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Original Article

Relationship between mouth guards use, dental injuries and infection in young combat sport athletes

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Abstract:

Sports are common cause of dental and orofacial injuries, dental accidents often have lifelong consequences. The use of the mouthguards in the combat sport has the ability to prevent many orofacial injuries in athletes. Lack Italian-based epidemiological information exists about the incidence of dental injury in sports and correlation with MRSA exposure and/or infection. Aim was to evaluate occurrence of dental traumas, level of knowledge of the participants about preventive measures, management of dental trauma during sports and to correlate with MRSA exposure in Italian combat sport athletes.

A cross-sectional study was conducted to 244 young athletes from different contact sports (taekwondo (n=81; 33,19%); judo (n=27; 11,06%); Kick boxing (n=24; 9,83%); Boxing (n=38; 15,57%) and Other Sport (n=74; 30,32%). Tow standardized questionnaires were used about socio-demographic characteristics, specific sport activities, participants health conditions, dental trauma (occurrence; circumstances regarding the dental trauma; area of incidence of trauma), habits regarding the use and type of mouthguard. The statistical analysis involved descriptive and inferential statistical measures. Eighty-nine percentage of participants (25±9,7 yrs; 66,09±13,01 kg; 1,70±0,1m; 6.00±3.1 years/experience) reported that no to suffer of dental injury, while 26 athletes (11%) reported higher rate of dental injuries in taekwondo (6,33±2,05) (P=0.005). Most participants were aware of mouthguards for dental trauma prevention and considered them efficient to prevent dental injuries during sports activities, 76% used them. Statistically significant difference was in the mouthguards characteristics: model was single arc (58%), boilt&bite type (93 %), standard measure (86%), gel material (55%) (P<0.001). S. aureus was carried by 42% of 244 enrolled athletes. A high prevalence of dental trauma in the enrolled athletes was not found. Participants were aware of mouthguards for dental trauma prevention but not so informed about the specific characteristics. Data showed a high prevalence of S. aureus carriage and a relevant resistance to antimicrobials frequently used for the treatment MRSA infections, but no correlated to dental trauma.

Key words: dental injury**,** combat sport, mouthguards, MRSA infection.

Introduction

Sports-related accidents are one of the most common causes of facial injuries, accounting for about a third of all dental injuries in children and adults. Dental trauma is a serious health problem that is steadily increasing in recent decades (Mestrovic S et al., 2008). The risk of sport-related dental injuries during body collisions and falls is six times higher than work accidents and three times higher than road accidents. One of the most important classification of sports is the relative risk categories for acute injuries, as follows: contact, medium, and non-contact (Stephen GR, 2008). However, when an athlete is injured, the consequences include emotional stress and frustration (Tuna et al., 2014). Any dental injury can have aesthetic, functional, physical, psychological and social implications (Tea Galic, 2018, D'Isanto et al.,2019, Raiola, D'Isanto, 2016). Wearing a mouthguard can markedly reduce the frequency of dental accidents in combat sports (Newsome et al. 2001; Schildknecht et al. 2012). Studies examining sports injuries have suggested that mouthguards tend to reduce the incidence of orofacial injuries in rugby (Quarrie KL et al., 2005), hockey (Delaney JS & Montgomery DL, 2005) football (Finch C et al., 2005; Wisniewski JF et al., 2004), taekwondo (Pieter W , 2005; Pieter W et al., 2012) and a variety of other sports (Cruz et al., 2008; Barbic B et al., 2005). In the literature, a distinction is normally made between three types of mouthguards (Filippi & Pohl 2001;Newsome et al. 2001; Patrick et al. 2005; Maeda et al. 2009): the stock mouthguard, the mouth-formed mouthguard, and the custom-made mouthguard from the dentist. The material should be elastic, disinfectable, easy to clean, tasteless, and odorless (Kirschner et al. 2006; Filippi 2008). A mouthguard must meet the following requirements: provide optimal fit and retention (Chaconas et al. 1985), absorb blow- and thrust-induced energy (Filippi 2008), and prevent sports-related orofacial injuries

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(Ranalli & Demas 2002). However, athletes accept reluctantly the use of mouthguards cause to difficulty to breath, to compromise communication and to create aesthetic irregularities. Only a few sports have rule that require wearing a mouthguard, while in high risk sports, it is an autonomous choice to wear its (Tea Galic, 2018).

