Orofacial injuries and mouthguard use among water polo and field hockey players in Catalonia

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"You can´t solve a problem on the same level it was created. You have to rise above it to the next level."
Albert Einstein

"Happiness can be found even in the darkest of times if one only remembers to turn on the light"
Albus Dambeldore

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CHAPTER 1

General introduction

GENERAL INTRODUCTION

Body Trauma

It has been reported that body trauma is the leading cause of death among young people aged 12–24 years. (Lam 2016) Traumatic injuries result from a variety of blunt, penetrating, or burn mechanisms. These include motor vehicle collisions, sports injuries, falls, natural disasters and other physical injuries at home, on the street, or while at work and require immediate care. Six major body regions can be affected, namely the head/neck, face, thorax, abdomen/pelvis, extremities, and external. (UFHealth 2020) Although the oral region comprises as little as 1% of total body area, it accounts for 5% of all bodily injuries. (Andersson 2013) After domestic injuries (3.7%), sports accidents are the joint second commonest type of injury (3.1%), alongside occupational accidents. Traffic accidents and pedestrian accidents are much rarer, with respective incidence rates of 1.8% and 0.8%. Among those who are physically active, the annual injury rate is 5.6%, (Schneider et al. 2006) with a physically active lifestyle being important in all age groups. Many reasons exist to take part in sports and physical activity, such as pleasure, relaxation, competition, socialisation, and health and fitness (maintenance and improvement). However, increased participation in sport and recreational activities increases the number of sport-related injuries among children and adults worldwide. (Echlin et al. 2005, Schneider et al. 2006) Most sports-related injuries occur as soft tissue injury, bony injury, or traumatic dental injury (TDI), with falls and collisions the most common causes. (Oliveira Werlich et al. 2020)

Dental Trauma

TDI has been reported as the fifth most prevalent disease or injury worldwide, affecting approximately a billion people. (Petti et al. 2018) It can occur in isolation or in association with facial or multi-system injury and has many consequences for the traumatized individual, his or her family, and wider society. The impact is not only physical but also psychosocial, (Gassner et al. 1999) with the potential for pain, distress, and disfigurement to be permanent or often require long-term management. (Tham et al. 2009) Treatment is estimated to be more expensive and time-consuming than that of all the other bodily injuries, and economic consequences have been reported at 5 million USD per million inhabitants. (Andersson 2013; Lam 2016; Petti et al. 2018)

Crown fracture involving enamel and dentin is the second most common TDI treated by dental clinics, it is associated with difficulty eating, avoidance of smiling, pain, and sensitivity, resulting in high levels of negative impacts on oral health-related quality of life. (Magno et al. 2019; Soares et al. 2018) Thus, crown fracture involving enamel and dentin requires treatment to reduce the negative impact on oral health-related quality of life, particularly in children and adolescents. (Magno et al. 2019) This is not least because, when the permanent successor is directly involved in the trauma, it causes crown or root dilaceration, displacement of the tooth germ, impacted teeth, and eruption disturbances. Therefore, long-term follow up of the patient becomes essential to diagnose and treat associated complications early. (Flores and Onetto 2019)

Sports-related accidents are one of the most common causes of facial injuries, accounting for approximately one-third of all dental injuries in children and adults. (Bazina et al. 2020; Galic et al. 2018; Glendor 2009; Tuna and Ozel 2014) Violent acts and accidents, such as fights, assaults, bicycle and motor vehicle, have also featured in most studies. (Glendor 2009) The incidence of sports-related orofacial and dental injuries is associated with the sport and athlete's age. (Galic et al. 2018) Although the prevalence has been reported to vary from 6% to 59% worldwide, (Lam 2016) a recent meta-analysis reported a global prevalence of 15.2% for all TDIs. (Petti et al. 2019) There is a general trend indicating that one-third of preschool (primary teeth) and one-quarter of adolescents and adults (permanent teeth) will experience dental trauma at least once, with TDI being more frequent in the younger and more physically active population. (Andersson 2013; Lam 2016)

It is important to note that the cumulative nature of prevalence data means that the prevalence of TDI should be greater in older cohorts even when the incidence is greater in younger cohorts (Gambucci 2018). It has been suggested that males are more likely to suffer TDI than females (a ratio of 1.5:1). (Gassner et al.1999; Petti et al. 2018) TDI in older persons also deserves attention, especially given increased activity levels and healthy lifestyles in this population. The annual incidence of TDI in older persons has been reported to be as high as 29%. (Marciani 1999) In a recent study it was highlighted that most older patients are injured in falls, with females involved significantly more often and with dentoalveolar TDI occurring in 8.8% of the cases. (Burkhard et al. 2019)

Sports and Risk of Injury

Although all sports carry a risk of injury, contact sports are associated with a particularly higher risk of dentofacial injury due to the intense competition, close proximity and physical interactions of players (Bergamn et al. 2017; Fernades et al. 2019; Oliveira Werlich et al. 2020) Further, the growth in the numbers of both amateur and professional players is another risk factor to consider in dentofacial injuries. (Oliveira Werlich et al. 2020)

The Federation Dentaire International (FDI) classifies sports into two categories by the risk of TDI: high-risk sports (e.g., American football, hockey, ice hockey, lacrosse, martial sports, rugby, in-line skating, skateboarding, and mountain biking) and medium-risk sports (e.g., basketball, soccer, handball, diving, squash, gymnastics, parachuting, and water polo). High-risk sports are characterised as team sports in which rough contact between the players is allowed or in which a ball, puck, or stick is used, but they also include some individual sports where good balance is required. Medium-risk sports comprise team sports in which rough contact is not allowed between the players, but in which there is still a risk of contact or falling. (Glendor 2009)

The overall pooled prevalence of dentofacial injuries among contact sport participants has been reported at approximately 30%. (Oliveira Werlich et al. 2020) Among Welsh and Swiss rugby players, this translates to orofacial trauma prevalence rates of 6,8% and 64.9%, respectively. (Ilia et al. 2014; Schildknecht et al. 2012) It has been estimated that up to 53.2% of child and adolescent athletes have sustained facial injuries when playing ice hockey, lacrosse, or field hockey. (Yard and Comstock 2006) The incidence of dental trauma in martial arts (e.g., jiu-jitsu, judo, taekwondo, and karate) varies from 14% to 41%. (Ferrari and Mediros 2002; Galic et al. 2018) In the Netherlands, head injuries among inline skaters have been reported in 28% of athletes. (Nooijer 2004) Additionally, TDI has been reported at rates of 20.2%–69.7% in basketball, 29%–49% in handball, and 23.1% in soccer, despite being medium-risk sports. (Bergman et al. 2017; Ferrari and Mediros 2002; Frontera et al. 2011; Galic et al. 2018; Lesić et al. 2011)

Some contact sports have also been ranked by the prevalence of dentofacial trauma, irrespective of the TDI risk. This ranking is led by rugby and followed by basketball, handball, field hockey, and soccer. In these cases, it was argued that protective devices are not used habitually in sports like soccer and handball despite the aggressive interaction among players. (Oliveira Werlich et al. 2020) Thus, it is advocated that mouthguard use should not be based solely on the risk of TDI.

Water Polo and Orofacial Trauma

Water polo is a competitive team sport that involves contact and in which injuries of the head are relatively frequent. As such, the sport has been classified as a medium risk for orofacial trauma. (ADA 2006; Blumenfeld et al. 2016; Cecchi et al. 2020; Junge et al. 2006; Mountjoy et al. 2019) The rules and governance of international water polo are overseen by the Federation Internationale de Natation (FINA), and now has 209 member federations since it was founded in 1908. Water polo is the oldest team sport in the Olympic programme, being debuted at the 1900 Olympic Games in Paris. Women's water polo joined the Olympic programme in the 2000 Olympic Games in Sydney (Mountjoy et al. 2019) and the sport has continued to gain popularity in Europe, the United States, China, and Australia. (Spittler and Keeling 2016)

In the 80s, the Spanish national team became one of the most powerful worldwide and Spain obtained a gold medal for the first time in its history in the 1996 Atlanta world championships, and again in the 1998 Perth and 2001 Fukuoka world championships, establishing itself as one of the great world powers of the sport. (Parra Jesús et al. 2006) The triumphs of men's and women's water polo teams have resulted in a large fan base and more athletes practicing the sport, with 3,443 federative licenses in Catalonia in the 2016/2017 season. (Natació.cat 2020) Water polo combines swimming, throwing, shooting, and grappling. It is physiologically very demanding due to the frequent bursts of activity (15 s) followed by brief periods of lower intensity (<20 s), and it requires a lot of physical contact, including blocking and pushing opponents. (Bazina et al. 2020)

More than a quarter of water polo injuries reported during four Summer Olympic Games (2004, 2008, 2012, and 2016) and four FINA World Championships (2009, 2013, 2015, and 2017) affected the head. (Mountjoy et al. 2019) The incidence of orofacial trauma in young water polo players has been reported at 28.8%, of which 18.6% had a dental injury. (Galic et al. 2018) Similar results were found among adolescents and adults from water polo clubs in Switzerland where 21% reported having suffered a tooth injury during training or competition. (Hersberger et al. 2012) However, the incidence of pain in the temporomandibular joints (TMJs) or masticatory muscles due to playing water polo have not been well established. Despite the great amount of contact between players, the FINA does not require the use of mouthguards as a part of the standard water polo equipment. (Balzina et al. 2020) Thus, only 5%–7.7% of water polo players reportedly use mouthguards during their sports activities. (Galic et al. 2018; Hersberger et al. 2012)

Field Hockey and Orofacial Trauma

Field hockey is another team sport that has seen a growth in popularity and participation in Catalonia. In 1964, the International Hockey Federation (FIH) included only 50 countries with affiliated national associations, but by 2019, this had increased to 137. The modern game of hockey emerged in England in the mid-eighteenth century where it was largely attributed to the growth of public schools. (FIH 2020a) For men, it has been part of 23 Summer Olympic Games, with women competing in field hockey at the Olympic Games since 1980. (Hollander et al. 2018) Hockey arrived in Catalonia at the beginning of the twentieth century, and the Regional Hockey Federation of Catalonia (FCH) was officially formed in 1923. Throughout the history of hockey in Spain, Catalan teams have dominated regional competitions and the Spanish national team in international competitions has mainly comprised Catalan players. (FCH 2020a) At the end of 2019, there were approximately 6000 federated taps according to the Catalan field hockey Federation. (FCH 2020b)

Like other high-risk sports, injuries are common in field hockey, with half of all athletes in this sport reporting injuries of the upper and lower limbs (Hollander 2018 et al.; Murtaugh 2001; Murtaugh 2009;) and 10%–68% reporting injuries of the head and face. (Collins et al. 2016; Dick et al. 2007; Hendrick et al. 2008; Hootman et al. 2007) Players who participate in stick sports, such as ice hockey, field hockey, and lacrosse, are at particularly increased risk of trauma because of the high-speed stick movement required to hit the puck or ball. (Yard and Comstock 2006) Among these contact sports, field hockey has the highest reported prevalence of dental injuries in high school athletes in the US. (Collins et al. 2016) Moreover, changes to field hockey rules (e.g., self-pass and high balls), the use of artificial turf as the playing surface, and technological advancements in hockey stick construction have potentially increased the risk of injury. The game is now faster overall and player are stronger and faster, and combined with the technical advances, the struck ball can travel at higher speeds in the air both during field play and during goal attempts, posing a high risk of injury to the head and face. (Mukherjee 2012; Theilen et al. 2016)

