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## Introduction

In the fields of neurology and sports medicine, concussion incidence among athletes has garnered significant interest. In contact and semi-contact sports, athletes are measured to be particularly susceptible to concussions and other forms of mild traumatic brain injury. Numerous studies have been conducted to identify patterns of concussion incidence within certain demographics, as well as assess the factors that may explain these patterns. Some have specifically evaluated differences in concussion incidence rates between male and female collegiate athletes in order to determine whether the risk of suffering a concussion is dependent on gender. These studies have focused on sports with relatively similar rules and play between men and women. Generally, investigations of this nature from the last decade have shown higher reported concussion incidence rates among collegiate females than males. These findings have produced considerable contemporary debate over the validity of these patterns, and whether or not they are almost wholly consequent of reporting bias as opposed to physiological or sport-specific factors. This essay accepts that reporting bias has exerted some degree of influence upon the aforementioned trends, but seeks to challenge the notion that there is no genuine correlation between gender and the risk of suffering a concussion through examination of anatomical, physiological, and sport-specific factors.

This research question is worthy of investigation because the issue of the incidence and potential prevention of concussions is a dominant topic in contemporary athletics and sports medicine. The possibility of a greater risk for women as opposed to men is a widely discussed topic in these fields, not only because it is a possibility that remains questioned and contested for its viability, but because further investigation into the legitimacy of such possibilities can, by

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extension, offer further investigation into concussion incidence among athletes, symptom expression, and lowered risks of occurrence.

### Contextualized Definition of Concussion

It is imperative to acknowledge in investigations involving concussions that the nature of the injury itself often creates difficulties in its definition; however, an underlying definition must be provided all the same. A concussion is best characterized as a syndrome rather than as an injury. According to the American Association of Neurological Surgeons, concussions are formally defined in medicine as “clinical syndrome[s] characterized by immediate and transient alteration in brain function, including alteration of mental status and level of consciousness, resulting from mechanical force or trauma.” As can be gleaned from this definition, concussions are injuries of an uncertain nature. The manner in which they can occur is highly variant, and during any analysis of concussion-related data, there is a degree of systematic error in identifying individual concussions, as well as distinguishing between separate concussions and escalations or continuations of ongoing post-concussion syndrome.

Such error is particularly significant in comparisons of concussion incidence rates between male and female athletes. Since the clinical diagnosis of a concussion is almost solely reliant on symptom expression rather than quantitative data, measured rates would likely be affected in some part by potential differences in how much one gender expresses concussion symptoms compared to the other – though it is unclear to what degree such error occurs.

### Introduction to Established Patterns of Concussion Incidence

Numerous studies on concussion incidence among collegiate athletes – across multiple sports and events – have found higher concussion incidence among participating females than

males. A comprehensive review of several such studies reveals certain patterns and proffered explanations for concussion incidence across several collegiate sports with male and female counterparts. Additionally, an expansive review of prominent existing data in the field will establish that researchers in this specific field do in fact find, on a notably consistent basis, that female athletes are reporting higher rates of concussion incidence than male athletes. Before this investigation on potential reasons for this pattern can proceed, the accepted existence of such a pattern must be proven, rather than the investigation operating on an unjustified assumption that there is sufficient data showing the existence of such a trend.

One notable research initiatives showing a significant difference in concussion rates between genders was a cohort study conducted using the National Collegiate Athletic Association (NCAA) Injury Surveillance system during the 1997-1998, 1998-1999, and 1999-2000 athletic seasons. The study found that in certain contact and semi-contact sports, female athletes suffered significantly more concussions than their male counterparts<sup>1</sup>. Lacrosse – a sport involving highly physical play between athletes – was one of the highlighted data sets, as women’s lacrosse was shown within the data to be the sport posing the “highest inherent risk of sustaining a concussion during a game situation” (Covassin, Swanik, and Sachs, 2003). Additionally, within the data provided by this study, female soccer players had the highest rate of concussions among all female and male sports featured in the investigation. Consistent with other studies, such as that of Powell and Barber-Foss<sup>2</sup>, such data suggests that women are at greater risk for suffering mild traumatic brain injuries than men.