Therefore our specific goals were to determine: the knowledge of mouthguard use and the incidence of sports injuries and their roles in the prevention of sports-related orofacial injuries; the association between MRSA and sports-related orofacial injuries.

Material & methods

Participants.

This cross-sectional study was conducted in a region of southern Italy (Calabria) in public and/or private gyms. Participants eligible in the study were subjects ≥16 years of age that practiced a contact/collision sport as defined by the American Academy of Pediatrics (AAP, 2018). In particular, "contact" sports are those in which athletes purposely hit or collide with each other or inanimate objects, including the ground, with great force (eg., martial arts, boxing, and wrestling). To all participants purpose and contents of the study were explained, and all signed an informed consent. In the case of minors, a person with parental responsibility had to give informed consent on behalf of the minor. Two questionnaires, assuring confidentiality of responses, were provided and swab samples were collected from the anterior nares, oropharynx and hand fingers of participating athletes during the training session. There were no incentives offered for participation.

Measure.

The questionnaires (MRSA_q and SPINJ_q) were validated by a panel of experts and based upon extensive review of the relevant literature. These included several sections and responses were designed in a variety of formats: closed-ended questions with multiple answers, yes or no questions and open option questions. MRSA_questionnaire included four sections: the first section examined the socio-demographic characteristics (sex, age, marital status, work activity) of participating athletes. In the second section, the specific sport activities were analyzed [type of practiced activity, number of practicing years and of weekly training days, use and sharing of personal items (e.g. towels, soap, clothes, sport equipment), hand washing, and frequency of showers]. The third part investigated the participants' health conditions, recent hospitalization or surgery, antibiotic use, previous MRSA exposure and/or infection. The last section was related to availability of prevention programs for infections in the gyms. SPINJ_questionnaire contained 20 items, including type of sports, number of practicing years, whether any dental and soft tissues injuries incurred (loosening of teeth, fracture of teeth, broken bones, bruises on the face and lacerations on lips, tongue) or cheeks while participating in sports activities; the possible to reimplant the avulsed tooth and also the extraoral time within which it is possible to reimplant the teeth; the reasons to use of mouthguard.

Sterile swabs were used to collect samples from the anterior nares, oropharynx and hand fingers. All samples were transported to laboratory in refrigerated containers and processed within 24 hours of collection. The swabs were inoculated on Mannitol Salt Agar (MSA) plates and incubated at 37°C for 24-48 hours. All typical *S. aureus* colonies were then sub cultured onto Nutrient Agar (NA) plates and incubated at 37°C for 24 hours. Afterward, Gram stain, catalase and coagulase tests were performed. All suspect strains were identified to the species level using the API Staph identification system (bioMérieux). All *S. aureus* isolates were tested for their antibiotic susceptibility by Kirby–Bauer disk diffusion method; the antibiotics for which sensitivity was tested were: ciprofloxacin (5 µg), clindamycin (2 µg), erythromycin (15 µg), gentamycin (10 µg), linezolid (10 µg), mupirocin (200 µg), sulfamethoxazole/trimethoprim (25µg), rifampicin (5µg), tetracycline (30µg), cefoxitin (30µg) and oxacillin (1 µg). *S. aureus* strains were classified as MRSA if resistant to cefoxitin and/or oxacillin, as indicated by the EUCAST expert rules in antimicrobial susceptibility testing (Leclercq R et al., 2013).

Statistical analysis

All data were statistically analyzed using the IBM SPSS Statistics 22.0 software program. Level of significance was set at $P<0.05$ for all the statistical analysis. Continuous data were presented as means ± standard deviation, age was presented as median with range, whereas categorical variables were presented as whole numbers and percentages. In the primary analysis, t-test (for continuous variables) and Pearson's chi-square or Fisher exact test (for categorical variables) were used, $\chi 2$-test, with Yates correction if necessary, was performed to test the differences between different categorical variables. Subsequently, a stepwise multivariate logistic regression model was performed to determine the association of several characteristics with *S. aureus* carriage among athletes (0=non-carrier, 1=carrier). The significance level for variable entering the logistic regression models was set at 0.2 and for removal from the model at 0.4. Adjusted odds ratio and 95% confidence intervals were calculated.

