

Research · Science
Forschung · Wissenschaft
Recherche · Science

Publisher Herausgeber Editeur	Editor-in-chief Chefredaktor Rédacteur en chef	Editors Redaktoren Rédacteurs	Assistant Editor Redaktions-Assistent Rédacteur assistant
Schweizerische Zahnärzte- Gesellschaft SSO Société Suisse d'Odonto-Stomatologie CH-3000 Bern 7	Prof. Adrian Lussi Klinik für Zahnerhaltung, Präventiv- und Kinderzahnmedizin Freiburgstrasse 7 3010 Bern	Andreas Filippi, Basel Susanne Scherrer, Genève Patrick R. Schmidlin, Zürich	Thiago S. Carvalho, Bern Simon Flury, Bern Klaus Neuhaus, Bern Brigitte Zimmerli, Bern

Articles published in this section have been reviewed by members of the Editorial Review Board.

Jede im SDJ eingereichte Arbeit wird von zahnärztlichen Fachpersonen begutachtet. Diese genaue Begutachtung macht es möglich, dass die Publikationen einen hohen wissenschaftlichen Standard aufweisen.

Ich bedanke mich bei den unten aufgeführten Kolleginnen und Kollegen für ihre wertvolle Mitarbeit, die sie in den vergangenen drei Jahren geleistet haben.

Adrian Lussi

M. Altenburger, Freiburg	A. Friedmann, Witten	K. Lädach, Bern	M. Schimmel, Bern
N. Arweiler, Marburg	K. W. Grätz, Zürich	J. T. Lambrecht, Basel	R. Schmelzeisen, Freiburg
T. Attin, Zürich	S. Hänni, Bern	O. Lieger, Bern	P. R. Schmidlin, Zürich
M. E. Barbour, Bristol	H. Hecker, Basel	H. T. Lübbers, Zürich	A. Sculean, Bern
C. E. Besimo, Brunnen	E. Hellwig, Freiburg	H. -U. Luder, Männedorf	R. Seemann, Bern
U. Blunck, Berlin	I. Hitz Lindenmüller, Basel	R. Männchen, Winterthur	P. R. Shellis, Bristol
M. M. Bornstein, Bern	T. Imfeld, Zürich	C. Marinello, Basel	V. Suter, Bern
T. S. Carvalho, Bern	R. Jacobs, Leuven	G. Menghini, Zürich	U. Thüer, Meikirch
V. Chappuis, Bern	S. Janner, Bern	A. Mombelli, Genève	J. Türp, Basel
B. Cvikl, Wien und Bern	T. Joda, Bern	F. Müller, Genève	H. van Waes, Zürich
D. Dagassan-Berndt, Basel	C. Katsaros, Bern	K. Neuhaus, Bern	C. Verna, Basel
K. Dula, Bern	J. Katsoulis, Bern	I. Nitschke, Zürich	T. von Arx, Bern
S. Eick, Bern	N. Kellerhoff, Bern	C. Ramseier, Bern	C. Walter, Basel
T. Eliades, Zürich	S. Kiliaridis, Genève	M. Rücker, Zürich	T. Waltimo, Basel
N. Enkling, Bern	K. Kislig, Bern	S. Ruf, Giessen	R. Weiger, Basel
A. Filippi, Basel	G. Krastl, Würzburg	G. Salvi, Bern	M. Zehnder, Zürich
S. Flury, Bern	I. Krejci, Genève	M. Schätzle, Luzern	B. Zimmerli, Bern
A. Franz, Wien	A. L. Kruse, Zürich	S. Scherrer, Genève	N. U. Zitzmann, Basel

TATJANA IFKOVITS¹
 SEBASTIAN KÜHL¹
 THOMAS CONNERT²
 GABRIEL KRASTL²
 DOROTHEA DAGASSAN-
 BERNDT¹
 ANDREAS FILIPPI¹

¹ Department of Oral Surgery, Oral Radiology and Oral Medicine, Center of Dental Traumatology, School of Dental Medicine, University of Basel

² Department of Periodontology, Endodontology and Cariology, Center of Dental Traumatology, School of Dental Medicine, University of Basel

