Can neck strengthening reduce sport-related concussion (SRC) risk?: A review and synthesis of the literature

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1 Introduction

Sport-related concussions (SRC) represent a growing health concern for athletes in Canada and around the globe. As such, there's a push to identify factors within athletes' control that may decrease their risk of injury. A factor that has gained attention over the last several years is the potential for improved neck strength to reduce SRC risk (Collins et al., 2014; Eckner et al., 2014; Honda et al., 2018; Hrysomallis, 2016). Researchers have suggested that incorporating neck strength training into an athlete's routine may be a feasible and inexpensive way to reduce injury risk (Collins et al., 2014; Hrysomallis, 2016). Neck strengthening may be particularly important for athletes often known to have lower neck strength, such as female and youth athletes (Cheng et al., 2019; Halstead et al., 2018; Streifer et al., 2019).

2 Purpose and objectives

This review's purpose is to summarize the research exploring the protective effects of neck strength on SRC risk. By summarizing that research, we want to provide sport organizations, coaches, trainers and clinicians with information to help them make educated decisions about including neck strengthening exercises in their athletes' training programs. Specifically, the review focuses on the neck's role during an impact as well as strategies for improving neck strength.

The review's objectives are to:

- Highlight the relationship between neck strength and SRC risk
- Identify at-risk populations for having low neck strength
- Explore the literature for programs on neck strengthening

3 Search strategy

To explore the literature surrounding the relationship between neck strengthening and SRC risk reduction, we searched 4 databases (PubMed, DOAJ, Google Scholar and Elsevier Science Direct) using the terms "neck strength" or "cervical musculature" and "sport-related concussion" and "risk reduction" or "prevention" or "biological sex differences." We identified additional articles by manually searching through reference lists of key articles included in this review. We included studies in the review if they were peer-reviewed and published in English between 2014 and 2021. In total, we identified 21 articles to include in this review.

4 Summary of findings

4.1 The relationship between neck strength and concussion risk

An SRC is caused by a hit to the head or body, which causes the brain to accelerate into the skull (Peek et al., 2020). Researchers have suggested that improving neck muscle strength may be a way to reduce SRC risk (Peek et al., 2020; Streifer et al., 2019). The reason is that individuals with increased neck strength may be able to absorb the forces of a hit through their muscles (Halstead et al., 2018). And as a result, the individuals may experience less head motion (that is, acceleration and velocity) after an impact, compared to what people with weaker neck muscles would experience (Collins et al., 2014; Eckner et al., 2014; Enniss et al., 2018; Peek et al., 2020; Streifer et al., 2019).

Individual studies' findings are mixed, so further investigation is required to determine the relationship between neck strength and SRC risk. However, several studies note that increased neck strength may be associated with a reduced risk of SRC (Hrysomallis, 2016). For example, over a two-year timeframe Collins et al. (2014) examined the relationship between SRC occurrence and neck strength in over 6000 male and female athletes playing soccer, basketball and lacrosse. In their study, the researchers found that neck strength was a significant predictor of SRC risk, meaning that individuals with greater neck strength and size had less risk of injury (Collins et al., 2014). Interestingly, the researchers found that athletes had a 5% decrease in SRC risk for each 1 pound of additional neck strength (Collins et al., 2014). Other studies further support the protective effects of neck strength. Those studies note that increased neck strength reduces the head's angular and linear velocity during an impact, which may in turn, decrease SRC risk (for example: Eckner et al., 2014). While these studies didn't explore the protective effects of neck strengthening programs on SRC, they indicate that neck strengthening may be one way to reduce SRC risk. More research is needed to know for sure.

Studies suggest there's potential for anticipatory neck muscle activation (hereafter called "bracing for impact") to reduce SRC risk (Chavarro-Nieto et al., 2021; Eckner et al., 2014; Honda et al., 2018; Jin et al., 2017). Bracing for impact causes the neck muscles to contract and couples the head to the torso (Enniss et al., 2018). This creates a more rigid segment with a greater segment mass. In turn, that segment mass may reduce the amount of head acceleration an athlete experiences following an impact (Eckner et al., 2014; Enniss et al., 2018). In their study, Eckner and colleagues (2014) noted that bracing for impact was beneficial for athletes, regardless of their neck strength. With this in mind, coaches may consider working with athletes, particularly those at risk of having low neck strength, so they're better able to anticipate and prepare themselves for an impact. For example, coaches could work with the athletes to improve their in-play awareness, through visual and sensorimotor training (Kung et al., 2020).