Results

A total of 244 athletes playing 6 different combat sports were included in the study [taekwondo 81/244 (33,19%), karate/old martial arts 74/244 (30,32%), boxing 38/244 (15,57%), judo 27/244 (11,06%), kick boxing

24/244 (9,83%)]. A total of 19 gyms located in Calabria region were involved. Their age mean age was 25±9,7years and them weight 66.09 ± 13.01 kg with height mean 1.70 ± 0.1cm . Age of the participants ranged from 16 to 50 years (mean 23.4 years, median 19 years, SD±8.7, interquartile range: 17-28 years). The male to female ratio was 3:1, male athletes (71,60%) were accounted more than female athletes (28,40%). The average number of years of practice was 2.6 (±1.7) and of weekly training days was 2.2 (± 0.8).

From the total of 244 athletes who filled in the SPINJ questionnaire, 198 (81%) athletes claim not to have suffered any dental injury outside of the sport practiced. Orofacial injury was experienced by 46 athletes (25.3%), but not as personal experience, where 19,34% of them sustained a combination of soft tissue and a dental injury which occurred on more than one occasion.

Out of the total participants, 29 (11,11%) had sustained orofacial injury during sport and out of a total of 27 athletes 33,33% had better specified the type of injury in dental injury avulsion of teeth (table 1).

Table 1 – Results of trauma direct experience –SPINJ questionnaire

Trauma direct experience	*Taekwondo*		*Judo*		*Kick boxing*		*Boxing*		*other*		*TOT*	
(n)	81		27		24		38		74		244	
	n	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*N*	*%*
Always	0	0	0	0	0	0	0	0	0	0	0	0
Often	0	0	1	4	0	0	0	0	0	0	1	0
sometimes	5	6	1	4	2	8	3	8	1	1	12	5
few times	9	11	0	0	1	4	0	0	4	5	14	6
never	67	83	25	93	21	88	35	92	69	93	217	89
χ^2 ($p<0.05$)	0,07											

In the second section of the questionnaire about the use of the mouthguard 76% (n 183/240 athletes) declared to use it. Table 2 shows the percentages of use by discipline. Statistically significant difference was in the mouthguard characteristics: model was single arc (58%), boilt&bite type (93 %), standard misure (86%), gel material (55%) ($P<0.001$).

Table 2 – Results of mouthguard use –SPINJ questionnaire

MOUTHGUARDS USE	*Taekwondo*		*Judo*		*Kick boxing*		*Boxing*		*other*		*TOT*	
(n)	79		27		23		37		74		240	
	n	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*	*n*	*%*
NO	12	15	18	67	2	9	4	11	21	28	57	24
YES	67	85	9	33	21	91	33	89	53	72	183	76
χ^2 ($p<0.05$)	0,00											

The logistic regression model (Table x) showed the use of mouthguard are associated mainly to combat sports (the highest OR for Kick boxing, Boxing and Taekwondo) and to years of practice (highest odds for athletes that practice over 6 years).

Table 3 – Results of the logistic regression analysis – dependent variable: use of mouth guard

Variable	OR	95%CI	P
Gender			
Male	1.35	0.67 – 2.88	0.383
Female (ref)	1		
Type of sport			
Taekwondo	9.40	3.20 – 27.57	<0.001
Kick boxing	24.90	4.59 – 135.09	<0.001
Boxing	20.71	5.32 – 80.64	<0.001
Other sports	4.38	1,60 – 12.01	0.004
Judo (ref.)	1		
Years of practice			
More than 6	5.33	2.28 – 12.46	<0.001
Until 6 (ref.)	1		