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<sup>1</sup> Covassin, T., Swanik, C. B., and Sachs, M. L. (2003). “Sex Differences and the Incidence of Concussions Among Collegiate Athletes.” *Journal of Athletic Training*, 38(3), 238-244.

<sup>2</sup> Powell, J.W., and Barber-Foss, K.D. (1999). “Traumatic Brain Injury in High School Athletes.” *The Journal of the American Medical Association*, 282(10), 958-63.

Yet another example of a project supporting a higher risk for female athletes was a retrospective cohort study conducted over a 15-year span at Columbia University by researchers for the American Academy of Orthopaedic Surgeons. The study published in 2017, examined 1,200 Columbia varsity athletes at risk for sports concussions. The study found that a higher percentage of female athletes (23.3%) suffered a concussion compared to 17.0% of male athletes, and concluded in its discussion that, based on its findings, “female athletes were more likely than male athletes to experience concussion.”<sup>3</sup>

Acknowledgement of the apparently significantly higher rates of concussion among female athletes was further echoed by a report published at McGill University on the unique challenges of female collegiate athletes concerning prolonged concussion symptoms. The authors of the report expressed disappointment at the high volume of concussion-related studies focused on American football (where athletes are exclusively male), stating, “this is unfortunate, given that females have experienced concussion rates that are 1.4 times higher than males in sex comparable sports”<sup>4</sup>. This statistic was cited as being sourced from a 2016 study by Covassin, Moran, and Elbin that recorded higher rates of concussion for female NCAA athletes in baseball/softball, basketball, ice hockey, and soccer than male athletes. The McGill report’s mention of this pattern demonstrates the prevalence of findings that suggest that female collegiate athletes are more vulnerable to concussions. Having established that such a trend is found with such consistency in frequency in relevant studies, it is now possible to investigate whether such an established pattern is reflective of a significant imbalance of risk between

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<sup>3</sup> Davis-Hayes, C., Gossett, J. D., Levine, W. N., Shams, T., Harada, J., Mitnick, J., and Noble, J. (2017). Sex-specific Outcomes and Predictors of Concussion Recovery. *Journal of the American Academy of Orthopaedic Surgeons*, 25(12), 818-828. doi: 10.5435/JAAOS-D-17-00276

<sup>4</sup> André-Morin, D., Caron, J. G., and Bloom, G. A. (2017). Exploring the Unique Challenges Faced by Female University Athletes Experiencing Prolonged Concussion Symptoms. *Sports, Exercise, and Performance Psychology*, 6(3), 289-303.

genders, or whether this imbalance is in fact negligible because the results of studies such as those aforementioned are too strongly affected by sources of error such as reporting bias.

### Discussion of Potentially Influencing Sources of Error

Before an attempt is made to explain possible reasons for female collegiate athletes across multiple sports demonstrating comparatively higher rates of concussion that would support that such patterns are in fact valid, the strongest potential counterarguments must be addressed. There are multiple factors to consider that may affect the results of studies measuring concussion incidence in collegiate athletes.

As previously discussed, the very nature of concussions themselves causes great difficulty in properly and accurately diagnosing them. There is a consequent necessity to consider the effect of reporting bias on measured concussion rates. R.W. Dick, in a 2009 study in the *British Journal of Sports Medicine* involving a critical literature of gender-specific concussion rates in sports, wrote that since a diagnosis of concussion is reliant on self-reporting, and since evidence suggests that females report concussions more honestly than males, “it is unclear whether the concussion incidence data, while generally consistent in showing a higher risk in females as compared to males [...] is influenced by a reporting bias.”<sup>5</sup> The evidence that Dick encountered in his critical literature review did strongly indicate that female athletes are at a higher risk for concussion, but Dick took care to note in his conclusion that the above sources of potential influence must be considered, and that there is also evidence to suggest differences in the outcomes of traumatic brain injury for females as opposed to males.

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<sup>5</sup> Dick, R.W. (2009). Is There a Gender Difference in Concussion Incidence and Outcomes? *British Journal of Sports Medicine*, 43(1), 46-50.