4.2 Risk factors for low neck strength

If low neck strength may increase a person's risk of SRC, then coaches, trainers and others may help to protect athletes from SRC by identifying who is likely to have low neck strength. This review identified 3 at-risk groups for low neck strength:

- children and youth
- female athletes
- individuals with forward head posture (FHP)

4.2.1 Children and youth

There's somewhat limited research exploring the correlation between neck strength and SRC risk in the youth population. However, preliminary evidence suggests that low neck strength may contribute to youth athletes' risk of SRC (Caswell et al., 2014; Peek et al., 2020). In the literature, researchers noted that youth often have lower neck strength and a greater head-to-neck mass ratio compared to adults (Caswell et al., 2014; Peek et al., 2020). As such, youth may experience more head acceleration and an increased risk of SRC, because they're unable to absorb the forces applied to their body during an impact (Caswell et al., 2014; Peek et al., 2020). Clinicians, coaches and trainers should be aware of youth athletes' vulnerability to low neck strength and its relationship to SRC risk. Additionally, clinicians should consider monitoring youth for neck pain, because neck pain in this population has been correlated with an increased risk of SRC (Streifer et al., 2018).

4.2.2 Female Athletes

Female athletes appear to be at an increased risk of sustaining an SRC compared to male athletes (Koerte et al., 2020; Lin et al., 2018). This increased SRC risk may partially be due to female participants having lower neck strength, smaller neck girth, and lower neck muscle mass, compared to their male counterparts (Covassin et al., 2018; Engleman et al., 2021; Koerte et al., 2020; Lin et al., 2018; Nagai et al., 2020; Streifer et al., 2019). Due to lower neck strength, female athletes may experience more significant angular acceleration and displacement of their heads during an impact, which may result in an increased risk of SRC (Cheng et al., 2019; Peek et al., 2020). While few studies have examined the role of strength training on reducing SRCs among female athletes, the existing research suggests female athletes with increased neck strength may be at a decreased risk of SRC. For example, in their review of the literature, Honda et al. (2018) noted that female soccer players with stronger neck muscles had a lower SRC risk than those who had weaker neck muscles.

4.2.3 Forward head posture (FHP)

An individual's posture may contribute to the amount of head acceleration they experience during an impact (Streifer et al., 2019). In turn, this may influence their SRC risk. For example, researchers have suggested that forward head posture (FHP or “text-neck”) can reduce head-neck segment stability (Streifer et al., 2019). Individuals who spend a lot of time leaning over phones or laptops often show signs of FHP.

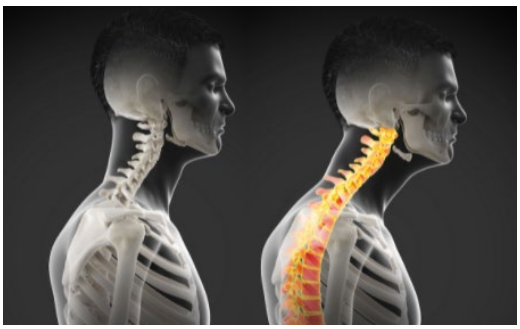

Figure 1: A normal head posture (left) compared to FHP (right).

Reduced head-neck stability can increase head acceleration during an impact, which may contribute to an increased risk of SRC (Streifer et al., 2019). This reduced head-neck stability happens in part because FHP activates superficial neck muscles, instead of deep neck muscles that are responsible for cervical support (Streifer et al., 2019). Additionally, FHP causes an imbalance in the ratio of neck flexor and extensor strength (Streifer et al., 2019). That imbalance has been associated with increased head acceleration following an impact (Peek et al., 2020). In general, clinicians should consider assessing neck strength and posture when screening for SRC risk (Streifer et al., 2019). Athletes who spend a lot of time working at a desk may benefit from neck strength training as well as from elevating their workspace and taking regular activity breaks to rest their neck.