CORRESPONDENCE

Prof. Dr. med. dent.
 Andreas Filippi
 Department of Oral Surgery,
 Oral Radiology and Oral
 Medicine, Center of Dental
 Traumatology
 School of Dental Medicine
 University of Basel
 Hebelstrasse 3
 CH-4056 Basel
 Tel. +41 61 267 26 10
 Fax +41 61 267 26 07
 E-mail:
 andreas.filippi@unibas.ch

SWISS DENTAL JOURNAL SSO 125:
 1322-1329 (2015)
 Accepted for publication:
 17 March 2015

Prevention of dental accidents in Swiss boxing clubs

KEYWORDS

mouthguard,
 boxing,
 dental accidents

SUMMARY

Boxing involves a high risk of dental trauma due to the impact of enormous external forces against the head. Wearing a mouthguard is, therefore, mandatory. The aim of this study was to evaluate the prevalence of dental trauma as well as the utilization and quality of mouthguards in Swiss boxing clubs. In order to achieve this, data on the mouthguards of 217 boxers in total were collected using questionnaires and examination forms, which were statistically evaluated. Out of the 217 boxers, 75 (34.6%) had already experienced a dental accident, but only 8 (10.7%) of them while practicing their sport. Professional boxers were most frequently affected by dental trauma ($p=0.001$). Crown fractures were most often observed, followed by tooth dislocations. All interviewed athletes owned a mouthguard, which they used much more consistently during full-contact sparring (practice fighting) than during regular partner exercises. Most of the boxers used prefabricated mouthguards, which could

be individually adapted using the “boil and bite” system. The majority of the athletes received their mouthguards from the boxing club. Impaired speaking when wearing a mouthguard was, by far, the problem most frequently mentioned by the athletes. In terms of these bothering factors, custom-made mouthguards from dentists received the best rating ($p=0.002$). The quality of the mouthguard was assessed by evaluating the following criteria: coverage of the buccal surface, occlusal support of the opposing dentition, thickness of the occlusal layer, and rounded edges. Of the 215 mouthguards examined, 193 (89.8%) were insufficient ($p=0.002$). Despite the observed deficiencies, only a few dental injuries occurred during boxing. This study shows that although basic preventive measures do exist in Swiss boxing, they should be improved substantially by providing better instruction and more information.

Introduction

Boxing is one of the most popular forms of combat and contact sports worldwide. Internationally, two different kinds of boxing are practiced: Olympic boxing, also referred to as amateur boxing, and professional boxing. There are three essential points that distinguish amateur boxing from professional boxing (KÄSER 2003): match duration, equipment, and attitude or motivation. Diverse weight classes, rules, and scoring systems are additional factors that set Olympic boxing apart from professional boxing (ELLWANGER & ELLWANGER 2008). In Switzerland, three types of boxing are practiced: professional, Olympic, and light-contact boxing. Light-contact boxing, also called “boxe

éducative”, is a variety of boxing from France which is used in school lessons, in projects dealing with prevention of violence, or in educational work with children and adolescents with behavioral problems (KÄSER 2003). In contrast to amateur and professional boxing, hard blows are prohibited in light-contact boxing and are penalized with point deduction and disqualification (KÄSER 2003).

Nevertheless, boxing involves a high injury potential (FÖRSTL ET AL. 2010). Points are given for blows or strikes to the front of the body, from above the belt to the forehead (KÄSER 2003). Some boxers win a match by means of well-directed blows to the temple, the point of the chin, the side of the neck, the

larynx, the heart, the solar plexus, the spleen, the stomach, and the liver, i.e. the so-called knockout points (SONNENBERG 2009). The impact speed of the fist on the opponent's head is on average 9.14 m/s (WALILKO ET AL. 2005). The punch force increases with increasing weight class, on average it is 3427 N and causes a mean rotational head acceleration of 6343 rad/s² (WALILKO ET AL. 2005). The risk of a blunt traumatic brain injury is correspondingly high (FÖRSTL ET AL. 2010). The face, head, neck, and upper limbs are the areas of the body most frequently injured in boxing (ZAZRYN ET AL. 2003, POTTER ET AL. 2011). The main diagnoses are lacerations in the facial area (ZAZRYN ET AL. 2003, BLEDSOE ET AL. 2005), cerebral concussions (ZAZRYN ET AL. 2003, ZAZRYN ET AL. 2006), and fractures of the upper extremities (POTTER ET AL. 2011).