Despite evidence of increased injury risk, the FIH only mandates protective equipment for goalkeepers and only recommends or permits certain forms of body protection for field players (i.e., shin, ankle, mouth, or leg protection; kneepads; or if there are valid medical reasons, a smooth preferably transparent or single coloured face mask that closely fits the face, a soft protective head-covering,

or eye protection in the form of plastic goggles). (FIH 2020b) In the United States, only the National Collegiate Athletic Association has mandatory equipment rules, including the use of mouthguards for certain sports, of which field hockey is one.(NCAA 2020) In the Netherlands, all Dutch field hockey players are required to wear a mouthguard during play, (KNHB 2020) and before this requirement, 77% reported using mouthguards regularly during practice sessions and matches. (Vucic et al. 2016a) Recently, the FCH began to require that field hockey players younger than 14 years wear a mouthguard for competition. (FCH 2020c)

Mouthguards

The primary method for preventing dentofacial injury during contact sports is by wearing protective devices such as mouthguards. (Tuna and Ozel 2014) These are devices that cover the teeth and some or all of the gingiva and dissipate the force of impact to surrounding structures and act as a barrier between the upper and lower dentition. This function reduces the risk of tooth fracture or avulsion; lips, tongue, or cheeks laceration; and other orofacial injury. (Farrington et al. 2016; Gawlak et al. 2017; Lloyd et al. 2017; Parker et al. 2017) It has been suggested that mouthguards offer significant protection from orofacial injury (Collins et al. 2016; Fernandes et al. 2019; Green 2017; Knapik et al 2019; Parker et al. 2017), potentially reducing the risk by half. (Knapik et al. 2019)

Mouthguards were first introduced in boxing in the 1920s and were later used in American football due to their effectiveness at reducing oral injuries. (Parker et al. 2017) Nowadays, their use has been extended and The American Dental Association (ADA) and Academy for Sports Dentistry (ASD) recommend using properly fitted custom mouthguards in over 30 sports (ADA 2006; ASD c2020). Table 1 summarizes the sports that are now considered to require a mouthguard according to ADA.

Acrobatics	**Handball**	**Softball**
Baseball	Ice hockey	Squash
Basketball	Inline Skating	Surfing
Bicycling	Lacrosse	Tennis
Boxing	Martial Arts	Track & Field Events
Equestrian events	Racquetball	Ultimate Frisbee
Extreme Sports	Rugby	Volleyball
field events	Skateboarding	Water polo
Field hockey	Skiing	Weightlifting
Football	Skydiving	Wrestling
Gymnastics	Soccer	

Table1. Sports in which mouthguard use is recommended by the ADA

Despite evidence of increased injury risk, the FIH only mandates protective equipment for goalkeeAdditionally, the FDI provides details on how to protect the mouth during sports matches and training. It must be mentioned, however, that regulations vary by country and age. (FDI 2020) More specific recommendations by type of sport are detailed in Table 2.

MANDATORY	RECOMMENDED		
Boxing	Martial arts	Football/Soccer	Weightlifting
Taekwondo	Rugby	Cycling	Squash
Ice hockey	Basketball	Gymnastics	Water polo
American football	Handball	Equestrian sports	Field hockey
	Volleyball	Skateboarding	

Table 2. Examples of sports in which mouthguards are mandatory and recommended according to the FDI

Three general types of mouthguard exist: prefabricated mouthguards, mouth-formed mouthguards (i.e., 'boil-and-bite'), and custom-made mouthguards Prefabricated mouthguards are not adapted specifically to the patient, coming only in different sizes from among which the patient must choose the best fitting. They are generally the cheapest type and are readily available from many retail outlets, including sports shops, department stores, and chemists.

Mouth-formed or 'boil-and-bite' mouthguards are made from thermoplastic material that becomes soft and mouldable when heated. The mouthguard is placed in hot water (following the manufacturers guidelines) until the plastic becomes malleable. It is then formed to the patient's teeth, soft tissues and occlusion by applying firm manual and occlusal pressure onto the softened plastic. The moulding process is completed by the patient with minimal input from their dentist or orthodontist. (Parker et al. 2017)

Custom-made mouthguards are fabricated by dental laboratories from dental impressions. They are usually made from polyethylene vinyl acetate and their fit is checked by the dentist. Thus, they are specifically adapted to the patient. This type of mouthguard generally offers superior fit and protection compared with mouth-formed and prefabricated mouthguards, and they also interfere less with oral function. (Gawlak et al. 2017; Lloyd et al. 2017; Parker et al. 2017) The main drawbacks of custom-made mouthguards are that they involve at least one dental appointment and are more expensive than the other types.

Patients undergoing fixed appliance orthodontic treatment can mould the mouth-formed mouthguards around their braces and remoulded the mouthguard as their teeth move. Alternatively, they can use orthoguards or custom-made mouthguards that can be designed to incorporate a cut-out channel for the orthodontic appliance and allow space for tooth movement. The frequency at which the mouthguard will need to be remoulded or remade will depend on the rate and extent of tooth movement and can be advised by the patient's orthodontist. (Parker et al. 2017) Although some orthodontists have expressed concern that custom-made mouthguards may hinder tooth movement if they are not remade several times during orthodontic treatment, no published research has evaluated whether mouthguard use affects orthodontic tooth movement. (Bastian et al. 2020)

The observed frequency of mouthguard use is heterogeneous across sports and studies, as shown by the use in different high- and medium-risk sports in Figure 1. Brazilian hockey players have the highest reported mouthguard use when compared with Dutch and English athletes, possibly

because the former have a greater awareness of the risk of orofacial injury or because they give more importance to mouthguards. (Ferrari and Mediros 2002) A significant difference in mouthguard use is also seen in ice hockey players. There is no universal agreement on the mandatory use of mouthguards in this sport, but the fact that its use is mandatory in ice hockey played at a high school level in the United States could explain why 100% of those players use mouthguards. (Collins et al. 2016) Among all martial arts, boxing has the highest use of mouthguard, probably because it is mandatory. (Ranalli 2002) Although basketball and soccer players are recommended to wear mouthguards, usage varies from 0% among high school athletes from the United States to relatively high levels among Australian and Turkish athletes. Knowledge of the protective nature of mouthguards was the main reason for wear it among these athletes (Çetinbaş and Sönmez 2006; Cornwell et al. 2003), but many high school athletes who use a mouthguard in sports when it is required choose not to when it is optional. (Collins et al. 2016) Although wearing a mouthguard is not mandatory in handball, a surprisingly high usage has been observed among Croatian athletes compared with other countries. This behaviour was attributed to the influence of dentists advocating mouthguard use. (Bergman et al. 2017) In general, although athletes tend to be aware of sports mouthguards, many reported that there is a lack of information about their use and potential benefits. (Costa Palau et al. 2014)

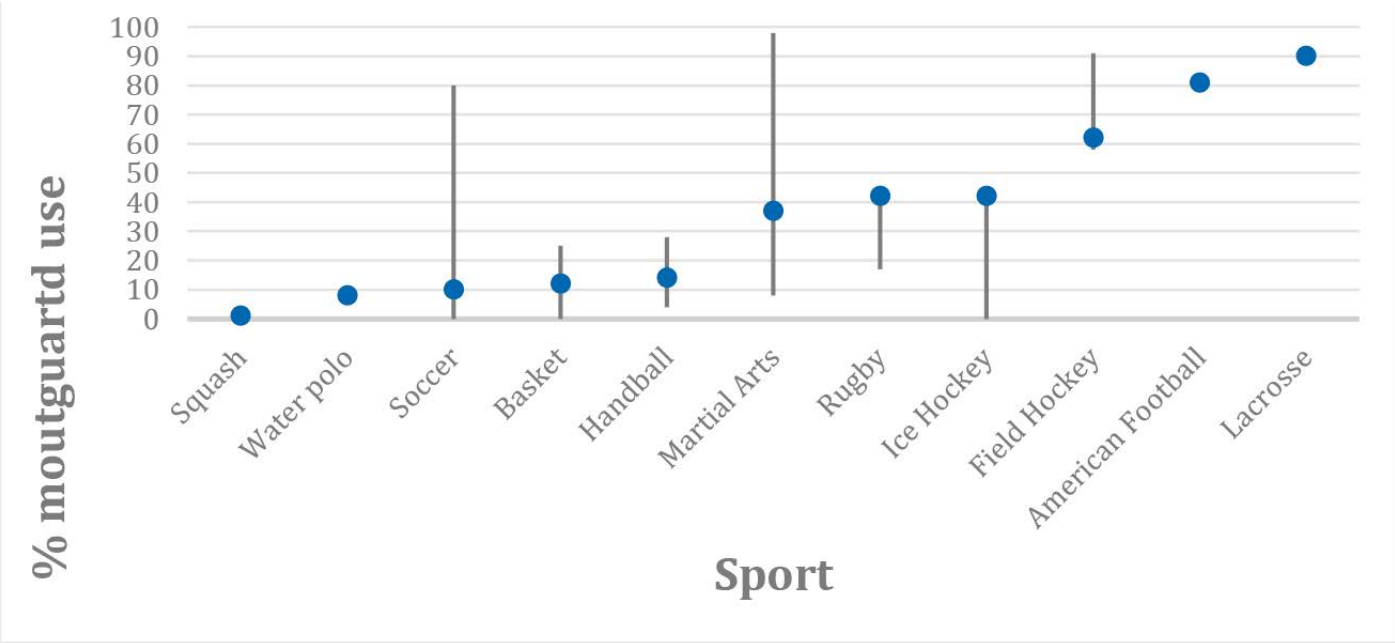

Figure 1. Frequency of mouthguard use in different sports.

Most studies have showed that the main reason athletes do not use a mouthguard is that they consider it unnecessary. (Hersberger et al. 2012; Galic et al. 2018; Kroon et al. 2016; Sepet et al. 2014; Vucic at al. 2016b) Other factors associated with the non-use of mouthguards concern impaired breathing and speech, dry mouth, nausea, high cost, and lack of information about their use. (Fernandes et al. 2019) More specifically, athletes have complained about the following: interference with speech (37%–55%), (Hendrik et al. 2008; Gómez-Gimeno et al. 2019; Vucic et al. 2016a) breathing problems (27%–45%), (Duddy et al. 2012; Gómez-Gimeno et al. 2019; Lieger 2006; Hendrik et al. 2008; Sepet et al. 2014; Vucic et al. 2016a), and discomfort (26–46%), (Boffano et al. 2012; Duddy et al. 2012; Hendrik et al. 2008) while others do not use mouthguards because they are consider expensive (36%) or to impair performance (11%). (Hendrik et al. 2008; Gómez-Gimeno et al. 2019; Vucic et al. 2016a)

Regardless of the sport, the labial flange of the mouthguard should extend to within 2 mm of the vestibular reflection and the palatal flange should extend to within 10 mm of the palatal gingival margins. (Parker et al. 2017) However, it would be of great interest to know the optimal mouthguard design for each sport, allowing us to minimise device-related discomfort if, for example, the problem is an unnecessarily oversized mouthguard. The end goal is to achieve maximum acceptance of the mouthguard from players to increase habitual use while maintaining their safety benefits. A study assessing the effect of reducing the palatal extension of a custom-made mouthguard (from 6 to 2 mm) among elite water polo players showed that almost all players preferred the shortened to the

conventional mouthguard. Players reported that the short mouthguard interfered less with speech, breathing, swallowing, and athletic performance than the conventional one. (Gómez-Gimeno et al. 2019)

The risk of orofacial injury among water polo and field hockey players in Catalonia has not been reported, nor is it known if this risk is associated with age, gender, and brace wearing. Finally, we do not know either the frequency of mouthguards use, the type used most often, or the issues experienced by athletes who use mouthguards.