4.3 Neck strengthening programs

Several studies have explored the effectiveness of strength training protocols for improving neck strength in athletes, but few have explored the link between neck strength training and SRC risk. Hrysomallis (2016) performed a literature review that noted significant increases in neck strength were seen in healthy athletes who underwent neck strength training programs. Among the strengthening programs used in the literature, common exercises included dumbbell shrugs and lateral neck flexion and extension exercises (Caswell et al., 2014; Hamlin et al., 2020; Hrysomallis, 2016; Rotto et al., 2020).

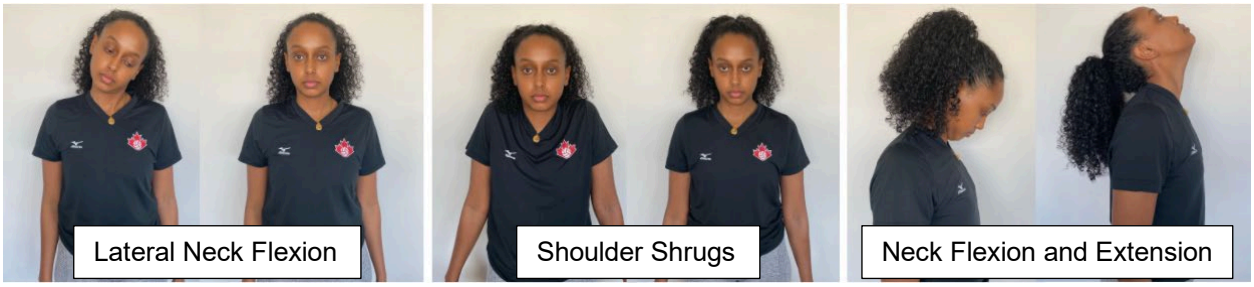

Figure 2: Examples of neck strengthening exercises seen in the literature. Note that these are just some examples of neck strengthening exercises. Please consult a trained professional to determine what exercises are right for you or your athletes.

Exercise programs of varying frequencies, intensities and durations were examined in the literature (Hrysomallis, 2016). However, programs with a higher frequency (more than twice per week) and intensity (more repetitions) typically resulted in more muscle gains than those with lower frequencies and intensities (Hrysomallis, 2016). This body of research also demonstrated that neck strength could increase in as little as 6 weeks (for example: Hamlin et al., 2020). Such research highlights the potential for neck strengthening to have protective effects in a short time frame.

A variety of equipment can be used for neck strengthening, including resistance and virtual reality devices (Hrysomallis, 2016). However, Hyrosommalis (2018) and Caswell et al. (2014) both recommend that neck strength programs use limited or inexpensive equipment to make these programs available to a larger portion of the population. Regardless of what equipment is used, to avoid injury to the athletes, they should be trained on proper neck strengthening techniques by a certified professional (Caswell et al., 2014; Hrysomallis, 2016).

5 Conclusion

This review provides sport organizations, coaches, trainers and clinicians with information that can help them promote and develop neck strengthening programs for athletes. Specifically, this review highlighted the neck's role in supporting the head during an impact and identified strategies to improve neck strength.

According to the research, athletes with lower neck strength may be more susceptible to SRC. This is because lower neck strength reduces an athlete’s ability to mitigate the forces applied to their head and body during an impact. Thus, athletes with lower neck strength may experience greater head motion than athletes with stronger neck musculature, which can increase SRC risk. Research suggests that youth and female athletes, and people with forward head posture are most likely to have low neck strength, and may benefit from neck strengthening programs.

While there's evidence showing that neck strengthening programs can increase neck strength, researchers have yet to establish a clear link between neck strengthening programs and SRC risk. That said, several studies have shown that SRC risk tends to be lower when neck strength is greater. Taken together, these studies support the use of neck strengthening interventions as a potential, preventative measure against SRC. However, more research is needed to explore a direct link between neck strengthening protocols and SRC risk reduction.

Takeaway points

- Athletes with lower neck strength may be more susceptible to SRC, because they may experience more head acceleration during an impact.
- Female and youth athletes may be more susceptible to SRC because of differences in their neck size and strength.
- Neck strengthening programs are effective for improving neck strength. However, more research is needed to determine if these programs can reduce SRC risk.

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