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Of course, as it is established that the diagnosis of concussions is almost exclusively reliant on the symptoms that the patient displays and reports, potential differences in the symptom expression of females compared to males are highly significant if they are in fact consistent. The previously referenced 2017 Columbia University study in the *Journal of the American Academy of Orthopaedic Surgeons* by Davis-Hayes, et al. collected follow-up data on those athletes within the study who suffered a concussion, and took note on any significant differences in postconcussion symptoms between males and females. Although the study noted that general postconcussion symptoms were similar by gender, the only statistically significant and notable difference was in sleep disturbance, which was reported by 42.0% of female athletes as opposed to 29.3% of male athletes.

If females are in fact more severely *impacted* by concussions (not necessarily that they are actually more prone to getting concussed and suffer more traumatic brain injuries), it appears likely that female athletes would report concussions more frequently than male athletes. This could cause medical professionals to more often grant a diagnosis of a concussion to females rather than males. Given that medical professionals must decide on a diagnosis to make based on the symptoms that females report (and the data obtained by the aforementioned study would be similarly reliant on the *reported* symptoms provided by the athletes participating in the study), if females report more symptoms or report being more affected than males, it is not unreasonable to assume that females are more likely to be given a diagnosis. By extension, then, it is possible to argue that this factor may inflate the reported concussion incidence rates of female athletes in multiple sports.

The 2016 study by Covassin, Moran, and Elbin that was cited in the McGill University report noted that female collegiate athletes in soccer, basketball, ice hockey, and softball/baseball

“took longer to recover from their concussions than did male collegiate concussed athletes”. In collegiate and professional sports teams, the time loss experienced by injured athletes is typically heavily impacted by the prescribed period of recovery given to them by their medical caregivers, and these athletes are often forced to wait for clearance from team doctors before being allowed to return to play. Time loss is a product of diagnosis and prescribed treatment, which, in the context of concussions, is in turn a product of self-reporting by potentially injured athletes. By that standard, the increased time loss experienced by female athletes would be directly influenced by their reporting honesty.

Reporting bias has been a critical point of focus for researchers investigating the concussion rates between male and female athletes, since it is so commonly considered to be a major potential source of error in this research. Studies have been conducted to examine whether a gender discrepancy exists in concussion reporting accuracy among athletes from a younger age itself, and whether those discrepancies may apply to collegiate demographics as well. A January 2017 study published by M. Wojtowicz, et al. in the *Journal of Neurotrauma* examined the consistency of self-reported concussion history in adolescent athletes and attempted to use the collected data to predict how the accuracy of self-reporting in female and male athletes could potentially predict and explain how accurately and how different female and male *collegiate* athletes report concussions. The data showed that “boys provided inconsistent concussion histories [...] somewhat more frequently than girls.”<sup>6</sup> The authors acknowledged that gender differences in rates of concussion incidence had been previously noted by other studies, as well as gender differences in symptom reporting, and wrote that “adolescent boys have been found to

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<sup>6</sup> Wojtowicz, M., Iverson, G. L., Silverberg, N. D., Mannix, R., Zafonte, R., Maxwell, B., & Berkner, P. D. (2017). Consistency of Self-Reported Concussion History in Adolescent Athletes. *Journal of Neurotrauma*, 34(2), 322–327. <http://doi.org/10.1089/neu.2016.4412>

have worse recall of injuries over time, compared with adolescent girls, and former male collegiate athletes have been found to be less likely to disclose concussion history” (Wojtowicz, Iverson, Silverberg, Mannix, Zafonte, Maxwell, and Berkner, 2016).

It is of great significance that studies appear to indicate that male collegiate athletes have been found to be less likely to disclose concussion history, as it has already been established that the accurate and honest disclosure of concussions and concussion symptoms are critical both to diagnosis and to data collection surrounding concussion incidence rates. A study published in *The American Journal of Sports Medicine* in 2016 investigated possible motivations for the non-disclosure of self-reported concussions in collegiate athletes. The researchers found that a greater percentage of males reported non-disclosed self-reported or self-identified concussions than females<sup>7</sup>, reflecting previous correlating behavioral findings. Of course, it seems highly likely that if males are more likely to neglect to report traumatic brain injury, measured concussion incidence rates among male athletes would be negatively impacted and would reflect lower numbers than what exists in actuality. From this standpoint, the argument that female athletes are in fact at greater *risk* for concussions – as opposed to simply reporting them with more frequency than their male counterparts – appears to be in question.