THESIS OVERVIEW

Objectives:

• To determine the incidence and prevalence of orofacial injuries among water polo and field hockey players in Catalonia. **(Chapters 2 and 3)**

• To assess the most reported orofacial injuries among water polo and field hockey players. **(Chapters 2 and 3)**

• To explore the factors associated with the incidence of orofacial injury among water polo players, such as age, gender, and brace wearing. **(Chapter 2)**

• To explore the factors associated with the prevalence of orofacial injury among field hockey players, such as age, gender, and brace wearing. **(Chapter 3)**

• To clarify the frequency of mouthguard use among water polo and field hockey players. **(Chapters 2 and 3)**

• To determine the mouthguard types used by water polo and field hockey players. **(Chapters 2 and 3)**

• To explore the degree to which each mouthguard type interferes with oral function among water polo and field hockey players (including any other adverse effects). **(Chapters 2 and 3)**

Hypothesis

Considering the theoretical framework, the following successive hypothesises were proposed:
• It was expected that there would be a high incidence of orofacial injury among water polo players.
• It was expected that there would be a high prevalence of orofacial injury among field hockey players.

Thesis Chapters

Chapter 1 provides a general introduction.

Chapter 2 describes the incidence of orofacial injury and the use of mouthguards in male and female water polo players from high-level clubs in Catalonia. More specifically, the study explores factors associated with the incidence of orofacial injury, such as age and gender, among a sample with a mean age of 15 years. The study also describes the frequency of mouthguard use, the type of mouthguard used, and the degree of interference of mouthguard use with oral function as reported by athletes.

Chapter 3 outlines the prevalence of orofacial injury among male and female field hockey players in Catalonia. Additionally, it describes the factors associated with an increased prevalence, such as age, gender, and brace wearing. The study also investigated aspects related to wearing a mouthguard, specifically the frequency of use, type, and adverse effects.

Chapter 4 concludes by offering a general discussion with recommendations for future research, finishing by outlining the more general conclusions.

Chapter 5 and 6 present summaries of this thesis in English and Catalan respectively.

Chapter 7 presents a list of abbreviations used in the text.

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CHAPTER 2

Risk of orofacial injuries and mouthguard use in water polo players

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Abstract

Background/aim. The incidence of orofacial injuries and the use of mouthguards in water polo players have not been well established. This study aimed to determine the incidence of orofacial injuries in water polo players. Frequency of mouthguard use, the types of mouthguards used and the degree of interference with oral functions were also assessed.

Material and Methods. In this cross-sectional study, 347 water polo players completed a questionnaire about the orofacial injuries suffered in the 2015-2016 season and the experience of using a mouthguard, such as the type of mouthguard used and the degree of interference with oral functions.

Results. In the 2015-2016 season, 58.8% of the players reported at least one orofacial injury, with a mean number of 2.7 oral lacerations, 0.4 episodes of temporomandibular pain and 0.06 dental injuries. Among the 35 players (9.7%) who had tried a mouthguard, 4 (1.1%) used it habitually. Some players had tried more than one type of mouthguard, 26 had tried the mouth-formed type, 11 the custom-made type and 7 the prefabricated mouthguard. Custom-made mouthguards were rated more comfortable than the mouth-formed type ($p < 0.05$).

Conclusions. The incidence of orofacial injuries in water polo players was 58.8% in one season. Ten percent of the players had tried a mouthguard, mainly the mouth-formed type, but only 1% used it routinely. The main disadvantages of mouth-formed mouthguards are interferences with speaking, breathing and swallowing.

Introduction

Playing sports has physical and social benefits, with the number of individuals practising sports increasing among all social classes and ages as well as both sexes. Unfortunately, there are some disadvantages of practising sports such as accidents and orofacial injuries, with sports causing a third of all dental injuries.[1,2] It has been reported that nearly 15% of handball, basketball, rugby or floorball players have suffered dental injuries.[3–6]

Water polo is gaining increasing popularity in Europe, the United States, China and Australia. It is a high-intensity sport that requires resistance, speed, strength and body contact, carrying a medium risk of orofacial injuries.[2,7] The majority of water polo injuries affect the head, with concussion, contusions and lacerations to the face being common.[8,9] It has been reported that 21% of adolescents and adults from different water polo clubs in Switzerland have suffered a tooth injury during training or competition.10 However, the incidences of orofacial injuries in younger players and of pain in the temporomandibular joints (TMJ) or masticatory muscles due to playing water polo have not been well established. Predictors of orofacial injuries associated with playing water polo, such as age and sex, have not been well documented.[8-10]

Mouthguards dissipate the force of impact towards surrounding structures and also act as a barrier between the upper and lower dentition, consequently reducing the risk of fractures or avulsions of the teeth, lacerations to the lips, tongue or cheeks, and other orofacial injuries.[11-15] Three main types of mouthguards are normally used: pre-fabricated mouthguards, which are not fitted to the patient; mouth-formed or 'boil-and-bite' mouthguards, which are made from a thermoplastic material that becomes soft and mouldable when heated; and custom-made mouthguards, which are fabricated from dental impressions. Custom-made mouthguards provide a better fit and more protection than mouth-formed and pre-fabricated mouthguards and interfere less with oral functions.[13,14,16] The American Dental Association (ADA) recommends the use of mouthguards in 30 sports;[2] however, the frequency of mouthguard use is very low in sports in which its use is not mandatory, such as basketball, handball and rugby.[3,5,6] Water polo is included in the ADA's list of 30 sports, but the Fédération Internationale de Natation (FINA) does not stipulate the use of mouthguards. Thus, only 7.7% of water polo players in Switzerland have been reported to use mouthguards.[10] The main reasons for not using a mouthguard are that it is not considered necessary and that it interferes with breathing, speaking and aesthetics.[10] However, more information about the frequency of use and how it may interfere with oral functions is needed for the different types of mouthguards in water polo players.

The main objective of this study was to determine the incidence of orofacial injuries in water polo players from high-level clubs in Catalonia, exploring different factors associated with the incidence of orofacial injuries such as age and sex. The frequency of mouthguard use, the type of mouthguard used and the degree of interference with oral functions were also assessed.

Material and Methods

In this cross-sectional study, 707 male and female players from Catalan water polo clubs were invited. The inclusion criteria were playing in the 2016-2017 season with a federated tab for the under-10s, under-12s, under-14s, under-16s, under-18s or senior team of one of the four clubs (CN Mataró, CN Terrassa, CN Atlètic-Barceloneta and Club Esportiu (CE) Mediterrani) or training at the High Performance Sports Centre (HPSC) at Sant Cugat. Each player was informed in detail about the study and gave their oral consent to their coach, who signed the informed consent approved by the local ethics committee (Code 2016-44).

The questionnaire administered to each player aimed to obtain data on the practice of or competing in water polo games, the episodes of orofacial injuries occurring in the 2015-2016 season, and the

experience of using a mouthguard. Orofacial injuries included dental injuries, oral lacerations and temporomandibular (TMD) pain. Dental injuries consisted of fractures or avulsions of the upper or lower teeth, while oral lacerations included bleeding of the lips, tongue, cheeks or gums. TMD pain referred to episodes of pain in the TMJ or masticatory muscles that increased during jaw movements. The questionnaire also asked about whether the player had ever tried a mouthguard, the type of mouthguard worn, the degree of interference with several oral functions, such as speaking, breathing and swallowing, and other adverse effects associated with each type of mouthguard. Sex, age and the use of braces were also recorded.

The incidence of each orofacial injury in the 2015-2016 season was expressed as a percentage of the players who had suffered the injury with respect to the total number of players. The mean number of each orofacial injury was calculated as the sum of injuries with respect to the total number of players. The relationship between the number of each type of injury and age was assessed using Spearman's rank correlation. The relationship between the number of each type of injury and sex or the use of braces was assessed using the Mann-Whitney U test. The relationship between mouthguard use and sports club, age or the use of braces was investigated using a chi-squared test. The degree of interference with oral functions and other adverse effects for each type of mouthguard was compared using pair-wise comparisons with the Kruskal-Wallis test. The level of significance was set at $p < 0.05$. Data analysis was undertaken using IBM SPSS Statistics v. 24.

Results

Of the 707 water polo players invited, 364 responded, , and 17 were excluded because information were missed in the questionnaire, constituting a response rate of 49.1%. The characteristics of the participants included in this study are shown in Table 1. Among the participants, 57.9% reported at least one orofacial injury during the 2015-2016 season. The mean number of orofacial injuries in each player was 3.2 (Table 2). Lacerations to the lip and tongue were the most frequent injuries reported. The percentage of episodes of TMD pain or the number of dental injuries did not vary between the age groups. However, the number of oral lacerations increased with age (Spearman's Rho = 0.14; $p = 0.009$). Among the orofacial injuries, only dental injuries were associated with sex, males suffering more than females ($p = 0.014$; Mann–Whitney U test). The use of braces was not associated with the number of any type of orofacial injury.

Among the 35 players (9.7%) who had ever tried a mouthguard, 4 (1.1%) used a mouthguard habitually during training and 3 (0.8%) also used it during competition (Table 3). Four players had tried all three types of mouthguards, while another player had tried the mouth-formed and custom-made mouthguards. Consequently, 26 players had tried the mouth-formed mouthguard, 11 the custom-made type and 7 the prefabricated mouthguard. Among the clubs, 21% of the players from CE Mediterrani, 8% from HPSC Sant Cugat, 7% from CN Terrassa, 5% from CN Atlètic-Barceloneta and 4% from CN Mataró had tried a mouthguard ($p < 0.005$; chi–squared test). The percentage of players who had ever tried a mouthguard varied between the age groups ($p < 0.005$; chi–squared test), with the under-10s and under-12s showing the lowest percentages and the under-18s and senior team the highest. The use of braces was not associated with having ever tried a mouthguard.

The degree of interference with oral functions and other adverse effects for each type of mouthguard are summarised in Table 4. Custom-made mouthguards were rated more comfortable than mouth-formed ones in terms of loosening and soreness and interfered less with speech, breathing and swallowing ($p < 0.05$; pair-wise comparisons, Kruskal-Wallis test).

Discussion

In the present study, 59% of the water polo players reported at least one orofacial injury during the 2015-2016 season, with the average number of orofacial injuries being 3.2 per player in one season.

