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## Is there any proof that protective equipment in rugby can prevent or reduce the severity of concussion?

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## Introduction

Concussion is a “complex pathophysiological process affecting the brain, induced by biomechanical forces”<sup>27</sup> and is a common sports injury with approximately 1.6 – 3.8 million sport-related concussions being reported annually in the USA<sup>22</sup>. Possible symptoms of concussion include headache, amnesia, confusion, visual disturbances, gait disturbances and loss of consciousness<sup>23</sup>.

Symptoms may persist, lasting from days to months post injury<sup>25,37</sup> and can result in absence from school, work or sporting competition. The recent emergence of studies suggesting potential detrimental long-term effects following repeated concussion injuries and their relative frequency in contact sports, highlights the need to try and reduce concussion rates.

One of the more common injury prevention strategies used in sport is the implementation of protective equipment.

Rugby union, hereafter referred to as rugby, is a game with frequent high impact collisions and therefore comes with a higher potential for concussion injuries than many team sports<sup>20</sup>. Currently rugby allows, but does not enforce, the use of mouth guards and soft foam padded headgear, which may not exceed a total thickness of 14mm (*a maximum padding thickness of 10mm, 2mm tolerance band, plus an additional allowance of 1mm on each side for fabric*)<sup>42</sup>.

Two surveys of rugby players found that 63% and 64% of rugby players, respectively, believed that headgear could prevent concussion injuries<sup>17,36</sup>. Furthermore, 40% of under 20 rugby players believed mouth guards could significantly reduce the risk of concussion<sup>1</sup>. However, the scientific literature is less clear on the effect of mouth guards and headgear in preventing concussion<sup>2,31,34</sup>.

Therefore the aim of this review is to investigate the effect of mouth guards and padded headgear on rugby concussion risk and severity reported in the published literature.

## Mouth guards

Mouth guards have been mandated in several sports worldwide in an attempt to reduce injuries. The use of mouth guards have consistently been shown to be protective against orofacial injuries<sup>7,15,21,24</sup>, but their effect on preventing and/or reducing the effects of concussion is less clear and has very weak scientific support at best, despite manufacturers’ claims.

## **Rugby Studies**

Several studies have investigated whether mouth guards can affect the incidence of concussion in rugby. Two prospective studies found no difference in concussion rates between those players using and those not using mouth guards<sup>4,24</sup>. However, these studies included only 22 and 15 concussions respectively, and thus may have lacked statistical power to show any associations. A large prospective cohort study, of professional rugby teams in England, included 81 medically diagnosed concussions<sup>19</sup>. This study showed that mouth guard use tended to reduce concussions, but the effect failed to reach statistical significance<sup>19</sup>.

## **Other sports**

The effect of mouth guards on concussion incidence has been investigated in other sports. Mouth guard use had no effect on concussion risk in a prospective cohort study on a collegiate basketball population<sup>21</sup> and had no effect on self-reported concussion history in adolescent soccer players<sup>5</sup>. However, both of these studies were limited by small sample sizes.

Delaney et al. (2002) noted a trend for increased concussion risk in American football players wearing mouth guards<sup>6</sup>. This result could have been caused by the risk compensation phenomenon<sup>11,12</sup>, which proposes that protective equipment wearers are more aggressive or risk taking and therefore may have a higher injury risk. However, this result should be interpreted with caution as only 40 concussions were reported in the study.

## **Concussion Severity**

In addition to investigating the influence of mouth guards on concussion incidence rates, several studies have also explored the effect of mouth guards on concussion severity.

A study on 180 athletes' post-concussion neurocognitive recovery found no difference in neurocognitive deficits between the players who wore mouth guards and those that didn't<sup>33</sup>.

In contrast, in another study, ice-hockey players who were not wearing mouth guards missed twice as many practices and matches following a concussion than players wearing mouth guards at the time of injury<sup>3</sup>. However, the interpretation of the study may have been limited because only 37 concussed players were observed and the groups also differed in the type of facial/head protection that they were using at the time.

### **Type of mouth guard**

Three studies looked at the effect of custom-fitted compared to standard “boil and bite” mouth guards on concussion risk.

Singh et al. (2009) in American football, investigated whether customised-mandibular orthotics, professionally fitted to both the upper and lower jaw, improved concussion prevention<sup>38</sup>. This longitudinal study showed a decrease in concussion rates after the introduction of the customised mouth guards. However, this study has been criticised for having several methodological limitations, including a poorly selected comparative group, a strong self-report bias, and a low sample size.

Contrary to Singh et al.’s findings, a large scale prospective cohort study on football players found that there was no significant difference in concussion rates between those using standard mouth guards and those with custom fitted mouth guards<sup>41</sup>.

A randomized control trial of Australian football players found that custom-fitted mouth guards reduced the incidence of all head and orofacial injuries compared to standard boil-and-bite mouth guards<sup>9</sup>. Unfortunately, this study was underpowered to statistically assess the effect on concussion injuries alone.

Custom-fitted mouth guards are regarded as more effective in preventing all injuries<sup>8,35</sup>, but there is limited evidence on whether they confer a protective effect against concussion.