However, that argument cannot be immediately refuted by the aforementioned data. There is little to no question that documented rates of concussion incidence would be impacted by the reliability with which athletes report their concussions; however, the previously mentioned study on concussion non-disclosure noted that while there are several studies suggesting that reporting honestly is worse among males, overall research results in the field

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<sup>7</sup> Kerr, Z. Y., Register-Mihalik, J. K., Kroshus, E., Baugh, C. M., & Marshall, S. W. (2016). Motivations associated with non-disclosure of self-reported concussions in former collegiate athletes. *The American Journal of Sports Medicine*, 44(1), 220–225. <http://doi.org/10.1177/0363546515612082>



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have been mixed, saying that there have been studies conducted among college athletes that did not find any sex difference in concussion reporting. Thus, while it is likely that concussion incidence rates are to some degree affected by error (as is often the case with any set of scientific data), it cannot be immediately concluded that this error's impact is to the extent that such consistently found differences in concussion incidence rates between males and females can be rendered statistically insignificant.

While the Wojtowicz et al. study found males to *more often* report inaccurately, this did not mean that girls were not also sometimes providing inconsistent reports. 17.2% of the girls in the study reported different concussion histories during a follow-up than they had reported before compared to 19.9% of boys. While the percentage of girls was lower, there was clearly some degree of inaccuracy in concussion reporting among females as well. If such error did in fact affect the results of collegiate studies, the numbers for females and males would have both reflected lower rates than reality. Even if the males' numbers were more skewed, the fact that such error applies to both genders means that it is far more difficult to justify rendering gender differences in concussion incidence rates statistically insignificant based on the fact that there are studies finding males to more often report inaccurately.

It is also of significance that both the Wojtowicz et al. study and the study on motivations of non-disclosure were based on self-reported concussions. The study on motivations on non-disclosure specifically mentioned that a greater percentage of males were reporting self-identified or self-reported concussions. This distinction implies that athletes were responding based on what they suspected to have been concussions and not necessarily what would have passed as a diagnosed concussion. Concussion-like symptoms can sometimes be isolated

remnants of past head injury history as opposed to indicators of a new injury, which is part of the criteria for giving a certain diagnosis of concussion.

Thus, while necessary to acknowledge and advisable to accept as offering a certain degree of error, reporting bias is by no means sufficient basis on its own to dispel the notion that females may in fact be at higher risk for concussion incidence than males.

### Discussion of Potential Anatomical, Physiological, or Sport-Specific Reasons for Gender Differences in Rates of Concussion Incidence

Having addressed factors that could potentially skew measured differences in concussion incidence rates between male and female collegiate athletes, it is the natural step to next consider anatomical, physiological, and sport-specific factors that may support that females are more vulnerable to suffering a concussion in the first place compared to males.

Leading studies on the topic have focused on collecting data from sports that both genders play, for obvious reasons. However, differences in the rules and the nature or style of play between males and females in certain sports could account for differences in risk. In their 2003 study, Covassin, Swanik, and Sachs found women to be producing particularly higher rates of concussion incidence in lacrosse and soccer, both of which are sports in which incidental contact between players and between players and equipment are frequent during play. The authors noted that, in contrast to male lacrosse players, female lacrosse players are not required to wear a helmet, because their sport is classified as noncontact.

Such a classification is a product of differing rules for play between male and female lacrosse players. According to the study's discussion, males are allowed to make physical contact with opponents, while females are not. However, the lack of permitted body checking in

a sport does not indicate an absence of potentially-concussive elements within the playing field. Even in technically “non-contact” or “semi-contact” sports, incidental contact still poses a risk. In lacrosse, for example, collisions with other opponents or equipment is not uncommon. In soccer, a sport where women appear to consistently report surprisingly high rates of concussion, players often suffer incidental contact from scenarios such as attempting to head the ball, even though the rules forbid intentional contact with opposing players. Heading the ball itself is a potentially concussive motion, due to the way in which the neck snaps backward and then forward and the contact made to a moving ball with the forehead. Combined with the frequently-observed scenario of two players competing for a header and striking each other in the head instead, it is obvious that this common element of soccer alone would add to the danger of concussions. Covassin, Swanik, and Sachs proposed their own potential explanations for the significantly greater number of concussions among female soccer players than male soccer players in the study. They noted that a possible factor could be the smaller general physical size of female athletes, which would suggest that female soccer players have a greater ball-to-head size ratio than male players (Covassin, Swanik, and Sachs, 2003). Of course, if the general smaller physical size of female athletes does influence concussion rates in some sports, it is not unreasonable to assume some degree of influence by the athletes’ physical size in other sports as well, especially those involving contact with other players.