However, most of these injuries were mild and consisted of oral lacerations to soft tissues. Only 4.4% of the players reported a dental fracture or avulsion. In a study with Swiss water polo players, the percentage of players reporting at least one tooth injury was 21%.[10] However, that study included dental injuries occurring throughout the whole sporting life of the participants in a sample with a mean age of 29 years.[10] In the present study, the mean age of the participants was 15 years and both elite players and beginners were included. Therefore, the risk of tooth injury in a water polo player might be about 5% in one season and about 20% during a sporting life.

Age was associated with the number of oral lacerations, but not with the number of dental injuries or episodes of TMD pain. Players under 14 years reported fewer oral lacerations than older players, with the relationship between age and oral lacerations becoming insignificant in players older than 15 years. Males reported more dental injuries than females, but the other types of orofacial injuries were not associated with gender. Blumenfeld et al.[8] noted that more females than males reported at least one concussion as a result of playing water polo; however, males reported, on average, numerically more concussions. Gender as a risk factor for orofacial injuries while playing sports in general or water polo in particular is not well established.[10,17] In the present study, players who wore braces did not report more orofacial injuries than those who did not wear braces. Although it seems plausible that the use of braces could be a risk factor for orofacial injuries during sports, especially lip lacerations, no study has demonstrated a significant relationship to date.[18]

Despite the risk of orofacial injuries, only 10% of the players reported to have tried a mouthguard, with only 1% using it routinely for training and competition. The percentage of Swiss water polo players who wore a mouthguard was about 8%.[10] Differences in social and cultural aspects and the different mean ages of the samples could explain the discrepancies between our results and those involving the Swiss water polo players. The type of mouthguard most frequently tried by the water polo players was the mouth-formed one. However, the players found this type of mouthguard to fit poorly and noticeably interfere with oral functions, especially speaking, breathing and swallowing. Water polo players had fewer complaints for the custom-made mouthguards compared to the mouth-formed ones, which is in accordance with the results obtained with players of other sports including field hockey and rugby.[19,20] The players considered cost to be the worst aspect of custom-made mouthguards.

The use of an appropriate mouthguard can reduce the severity of orofacial injuries and is recommended by the ADA for different sports including water polo.[2,20,21] Several strategies at the community and individual level could be considered to increase the frequency of mouthguard use in water polo players. Federations, clubs and coaches should be made aware of the convenience of wearing a mouthguard while playing water polo. Dentists and health professionals should also encourage the use of mouthguards during sports, both for professional and amateur players, and especially for teenagers.[19,22,23] To ensure maximum protection without compromising athletic strength and performance, custom-made mouthguards should be used.[13,24] Since this type of mouthguard is expensive and not easily accessible, there should be initiatives to make it cheaper and more accessible. Furthermore, the option of making mouthguard use mandatory in competitions, as proposed recently, could also be considered.10 In fact, the mandatory use of mouthguards in rugby and ice hockey has been associated with a decreased number of dentofacial injuries.[25,26]

The best design of mouthguards for water polo players is not known. Regardless of the type of sport, the labial flange of the mouthguard should extend to within 2 mm of the vestibular reflection and the palatal flange to within 10 mm of the palatal gingival margins.[14] For water polo players, the palatal margin could be shortened to reduce interferences with oral functions, such as breathing, swallowing and speaking, without affecting tooth deflection or mouthguard retention.[27-29] All these oral functions are especially important while playing water polo because of the aquatic environment. Thus, further studies are warranted to determine the best design of mouthguards for water polo players.

Although the risk of dental injury was similar between the age groups, the percentage of senior and under-18 players who had ever tried a mouthguard was ten times higher than that for the under-10 and under-12 players. Mouthguards in growing children should be replaced or adapted periodically to accommodate for tooth eruption and the growing mouth.[30] In addition, in players undergoing orthodontic treatment, mouthguards should also be replaced or remoulded during treatment depending on the magnitude of tooth movements.[14] Despite these inconveniences, it is important to encourage parents to convince their children to use a mouthguard, with the mouth-formed type being an alternative to the custom-made type during training and competition.

In the present study, 21% of the players reported at least one episode of TMD pain, i.e., muscle pain and TMJ pain, during the 2015-2016 season. TMD pain has been reported to be the second most frequently reported type of orofacial injury among basketball players, after soft tissue lacerations.[31] These pain episodes may be produced by direct blows to the TMJ or masticatory muscles or by indirect TMJ overloading elicited by an impact striking the mandible from below which causes traumatic closure of the mandible. In the first case, a mouthguard would not be useful in preventing these types of orofacial injuries, but in the second case, a mouthguard with a bilateral and balanced occlusion could prevent the TMJ overloading produced by indirect blows to the mandible. Although teeth clenching and/or wearing a mouthguard may reduce the magnitude of the impact to the TMJ,[32] more studies are needed to demonstrate the efficacy of mouthguards in preventing TMD pain.

This study had several limitations. First, the high number of non-responders could have affected the validity of our results. However, the characteristics of this sample regarding sex and age were representative of the whole population and the response rate was similar to those of other studies.[10,20] Second, the retrospective nature of this study and the fact that the orofacial injuries were reported by the participants themselves may have affected the accuracy of the diagnosis, especially those related to TMD disorders. Hence, prospective studies are required to confirm the results. Finally, the number of training sessions and matches played differed among the participants; thus, the amount of time playing water polo and being exposed to the risk of injury was not similar among the participants.

In conclusion, the incidences of orofacial injuries in general and tooth injury in particular were 58.8% and 4.4%, respectively, for one season among water polo players from high-level clubs. The incidence of oral lacerations increased with age in players aged below 15 years. Ten percent of the players had tried a mouthguard, mainly the mouth-formed type, but only 1% used it routinely for training and competition. The main disadvantages for mouth-formed mouthguards were interferences with speaking, breathing and swallowing, while the main disadvantage for custom-made mouthguards was the cost.

TABLE 2 Description of the participants regarding their gender, age, clubs and use of braces

Characteristics	Frequency (Percentage)
Gender	
Male	224 (64.6%)
Female	123 (35.4%)
Age group	
Senior	44 (12.7%)
Under-18	61 (17.6%)
Under-16	80 (23.1%)
Under-14	67 (19.3%)
Under-12	56 (16.1%)
Under-10	39 (11.2%)
Club	
CN Terrassa	114 (32.9%)
CE Mediterrani	78 (22.5%)
CNA Barceloneta	61 (17.6%)
CN Mataró	46 (13.2%)
HPSC Sant Cugat	48 (13.8%)
Use of braces	
No	315 (90.8%)
Yes	32 (9.2%)

TABLE 3 Incidence and number of orofacial injuries reported by the participants for the 2015-2016 season

	Category by age						ALL (n = 347)
	Senior	Under-18	Under-16	Under-14	Under-12	Under-10	
At least 1 dental injury (%)	0	3.3	1.3	7.5	8.9	5.1	4.3
Mean of dental injuries (95% CI)	0	0.03 (0-0.08)	0.01 (0-0.04)	0.15 (0-0.3)	0.11 (0-0.2)	0.08 (0-0.2)	0.06 (0.03-0.10)
Mean of dental fracture upper jaw	0	0	0.01	0.09	0.07	0.08	0.04 (0.01-0.07)
Mean of dental fracture lower jaw	0	0.03	0	0.01	0	0	0.01 (0-0.02)
Mean of dental avulsion upper jaw	0	0	0	0.04	0.04	0	0.02 (0-0.03)
Mean of dental avulsion lower jaw	0	0	0	0	0	0	0
At least 1 oral laceration (%)	59.1	65.6	61.3	47.8	48.2	35.9	54.2
Mean of oral lacerations (95% CI)	3.7 (1.5-5.9)	3.2 (0-6.5)	4.0 (1.7-6.3)	2.1 (0.9-3.3)	1.4 (0.8-1.9)	1.1 (0.3-1.9)	2.7 (1.9-3.6)
Mean of lacerations on the lip	2.02	2.72	2.43	1.09	0.66	0.41	1.7 (1.0-2.3)
Mean of lacerations on the tongue	0.57	0.20	0.69	0.25	0.38	0.21	0.4 (0.2-0.6)
Mean of lacerations on the cheek	0.84	0.10	0.36	0.24	0.07	0.18	0.3 (0.2-0.4)
Mean of lacerations on the gums	0.30	0.20	0.53	0.49	0.25	0.33	0.4 (0.2-0.5)
At least 1 episode of TMD pain (%)	27.3	24.6	20.0	13.4	21.4	15.4	20.2
Mean of episodes of TMD pain (95% CI)	0.64 (0.2-1.1)	0.39 (0.2-0.6)	0.46 (0.2-0.7)	0.18 (0.1-0.3)	0.32 (0.1-0.5)	0.51 (0.1-0.9)	0.4 (0.3-0.5)
Mean of episodes of TMJ pain	0.39	0.23	0.29	0.09	0.16	0.26	0.2 (0.2-0.3)
Mean of episodes of muscle pain	0.25	0.16	0.18	0.09	0.16	0.26	0.2 (0.1-0.2)
At least 1 orofacial injury (%)	61.4	68.9	66.3	50.7	53.6	38.5	57.9
Mean of orofacial injuries (95% CI)	4.4 (1.9-6.8)	3.6 (0.2-7.0)	4.5 (2.1-6.8)	2.4 (1.1-3.7)	1.8 (1.1-2.5)	1.7 (0.5-2.9)	3.2 (2.3-4.1)

TABLE 4 Percentage of participants who had ever tried a mouthguard and percentage of players who habitually used mouthguards among the different age groups

	Category by age						
	Senior (n = 44)	Under-18 (n = 61)	Under-16 (n = 80)	Under-14 (n = 67)	Under-12 (n = 56)	Under-10 (n = 39)	ALL (n = 347)
Had ever tried a mouthguard (%)	9 (20.5%)	12 (19.7%)	9 (11.3%)	3 (4.5%)	1 (1.8)	1 (2.6)	35 (10.1%)
Habitual use in practice (%)	1 (2.3%)	0	1 (1.3%)	2 (3.0%)	0	0	4 (1.2%)
Habitual use in competition (%)	0	0	1 (1.3%)	2 (3.0%)	0	0	3 (0.9%)

TABLE 5 The degree of interference with oral functions and other adverse effects for each type of mouthguard (assessed on a 10-point scale)

	1- Prefabricated (n = 7)	2- Mouth-formed (n = 26)	3- Custom-made (n = 11)	Kruskal-Wallis	Pairwise comparisons		
					1_2	1_3	2_3
Speech	4.86	7.73	3.27	0.003	0.128	0.249	0.001
Breathing	2.14	5.40	2.00	0.011	0.036	0.925	0.009
Swallowing	2.71	6.00	2.27	0.007	0.038	0.769	0.004
Nausea	1.14	2.32	0.91	0.141			
Soreness	0	1.96	0.27	0.013	0.022	0.699	0.018
Loosening	2.14	3.73	0.91	0.016	0.15	0.426	0.006
Price	2.43	2.42	4.27	0.587			

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CHAPTER 3

Experience with mouthguards and prevalence of orofacial injuries among field hockey players in Catalonia

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Abstract

Background/aim. Orofacial injuries are a serious problem in field hockey. The aim of this study was to determine the prevalence of orofacial injuries in field hockey players in Catalonia, the frequency of mouthguard use, the types of mouthguards used and the degree of interference with oral function.