Apart from the severe neurological and physical injuries (FÖRSTL ET AL. 2010), boxing belongs to the group of sports with a high risk of dental trauma (FILIPPI 2008). Between 4 and 44.2% of martial artists sustain a dental accident (FERRARI & FERREIRA DE MEDEIROS 2002, LEVIN ET AL. 2003, TULUNOGLU & ÖZBEK 2006, SHIRANI ET AL. 2010). Crown fractures are diagnosed most frequently (ANDRADE ET AL. 2010, EMERICH & NADOLSKA-GAZDA 2013), and mainly the maxillary central incisors are affected (ANDRADE ET AL. 2010). At the Pan American Games in 2007, more than two-thirds of the sport-induced dental injuries were observed in athletes who were not wearing a mouthguard (ANDRADE ET AL. 2010). Wearing a mouthguard can markedly reduce the frequency of dental accidents in contact sports (NEWSOME ET AL. 2001, SCHILDKNECHT ET AL. 2012).

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. 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 (RANALLI & DEMAS 2002). For this purpose, the dental arch and alveolar process must be covered, and the opposite jaw must be supported by occlusal impressions (FILIPPI & POHL 2001). Accurate adaptation to the intraoral situation ensures good retention and, thus, largely prevents disengagement of the mouthguard upon physical effort or an impact (KIRSCHNER ET AL. 2006, FILIPPI 2008). Rounded edges of the mouthguard prevent irritation to the soft tissue (KIRSCHNER ET AL. 2006, FILIPPI 2008). The material should be elastic, disinfectable, easy to clean, tasteless, and odorless (KIRSCHNER ET AL. 2006, FILIPPI 2008). Mouthguards should not impair either breathing or communication when carrying out a sporting activity (CHACONAS ET AL. 1985). A custom-made mouthguard from the dentist undisputedly exhibits the best properties (FILIPPI & POHL 2001) and provides the best protection (PATRICK ET AL. 2005).

Wearing a mouthguard is required in boxing (AIBA 2012, EBU 2012). The aim of this study was to evaluate the frequency of dental accidents as well as the usage and quality of mouthguards in Swiss boxing clubs.

Materials and Methods

According to the Swiss boxing federation "SwissBoxing", there are more than 390 licensed female and male amateur boxers as well as over 25 professionals in Switzerland (SWISS BOXING FEDERATION 2012). The exact number of light-contact boxers, however, is unknown. The parent organization "SwissBoxing"

comprises 80 boxing clubs (SWISS BOXING FEDERATION 2012). For this study, however, exclusively membership-only clubs from German-speaking Switzerland were contacted. The contact data of the boxing clubs were obtained from the website www.swissboxing.ch. Chairmen and coaches of the selected boxing clubs were informed beforehand about the topic and procedure of the study, and asked whether the athletes were allowed to participate. They all agreed and confirmed their support. After verbal clarification, the athletes consented to participate in this study. Female and male boxers from the following German-speaking Swiss cantons were included: Basel-Stadt, Basel-Landschaft, Bern, Aargau, Zurich, St. Gallen, and Lucerne. A total of 217 boxers in the German-speaking part of Switzerland were interviewed. They were subdivided into the following groups: light-contact, amateur, and professional boxers. The athletes' answers and data on their mouthguards were collected using questionnaires and examination forms. The kind of boxing (light-contact/amateur/professional), age, gender, and type of boxing (competitors/training participants) were identified at the beginning of the interview. The questionnaire consisted of questions about boxing training as well as the frequency of wearing a mouthguard, supplier, costs, cleaning, and storage of the mouthguard, bothering factors associated with the mouthguard, dental accidents, and the effects of the mouthguard on boxing (Tab. I). Mouthguards were examined using disposable gloves and a dial caliper, and findings were recorded in the examination form (Tab. II). The maximum and minimum occlusal material thickness was measured at the position of each tooth involved, but only the highest and lowest measurements were recorded. Cleanliness was assessed visually without a magnifying aid. Finally, the mouthguard was photographed using a digital camera and disinfected with a chlorhexidine rinsing solution. Using the data from the examination form, the quality of the mouthguard was determined based on the following criteria (SCOTT ET AL. 1994, FILIPPI & POHL 2001, PATRICK ET AL. 2005): the alveolar process and dental arch had to be covered, the opposing jaw had to be supported by occlusal impressions, the edges had to be rounded, and the occlusal thickness had to be at least 2 mm.