Ice hockey is another example of a sport with misleading rule variations. Although females are not allowed to body check purposefully like male players, they are still permitted to make contact – and, in fact, a 2014 study in the *Journal of Biomechanics* found that despite this rule difference, contact with another player was the most common source of injury for both genders. It was, however, noted in the same study that male players experienced both a higher

frequency of impacts and impacts of greater acceleration magnitude compared to females<sup>8</sup>. Similar trends were reported in some of the above studies, such as those of lacrosse, where male players are generally bigger and more aggressive during play. Of course, this leaves one to speculate why female athletes – if they are experiencing less frequent impacts of generally lesser magnitude – would truly be suffering more concussions.

One potential reason is that the lessened expectation for concussive contact in women's sports could cause a lessened likelihood in those women being pulled from play and checked for a concussion. The Wojtowicz et al. study noted that athletes in contact sports – including both males and females – reported concussions more inaccurately than athletes in non-contact sports, since athletes and trainers in contact sports were more used to potentially concussive impacts and were thus less likely to consider individual impacts to be of consequence. It is possible that a similar trend might apply to a comparison between men's and women's athletics, where the lessened expectation of there being concussive impacts in women's sports may lead to less frequent calls for tests to be conducted on a potentially injured athlete.

There have also been suggestions that anatomical and physiological factors may explain why women, despite suffering impacts of a lower magnitude, may nonetheless be more vulnerable to concussions. A 2018 article for the *Scientific American Mind* exploring the possibility of women being more vulnerable to concussions based on brain-wiring differences, highlighted a study done at the University of Pennsylvania. The study revealed that female axons – projections of neurons that are critical in conducting electrical impulses in the nervous system – were smaller and thinner. Under identical simulations of sudden head trauma, cell culture

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<sup>8</sup> Wilcox, B. J., Beckwith, J. G., Greenwald, R. M., Chu, J. J., McAllister, T. W., Flashman, L. A., ... Crisco, J. J. (2014). Head Impact Exposure in Male and Female Collegiate Ice Hockey Players. *Journal of Biomechanics*, 47(1), 109–114. <http://doi.org/10.1016/j.jbiomech.2013.10.004>

models of female axons revealed more subsequent damage than male axons. Such results led the director of the study to propose that when exposed to the same mechanical forces, the female brain is more injuriously impacted than the male brain<sup>9</sup>.

Differences in neck musculature and spinal anatomy may also play a part in women's apparently higher vulnerability. A 2008 study published in the *Journal of Biomechanics* quantitatively compared head/neck anthropometry, vertebral geometry, and neck strength in men and women of the same heights. The women were found to have significantly smaller proportions in their head and neck anatomy, and several of the women's vertebrae were smaller in the anterior-posterior dimension compared to males<sup>10</sup>. Additionally, when tested for flexion and extension, women's necks were significantly weaker.

Placing all of this information about the anatomy and physiology of men and women into the context of sports-related concussions offers a strong possible explanation for why women may experience more concussions and more symptoms. Concussions occur when the neck undergoes whiplash, thereby causing a difference in velocity between the moving skull and the brain. If men have greater neck musculature, they would likely be able to better handle impacts to the head, even if male athletes apparently experience impacts of greater magnitude. Women, meanwhile, would likely be far less resistant to impacts to the head, since their necks are less capable of resisting hyperextension and hyperflexion. Additionally, if their axons are more susceptible to damage, concussive impacts would have a higher impact on brain chemistry, causing more symptoms of greater severity.

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<sup>9</sup> Makin, S. (2018). Do Brain-Wiring Differences Make Women More Vulnerable to Concussions? *Scientific American Mind*, 29(2), 8-11.