Material and Methods. In this cross-sectional study, 325 field hockey players (28% women) from all age categories completed a questionnaire about orofacial injuries occurring during their sporting lives, including dental injuries, oral lacerations and episodes of acute temporomandibular disorder (TMD) pain. The questionnaire also asked about the experience of using a mouthguard, the type of mouthguard used and any adverse effects of use. The degree of interference with oral function was compared by type of mouthguard (mouth-formed, custom-made and prefabricated mouthguards) using the Kruskal–Wallis test.

Results. Half of the players (50.2%) reported at least one orofacial injury during their sporting lives. The mean number of oral lacerations, TMD pain episodes and dental injuries were 1.59, 0.24 and 0.18, respectively. In total, 310 players (95.7%) had tried a mouthguard, and of these 269 (86.8%) and 283 (91.3%) still used a mouthguard habitually during training and competition, respectively. Only 11 players (3.5%) had tried all three types of mouthguards, and 71 players (22.9%) had tried two types of mouthguard. By type, 217 players (70.0%) had tried mouth-formed (boil-and-bite) mouthguards, 156 (50.3%) had tried custom-made mouthguards and 30 (9.7%) had tried prefabricated mouthguards. Custom-made mouthguards were rated as more comfortable than the mouth-formed type ($p < 0.05$).

Conclusions. The prevalence of orofacial injuries among field hockey players is relatively high. Most players habitually use a mouthguard during training and competition, typically preferring custom-made or a mouth-formed types. Custom-made mouthguards were considered the most comfortable.

Introduction

Dental trauma is the fifth most prevalent disease or injury in the world, affecting one billion people and having economic consequences that amount to as much as US$ 5 million per million inhabitants.[1] One in four adolescents and adults have suffered some form of dental trauma, with many of these occurring while engaged in sport.[2] Although all team sports carry a risk of injury, players who participate in stick sports, such as ice hockey, field hockey and lacrosse, are at particularly increased risk of trauma because of the high-speed stick movement required to hit a puck or a ball.3 Among these contact sports, field hockey showed the highest prevalence of dental injuries in high school athletes in the US.4

Field hockey is a team sport that has seen a growth in participation, with great popularity in Catalonia. In 1964, the International Hockey Federation (FIH) had 50 countries with affiliated National Associations, and by 2019, this had increased to 137.5 However, injuries are common, with half of all field hockey athletes reporting injuries of the upper and lower limbs6-8 and 10%–68% reporting injuries of the head and face.[4,9-14] The specific prevalence of orofacial injury due to playing field hockey ranges from 11% to 32%,[10,15-17] but this data excludes cases of pain in the temporomandibular joints (TMJs) or masticatory muscles. Furthermore, predictors of orofacial injuries associated with playing field hockey, such as age, gender or wearing braces have rarely been studied, and where they have, the results have been inconclusive.[15,17,18]

Mouthguards primarily serve to dissipate the force of impact to surrounding structures and to act as a barrier between the upper and lower dentitions, thereby reducing the risks of fractures or avulsions of the teeth, lacerations (e.g., lips, tongue or cheeks), and other orofacial injuries.[19-22] Three general types of mouthguard are in existence: prefabricated mouthguards, which are not fitted to an individual's mouth; 'boil-and-bite' or mouth-formed mouthguards, which are made from a thermoplastic material that becomes soft and mouldable when heated; and custom-made mouthguards, which are fabricated from dental impressions. In general, custom-made mouthguards provide a better fit and more protection than mouth-formed and prefabricated mouthguards, and they also interfere less with oral function.[20-23] In the Netherlands, all Dutch field hockey players are required to wear a mouthguard while playing field hockey[24] and before this requirement, 77% reported using mouthguards regularly during practice sessions and matches.[17] Recently, the Catalan Hockey Federation (FCH) began to require that field hockey players aged less than 14 years wear a mouthguard for competition.[25] In Dutch, English and American leagues, it has been reported that most field hockey players use mouth-formed or custom-made mouthguards, and that less than 4% use prefabricated mouthguards.[4,10,17] The most frequent complaints are speaking (37%–55%) and breathing problems (27%–41%)[10,17] but more information about each type of mouthguard is required. This should include not only how they interfere with oral function but also the frequency and preference for use to determine the best mouthguard option.

The main aim of this study was to determine the prevalence of orofacial injuries in field hockey players in Catalonia. Additionally, different factors associated with the prevalence of orofacial injuries (e.g., age, gender and wearing braces) were explored and aspects related to wearing a mouthguard (e.g., frequency of use, type and adverse effects) were assessed.

Material and Methods

In this cross-sectional study, 600 male and female players from two field hockey clubs in Catalonia were invited to participate. The inclusion criteria were: playing in the 2016–2017 season with a federated tab for the under-10s, under-12s, under-14s, under-16s, under-18s or senior teams of Atlètic Terrassa Hockey Club or Catalonia Hockey Club. These two clubs were chosen for convenience because these clubs had sufficient number of players from all age categories and gender. Each player was informed in detail about the study and gave their oral

consent to their coach, who signed an informed consent form that had been approved by the local ethics committee (Code 2017-005).

The questionnaire administered to each player aimed to obtain data on playing in (or training for) field hockey games, related episodes of orofacial injury and experience of using a mouthguard, as has been described in detail elsewhere.26 Orofacial injuries included dental injuries, oral lacerations and temporomandibular disorder (TMD) pain. Dental injuries consisted of fractures or avulsions of the upper or lower teeth; oral lacerations included bleeding of the lips, tongue, cheeks or gums; and TMD pain referred to episodes of acute pain in the TMJ or masticatory muscles that increased during jaw movement. The questionnaire also asked about whether the player had ever tried a mouthguard, the type of mouthguard worn, the degree of interference with oral function (e.g., speaking, breathing and swallowing), and other adverse effects associated with each type of mouthguard. Gender, age and brace use was recorded.

The mean number of each orofacial injury is reported, and the prevalence of each type of orofacial injury is expressed as a percentage compared to the total number of players. The relationship between the mean number of a given injury and either age or gender was assessed by Spearman's rank correlation or the Mann–Whitney U test, respectively. The relationship between mouthguard use and sports club, age or the use of braces was investigated by chi-squared tests. The degree of interference with oral function and other adverse effects was compared by mouthguard type using pairwise comparisons with the Kruskal–Wallis test, adjusted by the Bonferroni correction for multiple tests. The level of significance was set at $p < 0.05$. Data were analysed in IBM SPSS version 25.

Results

Descriptive characteristics of the participants are presented in Table 1. Of the 600 field hockey players invited, 335 responded and 10 were excluded because information was missing in the questionnaire, constituting a response rate of 54%. Therefore, 325 participants (median age 14.1 years) were included in the analysis, among whom 50.2% reported at least one orofacial injury due to sport (Table 2). The mean number of orofacial injuries per player was 2.0, with lacerations of the lip being the most frequently reported (0.8). Only 11.7% reported at least one episode of TMD pain and 11.7% reported a dental fracture or avulsion. The number of oral injuries was unrelated to age and gender. However, participants who used braces reported a mean of 3.97 orofacial injuries and 3.15 oral lacerations, which was significantly higher than the 1.79 ($P = 0.008$; Mann–Whitney U test) and 1.41 ($P = 0.015$; Mann–Whitney U test) reported for participants who did not use braces (Table 3).

Of the 310 players who had ever tried a mouthguard, 269 (86.8%) still used a mouthguard habitually during training and 283 (91.3%) still used one during competition (Table 4). In total, 217 players (70.0%) had tried the mouth-formed type, 156 (50.3%) had tried the custom-made type and 30 (9.7%) had tried the prefabricated type, with 71 (22.9%) trying two different types and 11 (3.5%) trying all three types. The percentage of ever having tried a mouthguard was unrelated to club, age, gender, or brace use ($P > 0.05$, chi-square test). Analysis revealed that 40 (12.3%) did not use a mouthguard, 1 (0.3%) used a mouthguard for training only, 15 (4.6%) used a mouthguard during competition only, and 268 (82.7) used a mouthguard for both training and competition. Players in age groups above the under-14 category had a significantly higher odds of using a custom-made mouthguard than players in younger age categories (odds ratio, 2.0; 95% confidence interval, 1.3–3.2). Moreover, the number of matches played during the last season was positively associated with use of a custom-made mouthguard (odds ratio, 1.07; 95% confidence interval, 1.02–1.11).

The degree of interference with oral function and other adverse effects of each mouthguard type are summarised in Table 5. Custom-made types were rated more comfortable than mouth-formed types in terms of fitting and triggering the gag reflex, and they interfered less with speech, breathing and swallowing ($p < 0.05$; pairwise comparisons, Kruskal–Wallis test).

However, the price of custom-made mouthguards was considered less convenient than that of the mouth-formed types.

Discussion

The results of the present study suggest that half of the field hockey players have sustained at least one orofacial injury while engaged in sport. This prevalence is slightly lower than the 62%–68% reported by Bolhius et al.[15] or Hendrick et al,[10] who assessed not only the orodental region but also the facial region, recording black eyes and injuries of the cheekbone or nose. However, the prevalence was markedly higher than the 16% reported by Vucic et al.[17] among Dutch players, in which temporomandibular pain disorders were not considered. Although differences in the studied populations could partially explain these discrepancies (e.g., cultural and ages differences), the methods used to estimate the prevalence probably had a major impact. Hence, standardised data collection would favour comparability of future epidemiological data about orofacial injuries from clinical studies. The retrospective nature of this study implies that the orofacial injuries were reported by the participants themselves. Furthermore, the questionnaire responses required subjective assessments that may be interpreted differently, especially by young players. Ideally, a concise injury surveillance system for field hockey could be developed to help diagnose and report more valid data on injury characteristics based on comparable standards.[27]

Regarding the type of orofacial injury, lacerations of the lip have typically been the most frequently reported injury in previous studies.[4,17] However, the consequences of such injury are typically minor compared with dental trauma. The prevalence of dental injuries such as broken or loose teeth was 11.7% in this study, which is compatible with the rate of 20% reported among elite English female field hockey players,[10] the 14% reported in Dutch players[17] and the 11.5% reported for Brazilian players.[16] Dental trauma can have physical, economic and psychosocial consequences that may be absent with many other accidental injuries presenting to emergency clinics and hospitals.[2] In the present study, 11.7% of players reported at least one episode of TMD pain. Such pain has been reported to be the second and third most frequently reported type of orofacial injury among basketball and water polo players, respectively.[26,28] This is perhaps the first study to report the percentage of athletes who suffered at least one episode of TMD pain while playing field hockey. Further longitudinal studies could be designed to help better understand the natural evolution of these pain episodes and to assess how and whether they could be prevented by using a mouthguard.