For the statistical evaluation, mouthguards were categorized. In addition to the classification of mouthguard models described in the literature, the mouth-formed mouthguard was further divided into three subgroups: "boil and bite", shell-liner, and gel mouthguard. The "boil and bite" mouthguard consists of a thermoplastic formable plastic splint, which is heated and then adapted directly in the mouth (FILIPPI & POHL 2001, LANG & FILIPPI 2003). The shell-liner mouthguard is composed of a prefabricated outer shell, which is filled with an elastic material and can then be adapted intraorally (FILIPPI & POHL 2001, LANG & FILIPPI 2003). The gel mouthguard consists of three components: a plastic splint lined with a gelatinous, thermoplastic formable material and reinforced with a blow-absorbing scaffold. In order to better illustrate the differences between the various types of mouthguards, these three models were classified in separate categories. Stock mouthguards were only used by two athletes included in this study and were not, therefore, considered in the evaluation of the examination forms. As a result, a total of four categories of mouthguards were taken into account: the "boil and bite" mouthguard (1), the shell-liner mouthguard (2), the gel mouthguard (3), and the custom-made mouthguard from the dentist (4). In the evaluation of the questionnaires, data from the two athletes using a stock mouth-

Tab.1 Questionnaire

1. How long have you been boxing or practicing boxing?	___ years
2. How many times do you practice every week?	___ times a week, ___ hours, each
3. What does your training program look like?	Full-contact sparring and partner exercises Only partner exercises
4. When are you required to wear a mouthguard in boxing?	Match, sparring, partner exercises
5. Do you own a mouthguard?	Yes/No
6. Do you always wear a mouthguard when boxing?	Yes/No If no, when do you not wear it? Free answer
7. How often do you wear your mouthguard during sparring?	Always, mostly, rarely to never
8. How often do you wear your mouthguard during partner exercises?	Always, mostly, rarely to never
9. How long have you owned this mouthguard?	___ years
10. Why did you decide on this mouthguard?	Club, sports shop, product features, recommendation, gift, other reasons:
11. Did you pay for your mouthguard yourself? (Price)	Yes/No (CHF ___)
12. Would you recommend your mouthguard?	Yes/No
13. How often do you clean your mouthguard?	After every wear, rarely to never
14. How do you clean your mouthguard?	Free answer
15. Where do you keep your mouthguard?	Free answer
16. What bothers you about your mouthguard?	Insufficient retention, breathing problems, gag reflex, impaired speaking, dry mouth, wearing comfort/fit, other:
17. Have you ever sustained a dental accident?	Yes/No
18. If yes, did it occur when boxing?	Yes/No If yes, what kind of dental injury? Avulsion, dislocation, crown fracture
19. How does wearing a mouthguard affect you when carrying out your sporting activities?	Free answer

guard were, however, taken into account. Only the answers to the questions “Would you recommend your mouthguard?” and “What bothers you about your mouthguard?” were not used, because the number of cases was too low.

The qualitative attribute “bothering factors” was consolidated into three categories because there were too many specifications (for example, insufficient retention, breathing problems, etc.). The following categories were established for the attribute “bothering factors”: no bothering factors, impaired speaking, and other bothering factors.

All data from the questionnaire and examination form were recorded and statistically evaluated. For categorical parameters, contingency tables comprising the number of cases and their percentage values were made. Respective p-values were calculated using Fisher’s exact test. For continuous parameters, means and standard deviations (SD) or medians and interquartile ranges (IQR) were determined. Linear regression models were applied to compare these parameters (e.g. age) among the various groups. The linear regression models yielded the appropriate coefficients with a 95% confidence interval and corresponding p-values. For parameters that did not meet the criteria of normal distribution, the Wilcoxon rank-sum test or the Kruskal-Wallis test (in cases of more than two categories, e.g.

types of mouthguards) were applied. In all test procedures, the level of significance was set at 0.05 (two-sided). For visualization, additional graphical plots were made, which illustrated relative proportions. All statistical calculations were made using the “Statistical package R” software (The R Foundation for Statistical Computing, Version 2.12.2) (R DEVELOPMENT CORE TEAM 2011). Questions with multiple answers were evaluated descriptively using contingency tables.