### **Biomechanical Studies**

Evidence in support of the use of mouth guards in concussion prevention is often based largely on two biomechanical studies that observed an effect of mouth guards on dissipation of forces to the head after a blow to the mandible, or chin, in cadaver models. The first study found that mouth guards reduced the force transmitted to the head<sup>13</sup>, while the second study showed mouth guards significantly decreased head acceleration and distortion of the mandibular bone<sup>39</sup>.

The extent to which these findings can be applied to sports concussion has been questioned. Firstly, the use of a cadaver skull held in a fixed position may not accurately mimic the biomechanical and biological response seen in vivo.

Secondly, there is limited evidence of an association between force transduction and concussion induction<sup>26</sup>.

Thirdly, it has been argued that few sport concussions are actually caused by a blow to the mandible. It has been stated that in professional football, only 1.6% of concussions were caused by a blow to the jaw<sup>41</sup>.

Furthermore, it is unclear whether the biomechanical changes, caused by wearing mouth guards, are of a sufficient magnitude to significantly and measurably reduce the concussion incidence.

### **Conclusion around the effectiveness of mouth guards**

From the literature reviewed, there is very little evidence to support mouth guards effectively reducing concussion incidence rates or the severity of concussions.

The majority of studies are limited by small sample size or methodological inconsistencies and are therefore not properly equipped to accurately measure the effect of mouth guards. However, despite the limited evidence of mouth guards in concussion prevention, the benefits on orofacial injuries should be enough to promote the use of mouth guards in rugby.

### **Headgear**

Hard-shelled helmets have been associated with reduced concussion risk in snow sports and cycling<sup>2</sup> but the use of rigid helmets in other sports, such as rugby, is prohibited. Padded headgear has been shown to decrease the risk of abrasions and lacerations, but its effectiveness in preventing concussion is less clear<sup>16,40</sup>.

### **Rugby Studies**

In rugby, prospective cohort studies on adult club rugby players<sup>24</sup> and under 15 rugby players<sup>29</sup>, showed that headgear had no effect on concussion rates. Yet, the studies included only 22 and 9 concussions, respectively; the low numbers make any potential associations difficult to prove. A large prospective study, including 199 concussions, of under 13, 15, 18, and under 20 rugby players showed no difference in concussion rates between those players wearing headgear and those not wearing headgear<sup>31</sup>.

A study of self-reported concussion history in American rugby players noted that more concussions and longer symptom durations were reported in players not using headgear<sup>18</sup>. However, the study design was not adequately equipped to measure concussion risk as exposure was not accounted for.

In a large prospective cohort study (including 347 concussions) on adult amateur rugby players, players who stated that they always wore headgear, had a decreased risk of concussion<sup>14</sup>. A similar study in 13 professional rugby teams participating in the English Premier division, found headgear to significantly decrease concussion risk<sup>19</sup>. A major limitation of this study, was the large disparity between the numbers of players wearing headgear and those not wearing headgear to begin with. This coupled with the fact that only seven of the 81 concussions occurred in players wearing headgear, would make it difficult to compare proportional incidence or relative risk.

### ***Biomechanical Studies***

A biomechanical study of eight commercially available Australian football headgear products, similar to rugby headgear, showed no evidence for concussion prevention<sup>30</sup>. The foam of the headgear was completely compressed at 20 J, thus losing any potential protection above this level.

Concussions have been predicted to occur at 45 - 75 J, considerably higher than 20 J protection threshold offered by the headgear<sup>28,32</sup>. Therefore, based on these findings, it was proposed that thicker foam may be required and so the effect of standard and thicker modified headgear was examined in a large scale cluster randomised control trial in youth rugby<sup>31</sup>.

Teams participating in the under 13, 15, 18 and under 20 competitions were allocated into control, standard (10mm) or thicker modified headgear (16mm) groups. No risk reduction was found between standard or modified headgear<sup>31</sup>. However, a significant limitation of the study was the low compliance rate, that therefore resulted in an intention-to-treat analysis being used to examine the effect on concussion.

### **Risk compensation**

A possible confounder to the effects of protective equipment is risk compensation, described earlier, and also referred to as “Superman Syndrome”, where players become more confident and confrontational in contact because of the false sense of security provided. This was reported in a rugby study where the majority of under 15 players stated that they play more confidently and feel that they can tackle harder when they are wearing padded headgear<sup>10</sup>.

## Conclusions around the effectiveness of headgear

Although some studies showed headgear use caused a reduction in concussion risk, several studies, in conjunction with biomechanical studies, suggest that headgear use does not conclusively reduce concussion incidence.

The majority of studies are either limited by low concussion numbers or methodological inconsistencies and are therefore not adequately equipped to accurately measure the protective effect of headgear on concussions. However, headgear does reduce soft tissue injuries to the head and therefore is still beneficial in rugby.

## Take Home Message:

There is very little evidence to support the notion that the use of mouth guards or padded headgear can reduce the incidence or severity of concussion in rugby, or in other sports for that matter. However, mouth guards and headgear can provide protection against orofacial and superficial scalp or facial injuries, respectively, and therefore can still be beneficial to rugby players.

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