The present results suggest that wearing braces is associated with oral lacerations when playing field hockey. Although it is plausible that orofacial injuries will occur more readily when a player is wearing orthodontic appliances that may cause additional damage to the soft tissues following an accidental blow to the face, the relationship has not been previously demonstrated.[29,30] However, despite the findings, the cross-sectional design of the present study precludes any statements of a causal effect. This necessitates that well-controlled prospective studies be performed to confirm that the use of braces predicts orofacial injuries in field hockey, especially oral lacerations. During orthodontic treatment with fixed appliances, patients can use mouth-formed mouthguards that can be moulded around the brackets and re-moulded as teeth move. Alternatively, they can use orthoguards or custom-made mouthguards that can be designed to incorporate a cut-out channel for the orthodontic appliance and allow space for tooth movement.[22] The frequency at which the mouthguard will need to be re-moulded or remade will depend on the rate and magnitude of tooth movement, as advised by the patient's orthodontist.[22]

The present results confirm that custom-made mouthguards are the most comfortable and they interfere the least with oral function, which has been shown to be regardless of the sport.[17,22,26,31,32] Custom-made mouthguards have the advantages of being designed and fitted by a dentist to achieve optimal fit, retention, thickness and extension characteristics for each patient.[33] Furthermore, 90% of players who have ever tried a custom-made mouthguard continue using them during training or com-

petition, confirming their superior durability.[30] However, price remains a barrier to their use, possibly explaining why mouth-formed types were used or tried most often. Custom-made mouthguard use was positively associated with older age groups (above the Under-14s) and the number of matches played in the last season, consistent with the findings of Vucic et al.[17] It might be interesting to investigate ways to make custom-made mouthguards cheaper and more accessible to encourage all players, but especially parents and children, to use them during training and competition.

This study had several limitations. First, the fact that the orofacial injuries, especially TMD pain, were reported by the participants may have influenced their prevalence. Since it is probable that not all oral lacerations occurred when the players were wearing braces, this relationship should be interpreted with caution. Another limitation of the present study was that the clubs were chosen for convenience and may not represent the overall population of field hockey players of Catalonia. Finally, experience or level of players was not recorded and they were only classified by age categories.

In conclusion, the prevalence of orofacial injuries in field hockey players is relatively high in Catalonia. Oral lacerations were the most reported orofacial injuries and they were more prevalent among players wearing fixed orthodontic braces. Dental injuries and episodes of TMD pain were less common, being reported by about 10% of players. Most players habitually use a mouthguard during training and competition, typically preferring the custom-made or mouth-formed types. Although the custom-made types were rated as the most comfortable, especially in terms of fitting and interference with speech, the mouth-formed type was used more often, probably because of the cheaper cost.

Conflict of interest

The authors confirm that they have no conflict of interest.

TABLE 1 Description of the participants' demographic characteristics, clubs and use of braces (Catalonia-Spain, 2017)

Characteristics	Frequency (Percentage)
Gender	
Male	234 (72.0%)
Female	91 (28.0%)
Age group	
Senior	58 (17.9%)
Under-18	32 (9.8%)
Under-16	47 (14.4%)
Under-14	102 (31.4%)
Under-12	63 (19.4%)
Under-10	23 (7.1%)
Club	
Atlètic Terrassa Hockey Club	277 (85.2%)
Catalonia Hockey Club	48 (14.8%)
Orthodontic Braces	
No	292 (89.8%)
Yes	33 (10.2%)

TABLE 2 Prevalence and number of orofacial injuries during sports activity reported by the participants (Catalonia-Spain, 2017)

	Category by age						
	Senior n = 58	**Under-18 n = 32**	**Under-16 n = 47**	**Under-14 n = 102**	**Under-12 n = 63**	**Under-10 n = 23**	**All n = 325**
At least one dental injury (%)	20.7	9.4	8.5	8.8	7.9	21.7	11.7
Mean of dental injuries (95%CI)	0.34 (0.15-0.54)	0.13 (0-0.28)	0.17 (0-0.35)	0.13 (0.04-0.22)	0.10 (0.01-0.18)	0.39 (0.01-0.78)	0.18 (0.12-0.25)
Mean of dental fracture upper jaw	0.29	0.13	0.11	0.02	0.03	0.35	0.12 (0.07-0.16)
Mean of dental fracture lower jaw	0	0	0.06	0.01	0.03	0	0.02 (0-0.04)
Mean of dental avulsion upper jaw	0.03	0	0	0.06	0.03	0.04	0.03 (0.01-0.06)
Mean of dental avulsion lower jaw	0.02	0	0	0.04	0	0	0.02 (0-0.03)
At least one oral laceration (%)	46.6	18.7	55.3	50	36.5	29.1	43.7
Mean of oral lacerations (95%CI)	1.67 (1.04-2.30)	0.44 (0.04-0.84)	1.87 (1.21-2.53)	2.27 (1.18-3.36)	1.05 (0.59-1.51)	0.87 (0.03-1.71)	1.59 (1.20-1.98)
Mean of lacerations on the lip	1.03	0.25	1.13	0.84	0.56	0.52	0.78 (0.56-1.00)
Mean of lacerations on the tongue	0.31	0.06	0.19	0.17	0.29	0.17	0.21 (0.14-0.28)
Mean of lacerations on the cheek	0.12	0.03	0.36	0.37	0.06	0	0.21 (0.02-0.40)
Mean of lacerations on the gums	0.21	0.09	0.19	0.89	0.14	0.17	0.39 (0.26-0.53)
At least one episode of TMD pain (%)	8.6	0	12.8	17.6	12.7	4.3	11.7
Mean of episodes of TMD pain (95%CI)	0.22 (0.01-0.43)	0	0.17 (0.03-0.31)	0.42 (0.11-0.23)	0.17 (0.05-0.30)	0.09 (0-0.27)	0.24 (0.13-0.35)
Mean of episodes of TMJ pain	0.14	0	0.06	0.23	0.1	0.04	0.13 (0.07-0.19)
Mean of episodes of muscle pain	0.09	0	0.11	0.2	0.08	0.04	0.11 (0.05-0.17)
At least one orofacial injury (%)	56.9	25	61.7	44.9	39.7	52.2	50.2
Mean of orofacial injuries (95% CI)	2.24 (1.50-2.98)	0.56 (0.11-1.01)	2.21 (1.44-2.99)	2.82 (1.65-4.00)	1.32 (0.76-1.87)	1.35 (0.45-2.25)	2.01 (1.58-2.44)

Abbreviations: CI, confidence interval; TMD, temporomandibular disorder.

TABLE 3 The distributions of orofacial injuries during sports activities according to the wearing of orthodontic braces (Catalonia-Spain, 2017)

	Not using orthodontic braces n = 292	**Using orthodontic braces n = 33**	**Significance[a] (*P*)**
Mean of dental injuries (95%CI)	0.18 (0.12-0.24)	0.21 (0-0.46)	.708
Mean of oral lacerations (95%CI)	1.41 (1.07-1.76)	3.15 (0.84-5.46)	.008
Mean of episodes of TMD pain (95%CI)	0.20 (0.11-0.29)	0.61 (0-1.37)	.201
Mean of orofacial injuries (95% CI)	1.79 (1.40-2.18)	3.97 (1.47-6.47)	.015

Abbreviations: CI, confidence interval; TMD, temporomandibular disorder.

[a]Mann-Whitney *U* test.

TABLE 4 Number and percentage of participants who have ever tried a mouthguard and number and percentage of habitual use of mouthguard regarding the mouthguard type (Catalonia-Spain, 2017)

	Type of Mouthguard (n = 310)		
	Pre-fabricated N (%)	Mouth-formed N (%)	Custom-made N (%)
Have ever tried a mouthguard	30 (9.7)	217 (70.0)	156 (50.3)
Habitual use in practice	11 (3.5)	134 (43.2)	132 (42.6)
Habitual use in competition	11 (3.5)	145 (46.8)	137 (44.2)

Some athletes had tried more than one type of mouthguard.

TABLE 5 Ratings on the negative aspects of each mouthguard type (Catalonia-Spain, 2017)

	1	2	3		Pairwise comparisons†		
	Pre-fabricated (n = 28) Mean (SD)	Mouth-formed (n = 210) Mean (SD)	Custom-made (n = 156) Mean (SD)	*P*	1-2	1-3	2-3
Speech	6.57 (3.0)	6.29 (2.7)	2.62 (2.5)	<.0005	1	<0.0005	<0.0005
Breathing	4.18 (3.6)	3.40 (3.3)	1.47 (2.4)	<.0005	0.947	<0.0005	<0.0005
Swallowing	4.04 (3.4)	3.40 (3.0)	1.69 (2.5)	<.0005	1	0.001	<0.0005
Nausea	3.32 (3.7)	1.57 (2.8)	0.63 (1.9)	<.0005	0.005	<0.0005	<0.0005
Fit too tight	4.93 (3.3)	3.09 (3.1)	2.03 (2.9)	<.0005	0.021	<0.0005	0.002
Fit too loose	6.11 (3.7)	4.51 (3.5)	1.27 (2.3)	<.0005	0.197	<0.0005	<0.0005
Price	2.62 (3.0)	2.10 (2.8)	4.10 (3.8)	<.0005	0.881	0.740	<0.0005

Each item is measured on a 10-point scale.

Abbreviation: SD, standard deviation.

P-values are by Kruskal-Wallis test.

†Significance values have been adjusted by the Bonferroni correction for multiple tests.

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CHAPTER 4

General discussion

GENERAL DISCUSSION

The studies in this thesis have contributed to our knowledge of the risk of orofacial injury in water polo and field hockey, elaborating on the habits and issues surrounding mouthguard use. This improves our ability to optimise our recommendations to athletes in these sports. In this chapter, the main findings of the studies on water polo and field hockey are presented and discussed in order. Recommendations for future research are reflected in the discussion of each sport, ending with the limitations and general conclusions presented at the end of the chapter.

MAIN FINDINGS AND IMPLICATIONS

The results of the two core studies show that water polo and field hockey players are at risk of orofacial injury when participating in these sports. However, although half of the athletes had suffered an orofacial injury, most reported only mild injury, with oral lacerations being most common. To the best of our knowledge, this is the first study to have explored episodes of temporomandibular disorder (TMD) pain among water polo and field hockey players, showing that this type of injury is frequent among these athletes. The results also confirm that custom-made mouthguards are the most comfortable type for water polo and field hockey players, and it supports existing recommendations that promote using this type of mouthguard to reduce the risk of orofacial injury in sports in general. (Gawlak et al 2015; Green 2017; Lloyd et al. 2017; Newsome et al. 2001; Parker et al. 2017)

In Chapter 2, we found that approximately 58% of water polo players reported at least one orofacial injury during the 2015–2016 season, with an average of 3.2 per player that season. Regarding the type of injury, oral lacerations and lip lacerations were reported most frequently (54% suffered at least one laceration). Fortunately, more severe orofacial injuries were less common, such as dental injuries (e.g., dental fracture or avulsion), occurring in only 4.3%. In a study of Swiss water polo players, the percentage of players reporting at least one tooth injury was 21%, but that study included dental injuries occurring throughout the whole sporting life of participants in a sample with a mean age of 29 years. (Hersberger et al. 2012) In our study, the mean age of participants was 15 years and included both elite players and beginners. Therefore, the risk of tooth injury in a water polo player might be about 5% per season, increasing to 20% in a career.