Results

A total of 217 boxers, including 100 light-contact boxers (20 females/80 males), 100 Olympic boxers (20/80), and 17 professional boxers (2/15), were examined. Nearly one-fifth of the boxers were females (19.4%, n=42/217). The average age of the athletes was 23.7 years (9–63, SD = 8.98). 51.6% of the athletes (n=112/217) practiced boxing as competitors. On average, the light-contact boxers had practiced boxing for nearly 2 (0.25–20, SD = 2.78) years, amateurs for 3.8 (0.25–47, SD = 5.34), and professional boxers for 14.4 (4–30, SD = 6.86) years. 34.6% of the athletes (n=75/217) trained one to two times a week for 1 hour, 48.8% (n=106/217) attended training three to four times a week for 2 hours, and 16.6% (n=36/217) trained more than four times a week. All boxers interviewed owned a

Tab. II Examination form	
Type of mouthguard	I. stock mouthguard II. mouth-formed mouthguard a) "boil and bite" mouthguard b) shell-liner mouthguard c) gel mouthguard III. custom-made mouthguard
Shape	Mouthguard for the upper jaw Mouthguard for the lower jaw Mouthguard for upper and lower jaw
Buccolabial coverage	Only dental arch covered Dental arch and alveolar process covered
Occlusal support of opposing jaw	Opposing jaw supported by occlusal impressions* Insufficient** or missing occlusal impressions
Occlusal thickness	Max. ____ mm, min. ____ mm
Cleanliness	Clean*** Not clean
Edges	Rounded Sharp-edged
* occlusally supported in the front and posterior tooth region ** impressions only in the front or posterior tooth region *** no traces of dental plaque or blood	

mouthguard. The average age of the mouthguard was 1.4 years (minimum = 0.003, i.e. 1 day, maximum = 20, SD = 2.46).

The question "When are you required to wear a mouthguard in boxing?" was answered by 82% of the athletes (n=178/217) with "match, sparring, and partner exercises". Full-contact sparring (practice fighting during training) and partner exercises were an integral part of the training program for 57.1% of the boxers (n=124/217). The remaining 42.9% of the boxers (n=93/217), i.e. the light-contact boxers, did not practice full-contact sparring, but only partner exercises. During partner exercises, 48.4% of the boxers (n=105/217) always wore their mouthguards, 34.1% (n=74/217) mostly, and 17.5% (n=38/217) rarely to never. In terms of the frequency with which participants wore a mouthguard during partner exercises, there were no differences between the kinds of boxing (p=0.448), the types of boxing (competitors versus training participants, p=0.357), and the genders (p=0.804). However, there was a difference in age: boxers who always wore their mouthguards during partner exercises were 4.4 years older than those who wore them rarely to never (95% confidence interval = 1.1-7.7; p=0.009). In comparison to the partner exercises, boxers wore their mouthguards far more consistently during sparring. During full-contact sparring, 97.6% of the athletes (n=121/124) always protected their teeth, 1.6% (n=2/124) mostly, and 0.8% (n=1/124) rarely to never. Only 9.7% of the athletes (n=21/217) essentially always wore their mouthguards during practice. In doing so, their goal was to get more used to them. In competitive situations, the mouthguard should not be perceived as a nuisance and, hence, negatively affect concentration. Because of the impaired breathing conditions, 90.3% of the boxers (n=196/217) did not always wear their mouthguards. They refrained from wearing them during workouts (99%, n=194/196), during practice with the punching bag (39.8%,

n=78/196), during weight training (32.7%, n=64/196), during technique practice (26%, n=51/196), and during partner exercises (5.1%, n=10/196). Some (3.6%, n=7/196) said that they did not always wear their mouthguards because they often forgot them or because they did not use them during exercises without contact.

34.6% of the boxers (n=75/217) had already sustained a dental accident in the permanent dentition; of these, 10.7% (n=8/75) sustained the injury while practicing their sport. Dental trauma due to boxing were observed exclusively in males. Dental accidents frequently occurred in professional boxing (n=4/17) and were relatively seldom in amateur (n=3/100) and light-contact boxing (n=1/100; p=0.001). Competitors tended to be more frequently affected (p=0.066). During boxing practice or matches, athletes primarily suffered crown fractures (75%, n=6/8), but also tooth dislocations (37.5%, n=3/8). Seven of the eight athletes that had sustained a dental trauma during boxing were competitors and engaged in full-contact sparring. Six of them always wore their mouthguards during sparring and only one wore it rarely to never. Nonetheless, no difference in the frequency of dental accidents could be observed between boxers practicing full-contact sparring and those performing only partner exercises (p=0.142).

