO (if NO, you are completed with this survey)
5a. When did these headaches begin? _____
5b. How long do they typically last? Less than 1 hour / Longer than 1 hour
5c. How often do you get headaches? Daily / Several times per week / Once a week / Rarely
5d. Circle the number on the pain scale below that best describes the typical intensity/severity of your headaches.



6. Have you / do you take medication to treat your headaches? YES / NO (If NO, skip to question 7)

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6a. What kind of medication do you take as treatment? Over-the-counter / Prescription
6b. If you take prescription medication for headaches, please name it (optional):_____

7. Have you ever seen a doctor for your headaches? YES / NO (If NO, you are completed with this survey)
7a. Have you ever had a Cat Scan (CT) or MRI for your headaches? YES / NO
7b. Have you ever been diagnosed with migraine headaches? YES / NO

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Survey 2. Survey for Non-Contact Athletes

INTERVIEW QUESTIONS FOR NON-SOCCER PLAYERS

1. List your age:_____ **Today's date**:_____

CONTROLS – OTHER SPORTS

2a. What is your dominant sport? Tennis / Cross country / Golf / Swimming / Volleyball / Track and field

2b. In what context do you play this sport? College / Adult league

3. Do you participate in any other sports which involve striking your head such as soccer, boxing, martial arts, diving, football, rugby, basketball, etc? YES / NO (If yes, specify which sports)

4. Have you ever been diagnosed or told by a trained medical professional that you have had a concussion? YES / NO

4a. What year(s) were you diagnosed? _____

4b. How many days of practice and/or games did you have to miss because of your concussion? (if multiple concussions, _____ please list the number of days missed for *each* concussion)_____

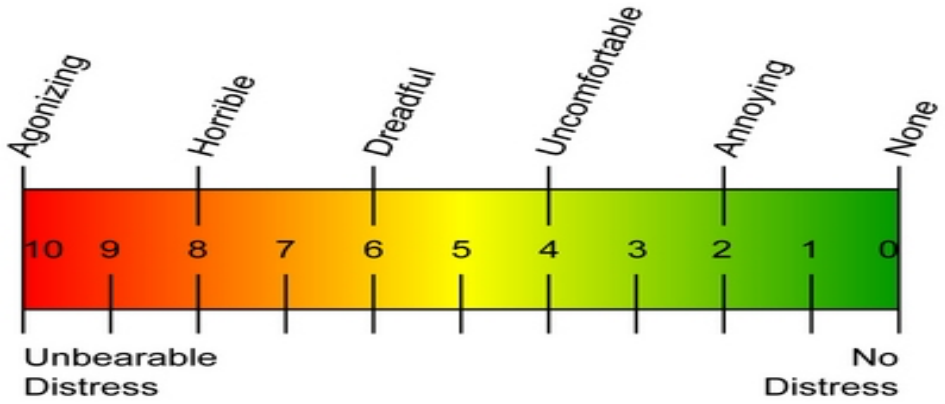
5. Are you currently experiencing headaches? YES / NO (if NO, you are completed with this survey)

5a. When did these headaches begin? _____

5b. How long do they typically last? Less than 1 hour / Longer than 1 hour

5c. How often do you get headaches? Daily / Several times per week / Once a week / Rarely

5d. Circle the number on the pain scale below that best describes the typical intensity/severity of your headaches.



6. Have you / do you take medication to treat your headaches? YES / NO (If NO, skip to question 7)

6a. What kind of medication do you take as treatment? Over-the-counter / Prescription

6b. If you take prescription medication for headaches, please name it (optional):_____

7. Have you ever seen a doctor for your headaches? YES / NO (If NO, you are completed with this survey)

7a. Have you ever had a Cat Scan (CT) or MRI for your headaches? YES / NO

7b. Have you ever been diagnosed with migraine headaches? YES / NO

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