The percentage of players reporting at least one episode of TMD pain was 21%. TMD pain has been reported to be the second most common orofacial injury after soft tissue lacerations among basketball players, (Lesić et al. 2011) and to be a frequent diagnosis among rugby players. (Bonotto et al. 2019) These pain episodes may be caused by direct blows to the temporomandibular joint (TMJ) or masticatory muscles, or they may be caused by indirect TMJ overloading if there is a strike to the mandible from below that causes traumatic closure. Notably, a mouthguard would not prevent damage from direct blows, but could prevent TMJ overloading produced by blows to the mandible, provided it is bilateral and gives a balanced occlusion. Although teeth clenching and/or wearing a mouthguard may reduce the magnitude of impact to the TMJ, (Tanaka et al. 2017) more studies are needed to prove the efficacy of mouthguards in preventing TMD pain. Moreover, TMJ injuries sustained during sports are often not apparent immediately because jaw injuries typically do not result in fractures, but the significant force transmitted to the soft tissues and supporting structures of the TMJ can result in severe injury. (Bonotto et al. 2019) Thus, further longitudinal studies could be designed to help better understand the natural evolution of these pain episodes and to assess how and whether they could be prevented by mouthguard use.

Age may be a risk factor for only oral lacerations because the incidence of such injuries increased with age. Gender differences were also evidence, with males suffering a greater number of dental injuries than females, though it has not been established whether gender is a risk factor for orofacial injuries while playing sport in general or water polo in particular. (Collins et al. 2016; Hersberger et al. 2012; Vucic et al. 2016b) This could be due to an increase in female participation in sports of nearly 1000% since 1971, leading to new patterns of injury that merit further investigation. (Goldberg et al. 2007) Interestingly, orofacial injury rates

were comparable in athletes who did and did not wear braces, despite our expectation that orofacial injuries would occur more easily when wearing orthodontic appliances that could cause additional soft tissues damage following an accidental blow to the face. No study has demonstrated a significant relationship to date. (Croll and Castaldi 2004; Newsome et al. 2001; Salam and Caldwell 2008) A limitation of our study was that the number of training sessions and matches differed among participants, meaning that the amount of time exposed to risk of injury differed among the participants.

Despite the clear role of mouthguards in preventing orofacial injury, (Farrington et al. 2016; Gawlak et al. 2017; Lloyd et al. 2017; Parker et al. 2017) there seems to be a continued resistance among athletes to use them routinely. Indeed, only 10% of athletes in our cohort reported having tried a mouthguard, and only 1% reported using it routinely for training and competition. This contrasts with 8% of Swiss water polo players routinely wearing a mouthguard. (Hersberger et al. 2012) Social, cultural, and age differences between these samples could explain the discrepancies. The low rate of mouthguard use among water polo players in the present study may result from a combination of factors, including the absence of regulations about mouthguard use, the presence of few or no recommendations from the club and/or coaches, and a passive attitude or lack of knowledge among parents regarding the importance of mouthguards. This is compounded by a lack of formal rules by organisations about mouthguard use in water polo produced by FINA, the Union of Sports Federations of Catalonia, or the Catalan Federation of Swimming. As proposed recently, introducing rules that mandate mouthguard use in water polo competitions could reduce risk. (Hersberger et al. 2012) Indeed, this has been proven in several other sports in which the risk of injury decreased significantly once the new regulation was implemented. (Duddy et al. 2012; Hawn et al. 2002; Quarrie et al. 2005)

Efforts to prevent sport injuries through preventive programmes or internal education by the sporting director and/or coaches are essential. A study of professional athletes in Switzerland showed that the attitude of officials towards mouthguard use corresponded with the acceptance of the athletes in each sport. (Lieger and von Arx 2006) A lack of parental awareness regarding the risk of orofacial injury in water polo could also explain why the percentage older players (seniors and under-18s) who had ever tried a mouthguard was ten times that of younger players (under-10s and under-12s). To increase mouthguard wear in children will require parental education about the necessity and benefits of mouthguard use. (Parker et al. 2017) Additionally, dentists and health professionals should encourage mouthguard use by both professional and amateur players, especially teenagers. (Sepet et al. 2014; Persic et al. 2006; Vucic et al. 2016b) Further studies are warranted regarding the preventive measures and recommendations given by water polo federations, clubs, sports director, and coaches to promote mouthguards use at all levels of the sport.

Interference with oral function, such as speech, breathing, and swallowing, was the main complaint with all mouthguard types. However, custom-made were better rated than mouth-formed mouthguards, consistent with the results of other studies. (Duddy et al. 2012; Ilia et al. 2014; Lieger and von Arx 2006; Vucic et al. 2016a) It is possible that a shortened mouthguard that interferes less with oral function, as described by Gómez-Gimeno et al., could promote mouthguard use among water polo players. (Gómez-Gimeno et al. 2019)

Chapter 3 showed that almost half of the field hockey players sustained at least one orofacial injury during the season 2016–2017, with a mean of 2.0 orofacial injuries per player. This prevalence was slightly lower than the 62%–68% reported by Bolhius et al. (Bolhius et al. 1987) or Hendrick et al., (Hendrick et al. 2008) although those assessed not only the orodental region but also the facial region (i.e., black eyes and cheekbone or nasal injury). However, the prevalence was markedly higher than the 16% reported by Vucic et al. among Dutch field hockey players, among whom TMD pain episodes were not considered. (Vucic et al. 2016a) In the current study, 11.7% of players reported at least one episode of TMD pain, though lip lacerations were the most common orofacial injury, as previously reported. (Collins et al. 2016; Vucic et al. 2016a) The prevalence of dental injuries, such as broken or loose teeth was 11.7%, was also comparable with previously reported rates of 20, 14%, and 11.5% reported among elite English female field hockey players, (Hendrick et al. 2008) Dutch players, (Vucic et al. 2016a) and Brazilian players, (Ferrari et al. 2002) respectively.

Discrepancies regarding the occurrence of orofacial injuries between the current study and those of Bolhius et al., [Bolhius et al. 1987] and Hendrick et al., [Hendrick et al. 2008] could have resulted from differences in the studied populations (e.g., culture and age) or in the methodologies used (e.g., injury case definition, data collection method, play level, and data collection period). [Knapik et al. 2019] Standardising the injury definitions and data collection methods would improve our overall understanding of the epidemiology of field hockey injuries, helping to clarify the relative burden and risk factors in different cohorts. [Lynall et al. 2018] Implementing injury surveillance will help with documenting injury and the associated factors. [Gambucci 2018] A carefully designed injury surveillance programme with accurate data capture and careful analysis then form the building blocks for sports injury/illness prevention programmes. [Bahr et al. 2020; Mountjoy et al. 2018] The ultimate goal of these are then to institute policies and protocols to mitigate risk, [Gambucci 2018] and they represent the first step in translating research into injury prevention practice. [Mountjoy et al. 2018]

An optimal injury surveillance system will collect the minimum data, focusing on the following: the nature, time, and location of the injury; the cause and mechanism of injury; the activity performed when injured; the use of protective equipment; a description of the event; and any diagnosis or discharge status. [Tham et al. 2009] In the United States, the advent of Web-based sports injury surveillance via programmes such as the High School Reporting Information Online (RIO) system and the National Collegiate Athletic Association Injury Surveillance Program (NCCA-ISP) has improved data collection about field hockey injuries among women. [Lynall et al. 2018]

The results in Chapter 3 indicated that wearing orthodontic braces was associated with oral lacerations when playing field hockey. As stated previously, although it seems plausible that orofacial injuries will occur more readily when wearing orthodontic appliances, the relationship has not been previously demonstrated. [Croll and Castaldi 2004; Newsome et al. 2001; Salam and Caldwell 2008] However, despite our findings, the cross-sectional design precludes any statements of a causal relationship. It must also be considered that not all oral lacerations occurred when players were wearing braces, emphasising the need for caution when interpreting this relationship. Well-controlled prospective studies will be able to confirm if orthodontic braces wearing predicts orofacial injury in field hockey.

Most players had at least tried to use a mouthguard and 82.7% had used it for both training and competition. This high compliance could be due to recommendations given by the sports club, coaches, or both. In younger players, compliance could also be influenced by conscientious parents being aware that field hockey is a high-risk sport. Further studies could be designed to clarify the attitudes of clubs, coaches, and parents regarding mouthguard use in field hockey. Hopefully this would help to establish the best method for promoting habitual mouthguard use, providing data that could be extrapolated to other sports in which mouthguard use is low and not mandatory.

In Chapter 3, the results confirmed that custom-made mouthguards were most comfortable and interfered least with oral function. This is consistent with research in a variety of sports, [Bergaman et al. 2017; Galic et al. 2018; Parker et al. 2017; Vucic et al. 2016a] and is evidenced by the fact that most players who have ever tried a custom-made mouthguard continue to use it during practice or competition compared with those who have tried prefabricated or mouth-formed mouthguards. However, the price of custom-made mouthguards remains a barrier compared with the relatively inexpensive mouth-formed types. Despite the apparently valid argument that mouth-formed types are more widely used due to their lower costs, convenience, and ease of availability, in vitro laboratory tests have shown that they are not as strong or resilient as custom-made types. [Salam and Caldwell 2008]

Custom-made mouthguard use was positively associated with older age (above the under-14s) and the number of matches played in the last season, as reported previously. [Vucic et al. 2016a] Concerning children, it is the parent who decides the type of mouthguard in the absence of guidance from the sport club. In growing children, mouthguards need to be replaced approximately every year to accommodate growth (i.e., mouth and jaws) and development of the adult dentition, resulting in parents basing

decisions on cost. It is also possible that dentists do not know the type of mouthguard to recommend, resulting in suboptimal protection and poor compliance. (Parker et al. 2017) The high prevalence of orofacial injuries seen among field hockey players despite the high use of mouthguards may reflect the inadequacy of protection conferred by prefabricated or mouth-formed mouthguards (used by 4% and 47%, respectively). Promoting the use of custom-made mouthguards over prefabricated and mouth-formed types could help to reduce the risk of orofacial injury among field hockey players.

The retrospective nature of the studies in Chapters 2 and 3, together with the self-report of orofacial injuries, may have affected diagnostic accuracy, especially in those related to episodes of TMD pain. Furthermore, younger participants could have had more difficulty with the responses, even though they were instructed about the meaning of each question. Prospective studies are therefore needed to confirm the results. Another limitation of both studies was that the clubs were chosen for convenience, and as such, may not represent all field hockey players in Catalonia.

General Conclusions

The following conclusions were drawn from the research in this thesis:

1. In Catalonia, orofacial injury has a high incidence and prevalence among water polo and field hockey players, respectively.
2. Oral lacerations are the most reported orofacial injuries in both sports.
3. The incidence of oral lacerations in water polo players increases with age for those younger than 15 years.
4. Oral lacerations were more prevalent among field hockey players wearing fixed orthodontic braces.
5. Most water polo players do not routinely use a mouthguard for training or competition.
6. Most field hockey players habitually use a mouthguard for training and competition.
7. Water polo players who have tried to use mouthguards typically use the mouth-formed type.
8. Field hockey players use custom-made or mouth-formed mouthguards more often than prefabricated ones.
9. Water polo and field hockey players consider custom-made mouthguards to be the most comfortable type in terms of fitting and triggering the gag reflex. Although players also report that these mouthguards interfere less with speech, breathing, and swallowing, cost remains the main barrier to their use.