When asked about the effects of mouthguards on boxing, 86.2% of the athletes (n=187/217) declared that they felt safer as a result of wearing a mouthguard. Some boxers (5.1%, n=11/217) said that the mouthguard had a positive effect on their concentration and courage, and a further 12.4% (n=27/217) stated that the mouthguard positively affected their breathing or prevented them from biting their tongues. In contrast, 12.4% of the boxers (n=27/217) indicated that they perceived the mouthguard as bothersome and did not feel safer as a result of wearing it.

The majority of the boxers received their mouthguards from their clubs (53%, n=115/217) and sports shops (20.7%, n=45/217). Some reported (12%, n=26/217) that the product features (price, appearance) had influenced their purchase. Others decided on their mouthguards based on recommendations (6%, n=13/217) from colleagues, dentists, and salesmen, or received them as a gift (7.4%, n=16/217). A few (8.8%, n=19/217) mentioned chance, the internet, or something else as reasons for deciding to purchase their mouthguards. 85.7% of the athletes (n=186/217) paid for their mouthguards themselves. Ready-made mouthguards cost CHF 10 on average, "boil and bite" mouthguards cost CHF 13, shell-liner mouthguards cost CHF 20, and gel mouthguards cost CHF 22. The custom-made mouthguards from the dentist were by far the most expensive, costing CHF 383 on average.

The question "How often do you clean your mouthguard?" was answered by 90.8% of the athletes (n=197/217) with "after every wear". Only 9.2% (n=20/217) cleaned their mouthguards rarely to never. Males and females behaved similarly (p=1). To the question "How do you clean your mouthguard?" only two athletes (0.9%) responded with "not at all". Most boxers cleaned their mouthguards mainly with water (96.8%, n=210/217), some used toothbrushes (28.1%, n=61/217) or toothpaste (23.5%, n=51/217). A few even used soap (5.1%, n=11/217), denture cleaning tablets (3.7%, n=8/217), disinfectants (2.3%, n=5/217), or mouthwash (1.8%, n=4/217). Nevertheless, 42.3% of the mouthguard models examined (n=91/215) were not observed to be clean and exhibited traces of dental plaque and blood (Fig. 1). The dirty models were 0.5 years older than the clean ones (p=0.001). 77% of the boxers (n=167/217) kept their mouthguards in a mouthguard box,

9.2% (n=20/217) in a sports bag, and 5.5% (n=12/217) in a lunch-box. Plastic bags (3.2%, n=7/217), boxing gloves (1.4%, n=3/217), and other items (3.7%, n=8/217) such as a jewelry box, gym pants, handkerchief, and toffee tin were mentioned as well.

59.5% of the athletes (n=128/215) had a “boil and bite” mouthguard, 25.1% (n=54/215) had a shell-liner mouthguard, and 8.4% (n=18/215) had a gel mouthguard. Only 7% (n=15/215) of the boxers owned a custom-made mouthguard from the dentist. In terms of shape, the majority of the athletes (96.3%, n=207/215) preferred a mouthguard model for the upper jaw. A few (3.7%, n=8/215) used models which simultaneously protected both maxilla and mandible. Among the various groups of boxers, there were different preferences with regard to the mouthguard type ($p < 0.001$). Light-contact boxers (72.7%, n=72/99) preferred the “boil and bite” model, as did the amateurs (51.5%, n=51/99). The shell-liner mouthguard was also very popular among the amateurs (30.3%, n=30/99) and the light-contact boxers (23.2%, n=23/99). More than half of the gel mouthguard models examined (61.1%, n=11/18) were used by amateur boxers, whereas the custom-made mouthguards from the dentist were exclusively used by professional (47.1%, n=8/17) and Olympic boxers (7.1%, n=7/99).