<sup>10</sup> Vasavada, A. N., Danaraj, J., and Siegmund, G. P. (2008). Head and Neck Anthropometry, Vertebral Geometry, and Neck Strength in Height-Matched Men and Women. *Journal of Biomechanics*, 41(1), 114-121.

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## Conclusion

Factors such as neck strength and axon structure eclipse the boundaries of the play and rules of certain sports – regardless of how head impact occurs, it seems expected that female athletes would experience concussions more often than men. Even after one considers potential factors of error, it appears that women who suffer even incidental contact in the various scenarios present in sports of high concussion rates are at a greater danger for suffering significant mild traumatic brain injury. Impacts that may not warrant a concussion for a male athlete would not necessarily be safe for a female, either. In sports such as soccer, where males and females play a similar game with similar potentials for incidental contact with equipment or other players, it is in consideration rather unsurprising that females would report significantly greater rates of concussion incidence, since anatomy would suggest that their risk of concussion is greater than males' risk of concussion in the same scenarios.

Again, it would be difficult to suggest that the higher reporting honesty of women would not skew the data – it most probably does. That higher reporting honesty, however, may in some part be because women are experiencing more damage from concussive impacts than men; this would actually support that their risk of meeting the criteria for what is clinically considered a concussion is greater. Although gender differences in concussion incidence may be inflated by factors such as reporting bias, the sheer volume of studies showing higher rates of concussion in female athletes across multiple collegiate sports, examination of the perceived and real differences in athletic play between genders, and the differences in pertinent anatomy give ample support to the notion that such differences do, in fact, reflect a difference in risk of injury.

## References

- André-Morin, D., Caron, J. G., and Bloom, G. A. (2017). Exploring the Unique Challenges Faced by Female University Athletes Experiencing Prolonged Concussion Symptoms. *Sports, Exercise, and Performance Psychology, 6*(3), 289-303.
- Covassin, T., Swanik, C. B., and Sachs, M. L. (2003). "Sex Differences and the Incidence of Concussions Among Collegiate Athletes." *Journal of Athletic Training, 38*(3), 238-244.
- Davis-Hayes, C., Gossett, J. D., Levine, W. N., Shams, T., Harada, J., Mitnick, J., and Noble, J. (2017). Sex-specific Outcomes and Predictors of Concussion Recovery. *Journal of the American Academy of Orthopaedic Surgeons, 25*(12), 818-828. doi: 10.5435/JAAOS-D-17-00276
- Dick, R.W. (2009). Is There a Gender Difference in Concussion Incidence and Outcomes? *British Journal of Sports Medicine, 43*(1), 46-50.
- Kerr, Z. Y., Register-Mihalik, J. K., Kroshus, E., Baugh, C. M., & Marshall, S. W. (2016). Motivations associated with non-disclosure of self-reported concussions in former collegiate athletes. *The American Journal of Sports Medicine, 44*(1), 220–225.  
<http://doi.org/10.1177/0363546515612082>
- Makin, S. (2018). Do Brain-Wiring Differences Make Women More Vulnerable to Concussions? *Scientific American Mind, 29*(2), 8-11.
- Powell, J.W., and Barber-Foss, K.D. (1999). "Traumatic Brain Injury in High School Athletes." *The Journal of the American Medical Association, 282*(10), 958-63.
- Vasavada, A. N., Danaraj, J., and Siegmund, G. P. (2008). Head and Neck Anthropometry, Vertebral Geometry, and Neck Strength in Height-Matched Men and Women. *Journal of Biomechanics, 41*(1), 114-121.

Wilcox, B. J., Beckwith, J. G., Greenwald, R. M., Chu, J. J., McAllister, T. W., Flashman, L. A., ... Crisco, J. J. (2014). Head Impact Exposure in Male and Female Collegiate Ice Hockey Players. *Journal of Biomechanics*, 47(1), 109–114.

<http://doi.org/10.1016/j.jbiomech.2013.10.004>

Wojtowicz, M., Iverson, G. L., Silverberg, N. D., Mannix, R., Zafonte, R., Maxwell, B., & Berkner, P. D. (2017). Consistency of Self-Reported Concussion History in Adolescent Athletes. *Journal of Neurotrauma*, 34(2), 322–327. <http://doi.org/10.1089/neu.2016.4412>