S. aureus was carried by 101 athletes (42.4%), ranging from 23.8% for the judo players to 54.8% for the karate/old martial arts athletes. The most common site of isolation among of the 101 S. aureus carriers was the oropharynx (n=68, 67.3%) followed by the anterior nares (n=46, 45.5%) and the fingers (n=30, 29.7%); in 33 (32.7%) subjects S. aureus harbored more than one site, whereas in 43 (42.6%) only the oropharynx, in 20 (19.8%) only the anterior nares and in 5 (5%) only the fingers were colonized. Also, the results showed that S.

aureus colonization was more common among the athletes who share the sport equipment ($\chi 2$ =4.95, p=0.02) and in those who do not take showers immediately after training ($\chi 2$ =10.8, p=≤0.001). Moreover, there was a statistically significant association with a previous history of pharyngitis or sinusitis ($\chi 2$ =52.9, p=≤0.001), skin manifestations ($\chi 2$ =3.59, p=0.05) and the lack of appropriate information or training programs regarding the prevention of infectious diseases ($\chi 2$ =4.82, p=0.002) (Table 4).

Table 4. Multiple logistic regression results for estimates of associations of Staphylococcus aureus colonization with potential determinants.

Variable	OR	95% CI	p
~~*Log likelihood = -105.4; χ^2=109.13 (10 df); p<0.4000, No. of observations=234*~~			
Weekly training days (ordinal)	2.44	1.56-3.83	<0.001
Pharyngitis/sinusitis			
No	1.00[a]		
Yes	13.79	5.64-33.71	<0.001
Shower after training			
No	1.00[a]		
Yes	0.42	0.20-0.86	0.018
Age, years (ordinal)	1.76	1.14-2.71	0.011
Sharing sports equipment (helmet, shin guards, headgear, ankle braces, etc.~~helmet, shoes, gloves, bands, shell, etc~~)			
No	1.00[a]		
Yes	2.08	1.01-4.30	0.048
Skin manifestation			
No	1.00[a]		
Yes	2.73	0.90-8.30	0.076
Training programs regarding the prevention of infectious diseases in the gym			
No	1.00[a]		
Yes	0.19	0.03-1.18	0.074
Sharing creams/lotions			
No	1.00[a]		
Yes	0.20	0.03-1.28	0.089
Number of years in practice (ordinal)	1.19	0.96-1.48	0.120
Sharing soap			
No	1.00[a]		
Yes	0.33	0.07-1.65	0.178

NOTE. *Log likelihood = -105.4; χ^2=109.13 (10 df); p<0.4000, No. of observations=234*

[a] Reference category

Discussion

Sports are common cause of dental and orofacial injuries, dental accidents often have lifelong consequences (Tiwari et al., 2014). The use of the mouthguard in the combat sport have the ability to prevent many orofacial injuries in athletes. The Academy for Sports Dentistry recommends that national dental associations inform the public and oral healthcare professionals of the benefits of sport mouthguard. In the present study, the prevalence of the orofacial injuries during sporting activities was 12% while the mouthguard use was reported by 76 % of the participants. This results was support by 81% of the population said they did not suffer from orofacial injuries outside of sport. Similar finding were reported among studies conducted in Brazil, Israel, Birmingham, England, where the prevalence of the orofacial injuries was 28,8%, 27% and 12% respectively (Ferrari CH & Ferreria de Mederios JM, 2002; Levin L et al., 2003; Keçeci AD et al., 2005).

In present study most participants were aware of mouthguard for dental trauma prevention and considered them efficient to prevent dental injuries during sports activities, 76% used them. The prevalence of these cases was similar to that of the mouthguard, whose protection of dental and periodontal structures was confirmed during the fight. In previous studies the occurrence of dental injuries varied from 8,5 % to 37% according to the sport and the age of athlete (Ashley P et al., 2015). Biagi et al. studied dental trauma in seven different sports (not just combat sports), reporting that the occurrence of dental trauma was lower than the present study, only 8.5%. On the other hand, in a specific previous study, on taekwondo athletes, the incidence of dental trauma was 20% (Vidovic et al., 2015), while in our study the incidence of orofacial and dental trauma in athletes of taekwondo was 11%. These differences could be related to the participants' lack of knowledge about the technical features of the mouthguard. An ideal mouthguard should protect the teeth, soft tissue, bone structure, and temporomandibular joints; it should also diminish the incidence of concussion and neck injury,