The question “Would you recommend your mouthguard?” was answered with “yes” by 88.8% of the boxers (n=191/215). No one type of mouthguard was recommended more than any other ($p = 0.59$). Nevertheless, only 22.3% of the athletes

(n=48/215) were satisfied with their mouthguards, while 77.7% (n=167/215) criticized some aspect. The assumption that the three mouth-formed models exhibited the most bothering factors was confirmed ($p = 0.002$; Fig. 2). The custom-made mouthguard was the least criticized model by the boxers. Ten (66.7%) out of 15 users did not mention any bothering factors. Boxers most frequently complained about impaired speaking (56.3%, n=121/215), followed by other points of criticism such as breathing problems (18.1%, n=39/215), insufficient retention (13.5%, n=29/215), gag reflex (10.2%, n=22/215), dry mouth (9.3%, n=20/215), and wearing comfort and fit (8.8%, n=19/215). Additional issues (32.1%, n=69/215) were taste, pressure sores, soft tissue irritation, constant spitting, and difficulties with adaptation in the mouth.

In terms of quality, the mouthguard models examined even differed within each category when criteria were considered individually:

Buccolabial coverage

Only 66% of the mouthguard models (n=142/215) covered the dental arch and the alveolar process. In terms of the intraoral fit to the dental arch and alveolar process, the custom-made mouthguards from the dentist (93.3%, n=14/15) performed by far the best ($p = 0.005$). More than two-thirds of the “boil and bite” models examined (70.3%, n=90/128) met the requirements. Worst rated were the gel and shell-liner mouthguards,