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CHAPTER 5

Summary

SUMMARY

Dental trauma has been reported as one of the most prevalent diseases in the world, affecting approximately a billion people. The impact on the individual is not only physical but also psychosocial. Sports-related accidents are the cause of one-third of all dental injuries in children and adults. It has been suggested that males are more likely to suffer TDI than females, however, these association has not been well documented. Contact sports are associated with a particularly higher risk of orofacial injury due to the intense competition, close proximity and physical interaction. Water polo and field hockey are two contact sports enjoying high popularity and participation in Catalonia, in which orofacial injuries are common and mouthguards are not mandatory. Mouthguards are devices that cover the teeth and gums and aim to reduce the risk of orofacial injuries. Mouthguards are classified into prefabricated, mouth-formed, and custom-made. The purpose of this thesis was to investigate the incidence and prevalence of orofacial injuries in Catalan water polo and field hockey players respectively, to explore the factors associated with these incidence and prevalence, such as age, gender, and brace wearing. Finally, the frequency of mouthguard use, the type of mouthguard used and the degree of interference with oral functions were also assessed (chapter 2 and 3).

In Chapter 1, a general introduction is presented in which the objectives and hypotheses are described.

Chapter 2 describes the incidence of orofacial injury and the use of mouthguards in male and female water polo players from high-level clubs in Catalonia. More specifically, the study explores factors associated with the incidence of orofacial injury, such as age and gender. The study also describes the frequency of mouthguard use, the type of mouthguard used, and the degree of interference of mouthguard use with oral function as reported by athletes. Results show that more than a half of water polo players reported at least one orofacial injury during the 2015- 2016 season. Lacerations to the lip and tongue were the most frequent injuries reported and these increased with age. The percentage of episodes of TMD pain or the number of dental injuries did not vary between the age groups. Among orofacial injuries, only dental injuries were associated with gender with males suffering more than females. Brace wearing was not associated with the number of any type of orofacial injury. Among the 35 players who had ever tried a mouthguard, only 4 used a mouthguard habitually during training and 3 also used it during competition. Twenty-six players had tried the mouth-formed mouthguard, 11 the custom- made type and 7 the prefabricated mouthguard. Custom-made mouthguards were rated as the most comfortable ones.

Chapter 3 outlines the prevalence of orofacial injury among male and female field hockey players in Catalonia. Additionally, it describes the factors associated with an increased prevalence, such as age, gender, and brace wearing. The study also investigated aspects related to wearing a mouthguard, specifically the frequency of use, type, and adverse effects. The study showed that half of the players reported at least one orofacial injury during their sporting lives and that the most frequent type were oral lacerations. However, athletes also reported episodes of TMD pain and dental injuries. In total, 310 players had tried a mouthguard, and of these 269 and 283 still used a mouthguard habitually during training and competition, respectively. The mouth-adapted and the custom-made mouthguards were the most tried by the athletes. Custom-made mouthguards were rated as the most comfortable ones.

Chapter 4 concludes by offering a general discussion with recommendations for future research, finishing by outlining the more general conclusions.

CHAPTER 6

Resum

RESUM

Els traumatismes dentals són considerats una de les patologies més prevalents del món, afectant aproximadament a un bilió de persones. L'impacte en l'individu no és només físic, sinó que també té implicacions psicosocials. Els accidents relacionats amb l'esport són la causa d'un terç de les lesions dentals en nens i adults. El sexe masculí s'ha associat a un major risc de patir aquest tipus de lesions, però, els estudis no són concloents. Els esports de contacte s'associen amb un major risc de lesions orofacials pel major nivell de competició i interacció física dels atletes. El waterpolo i l'hoquei herba són dos esports de contacte molt populars a Catalunya, on les lesions orofacials són freqüents, però en els quals l'ús de protectors bucals no és obligatori. Els protectors bucals són un tipus de dispositius que recobreixen les dents i la geniva amb l'objectiu de reduir el risc de lesions orofacials. Aquests protectors es classifiquen en prefabricats, adaptats a boca o fets a mida. El propòsit d'aquesta tesi doctoral ha estat el d´estudiar la incidència i la prevalença de lesions orofacials en jugadors catalans de waterpolo i hoquei herba respectivament; explorar diferents factors de risc a patir aquest tipus de lesions com el sexe, l'edat i ser portador de bràckets i finalment conèixer la freqüència d'ús de protectors bucals, el tipus més usat i les experiències negatives referides pels atletes que fan servir un protector (capítols 2 i 3).

Al Capítol 1, es presenta una introducció general en la qual es descriuen els objectius i les hipòtesis.

El Capítol 2 descriu la incidència de lesions orofacials en jugadors de waterpolo masculins i femenins de clubs d'alt nivell a Catalunya durant la temporada 2016-2017. L´estudi explora factors associats a la incidència de lesions orofacials, com l'edat i el gènere. L'estudi també descriu la freqüència d'ús de protecció bucal, el tipus de protecció bucal que s'utilitza i el grau d'interferència de l'ús de protecció bucal amb la funció oral. Els resultats mostren que més de la meitat dels jugadors de waterpolo han patit almenys una lesió orofacial, essent les laceracions orals les més freqüents seguides pels episodis de dolor TMD i les lesions dentals. Es va observar que el nombre de laceracions orals va augmentar amb l'edat. Entre les lesions orofacials, només es van associar les lesions dentals al gènere, sent els homes els que més les pateixen. El fet de portar bràckets no es va associar al nombre de cap tipus de lesió orofacial. Entre els 35 atletes que havien provat un protector bucal, només 4 l'utilitzaven habitualment. Alguns jugadors havien provat més d'un tipus de protector bucal; 26 havien provat el protector adaptable, 11 el fet a mida i 7 el protector bucal prefabricat. Els protectors bucals a mida es van classificar com els més còmodes. Els principals desavantatges dels protectors bucals adaptats a boca eren les interferències en parlar, respirar i empassar.

El Capítol 3 descriu la prevalença de lesions orofacials en jugadors d'ambdós sexes d'hoquei herba a Catalunya. A més, descriu els factors associats a un augment de la prevalença, com ara l'edat, el gènere i ser portadors de bràckets. També es van investigar aspectes relacionats amb l´ús de protectors bucals, específicament la freqüència d'ús, tipus i efectes adversos. Els resultats reflecteixen que la meitat dels jugadors van patir almenys una lesió orofacial durant la seva vida esportiva. Les laceracions orals van ser les més referides tot i que els atletes també van patir episodis de dolor TMD i lesions dentals. En total, 310 jugadors havien provat algun protector bucal, i d'aquests 269 i 283 encara l´utilitzen habitualment durant l'entrenament i a la competició, respectivament. Els protectors bucals més provats van ser els adaptats a boca i els fets a mida. Els protectors bucals fets a mida es van qualificar com els més còmodes.

El Capítol 4 conclou oferint una discussió general amb recomanacions per a futures investigacions i finalitza amb les conclusions més generals.

CHAPTER 7

Abbreviations

ABBREVIATIONS

TABLE OF ABBREVIATIONS

FDI.....Federation Dentaire International
RIO.....Reporting Information Online
TDI.....Traumatic dental injury
TMD.....Temporomandibular disorders
TMJ.....Temporomandibular joint

CHAPTER 8

About the author
Acknowledgements

ABOUT THE AUTHOR

Carla Zamora Olave was born in 1982 in Berlin, Germany. In 2000 she graduated from high school at the IES Algarb de Sant Jordi in Ibiza, Spain. In the same year she moved to Barcelona where she studied Dentistry in the University of Barcelona. She attended the Master´s degree program of Occlusion and Oral Rehabilitation at the University of Barcelona from 2005 to 2007 while working as a general practitioner in private dental practice. After four years of completing the Master´s degree she joined as an associate collaborator in it, where she is fully dedicated to the field of Temporomandibular Disfunction. Moreover, since 2012 she belongs to the Department of Prosthodontics at the Faculty of Medicine and Health Sciences, School of Dentistry at the University of Barcelona as an assistant teacher of prosthodontics for undergraduate students at the Dental Hospital of the University of Barcelona. In that year, she started her PhD research.

She currently combines teaching work with private practice where she is fully dedicated to prosthodontics.

She speaks German, Catalan, Spanish and English. She never moved again from the beautiful city of Barcelona where she lives happily with her family.

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For my family…
I love you.

Hospital Odontològic
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Comitè d'Ètica i Investigació Clínica

JORDI MARTINEZ GOMIS

Facultat d'Odontologia

Benvolgut,

Adjunt us trametem el dictamen del Comitè d'Ètica i Investigació Clínica de ***l'Hospital Odontològic Universitat de Barcelona*** i la conformitat de la direcció del Centre. També i tal com indica la normativa li adjuntem la composició del comitè.

Li recordo que cal que comuniqui a la gerència de la ***Fundació Josep Finestres*** l'inici d'aquest estudi a l'adreça de correu electrònic giniguez@ub.edu.

Restem a la seva disposició per a qualsevol aclariment.

Atentament,

Silvia Sánchez

Dra. Silvia Sánchez

Secretària del CEIC-HOUB

L'Hospitalet, 21 / desembre / 2016

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CERTIFICA

Que este Comité ha evaluado la propuesta del promotor del estudio:
CÓDIGO: **2016-44** NÚMERO EUDRACT:
VERSIÓN: versión 2.
TÍTULO: **Risc de lesions al sistema masticatori i freqüència d'ús de protector bucals en la pràctica del waterpolo.**
PROMOTOR: JORDI MARTÍNEZ GOMIS

Y considera que:

- El estudio se plantea siguiendo los requisitos del Real Decreto 223/2004, de 6 de febrero y las normas que lo desarrollan, y su realización es pertinente.

- Se cumplen los requisitos necesarios de idoneidad del protocolo en relación con los objetivos del estudio y están justificados los riesgos y molestias previsibles para el sujeto, teniendo en cuenta los beneficios esperados.

- Son adecuados tanto el procedimiento para obtener el consentimiento informado como la compensación prevista para los sujetos por daños que pudieran derivarse de su participación en el estudio.

- La capacidad del investigador y sus colaboradores, y las instalaciones y medios disponibles, tal y como ha sido informado, son apropiados para llevar a cabo el estudio.

- El alcance de las compensaciones económicas previstas no interfiere con el respeto a los postulados éticos.

Este CEIC como comité de referencia y, habiendo tenido en cuenta las respuestas a las aclaraciones solicitadas al promotor, resuelve **AUTORIZAR** que dicho estudio sea realizado en los centros siguientes por los investigadores principales que se relacionan a continuación:

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Dr. Josep Mª Ustrell, Director Facultativo del ***Hospital Odontològic Universitat de Barcelona*** y vista la autorización del Comité Ético de Investigación Clínica,

CERTIFICA

Que conoce la propuesta realizada por el promotor para que sea realizado en este Centro el estudio código de protocolo 2016-044 titulado: "Risc de lesions al sistema masticatori i freqüència d'ús de protector buscals en la pràctica del waterpolo" y que será realizado por los Dres. JORDI MARTINEZ GOMIS y CARLA ZAMORA OLAVE como investigadores principales y como colaboradores: EVA WILLAERT JIMÉNEZ-PAJARERO y MARIA PERAIRE ARDÈVOL.

Que acepta la realización de dicho estudio en este Centro.

Lo que firma en Hospitalet de Llobregat, a **21/12/2016**

Firmado:

Dr. Josep Mª Ustrell