and exhibit protective properties that include high power absorption and power distribution throughout expansion (Tiwari et al., 2014). Certain thicknesses and extensions are necessary for proper mouthguard protection; however, it should be noted that each athlete should be evaluated individually for thickness and design in order to promote comfort and sufficient protection (Kracher et al., 2013). In the current study, statistically significant difference (P<0.001) was in the mouthguard characteristics: most participants used model single arc (58%), boilt&bite type (93 %) with standard measure (86%) in gel material (55%). In regard to jaw relationships, mouthguard may have to be designed on the mandibular arch or maxillary arch. ''Boil&bite'' type mouthguard, are made from a thermoplastic material adapted to the mouth by finger, tongue and bite pressure after immersing the appliance in hot water (Newson PR et al., 2001). This mouthguard appears to be the most popular of the three types and is used by more than 90 % of the athletes (Parker K. et al., 2017). In this study the reasons for using single-arc material and gels include less problems during breathing and less difficulty speaking, present when they choose to use the boilt&bite mouthguard because they tend to become unsuitable with continued use. In previous studies most athletes used mouth-formed mouthguard which are easier to acquire and are less expensive, but have been shown as less protective (Newsome et al., 2001). The logistic regression model showed the use of mouthguard are associated mainly to combat sports (the highest OR for Kick boxing, Boxing and Taekwondo) and to years of practice (highest odds for athletes that practice over 6 years). This showed that older Kick boxing, Boxing and Taekwondo athletes in practice wearing mouthguard because they considered it significant to prevent injury.

Lack Italian-based epidemiological information exists about the incidence of dental injury in sports and correlation with *MRSA* exposure and/or infection. Mascaro et al. (2019) conducted the first study investigating S. aureus and MRSA colonization in Italian contact sports athletes: they have shown an emerging scenario of a high prevalence of *S. aureus* carriage, as well as a relevant resistance to antimicrobials frequently used for the treatment MSSA and MRSA infections. In the current study an univariate analysis showed that S. aureus colonization was associated, although not significantly, with athletes' age, ranging from 35.2% in the young subjects to 49.2% in those old athletes ($\chi 2$ =4.03, p=0.13), with increasing number of years of practice ($\chi 2$ =15.6, p=≤0.001), as well as with number of weekly training days ($\chi 2$ =27.6, p=<0.001). Consistent with other reports, these results implicate the sharing of personal sports equipment, poor hygiene practices, as well as frequency of sports activity, as factors associated to *S. aureus* colonization.(Hageman JC et al., 2005; Many PS, 2008; Nguyen DM et al., 2005). The Centers for Disease Control and Prevention (CDC) recommend measures to control MRSA among sports participants, including hand hygiene both before and after contact, wound care, regular cleaning of the personal athletic equipment and avoid the sharing of towel and personal items (CDC, 2018). Effectiveness of these preventive measures has been indirectly confirmed by our results showing that athletes attending gyms where educational programs regarding the prevention of infectious diseases were organized were less likely to be colonized by *S. aureus (*Collins CJ & O'Connell B, 2014*).* Data showed a high prevalence of S. aureus carriage and a relevant resistance to antimicrobials frequently used for the treatment of MRSA infections, but not correlated to dental trauma.

Conclusions

The literature views mouthguard as offering considerable protection against sports-related dental injuries. Due to the increasing participation in combat sports, the need for a specific mouthguard and its correct use is of fundamental importance. In the present study participants were aware of mouthguards for dental trauma prevention but not so informed about the specific characteristics. All health professionals and sports operators must work more closely together in reporting sports-related dental injuries and explain preventive measures such as hand hygiene before and after combat, wound care, regular cleaning of personal athletic equipment and avoid sharing towel and personal belongings to be able to control MRSA among sports participants. It would be important to organize educational programs on the prevention of infectious diseases in gyms and sports centers.

Conflict of interest: The authors declare no conflict of interest.

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