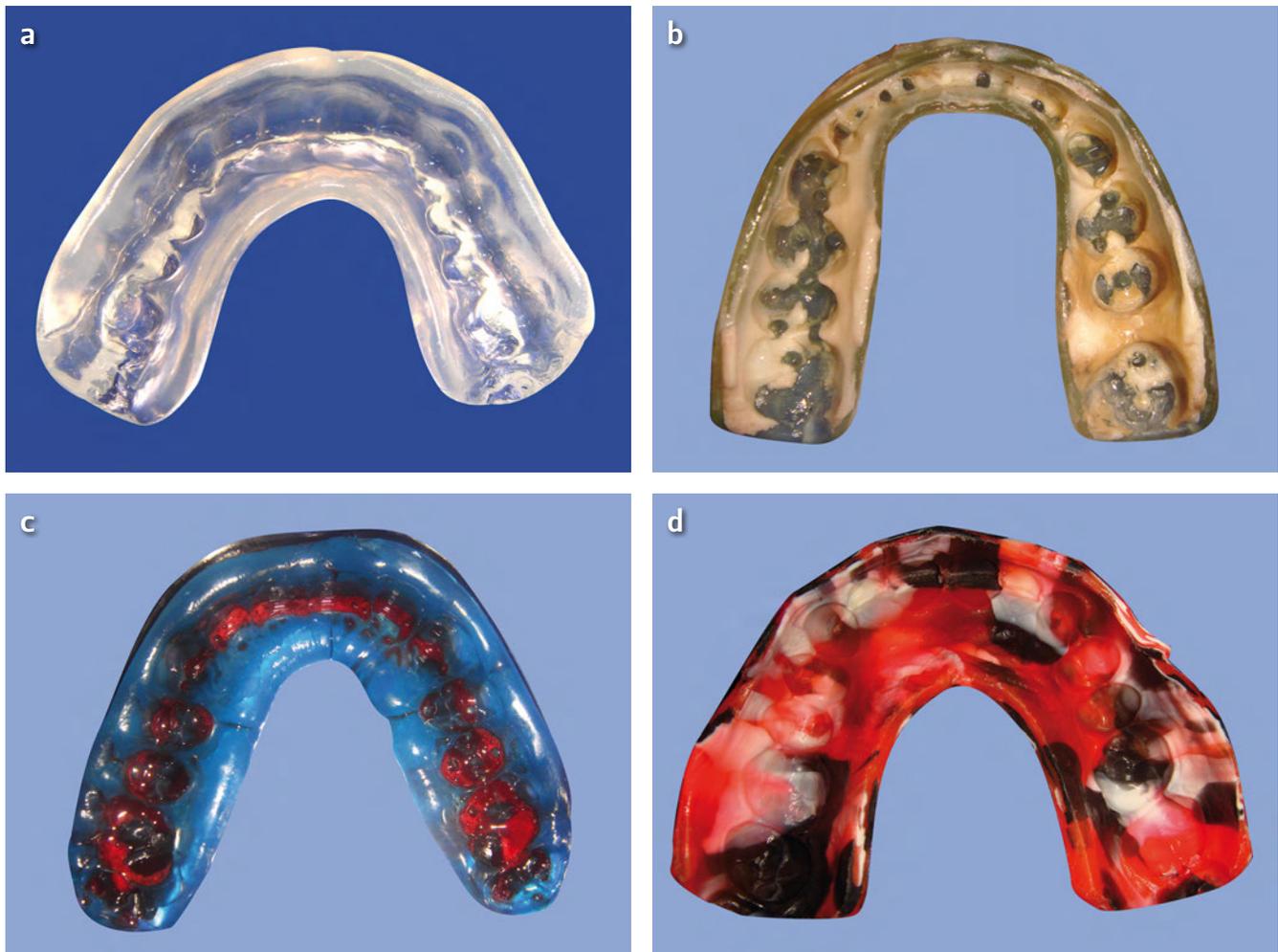


Fig. 1 Examples of the various models: “boil and bite” mouthguard (a), shell-liner mouthguard (b), gel mouthguard (c), and custom-made mouthguard (d)

of which 55.6% (n=10/18) and 44.4% (n=24/54) respectively did not meet the requirements.

Occlusal support

More than half of the models examined (54.9%, n=118/215) exhibited insufficient occlusal support of the opposing jaw. In this respect, the shell-liner mouthguard performed worst ($p < 0.001$): not a single one (0%, n=0/54) provided occlusal support. 77.8% of the gel mouthguard models (n=14/18) and 36.7% of the “boil and bite” type (n=47/128) showed no or insufficient occlusal impressions, because they were not at all or inadequately adapted. The best performance was observed with respect to the custom-made mouthguards (80%, n=12/15) from the dentist.

Occlusal thickness

In terms of maximum and minimum occlusal thickness, no differences were observed between the mouthguard models ($p \geq 0.513$). The median maximum occlusal thickness was 3.5 mm (IQR = 3.0–4.1) in the “boil and bite”, 3.5 mm (IQR = 3.0–4.5) in the shell-liner, 4.0 mm (IQR = 3.3–4.8) in the gel, and 4.0 mm (IQR = 2.5–4.7) in the custom-made mouthguards. The median minimum occlusal thickness was 2.1 mm (IQR = 1.4–3.0) in the “boil and bite”, 2.1 mm (IQR = 1.8–2.5) in the shell-liner, 2.2 mm (IQR = 1.9–2.7) in the gel, and 2.0 mm (IQR = 1.2–3.0) in the custom-made mouthguards.

Rounded edges

Rounded edges were noted in 71.2% of the models examined (n=153/215). The “boil and bite” mouthguards (96.9%,

n=124/128) performed best, followed by the gel (88.9%, n=16/18) and the custom-made mouthguards (80%, n=12/15) from the dentist. Worst rated were the shell-liner mouthguards ($p < 0.001$), of which 98.1% (n=53/54) were sharp-edged.

Outcome of the quality control

89.8% of the mouthguard models examined (n=193/215) were insufficient because they did not meet all of the requirements (Fig. 3). By comparison, the shell-liner mouthguards (100%, n=54/54) performed worst, followed by the gel (94.4%, n=17/18), the “boil and bite” (86.7%, n=111/128), and the custom-made mouthguards (73.3%, n=11/15) from the dentist ($p = 0.002$).

Discussion

Frequent blows as well as high force effects and forceful impacts against the head are characteristic of the sport of boxing (FÖRSTL ET AL. 2010). Given the high risk of dental accidents (FDI 1990), wearing a mouthguard is obligatory in boxing (AIBA 2012, EBU 2012). In this study, all of the boxers owned a mouthguard. Only 3.7% of the 217 interviewed athletes had sustained a dental trauma when practicing their sport. The athletes in the Swiss boxing clubs wore their mouthguards more consistently during exercises involving contact than Polish amateur boxers (EMERICH & NADOLSKA-GAZDA 2013). Thus, dental accidents among Polish boxers were sustained more frequently during training (36.5%) and at tournaments (26.1%) (EMERICH & NADOLSKA-GAZDA 2013). Nevertheless, the low injury rate in the Swiss boxing clubs cannot be unequivocally attributed to wearing frequency, because the boxers did not wear their mouthguards consistently during the various training sessions (sparring/partner exercises).

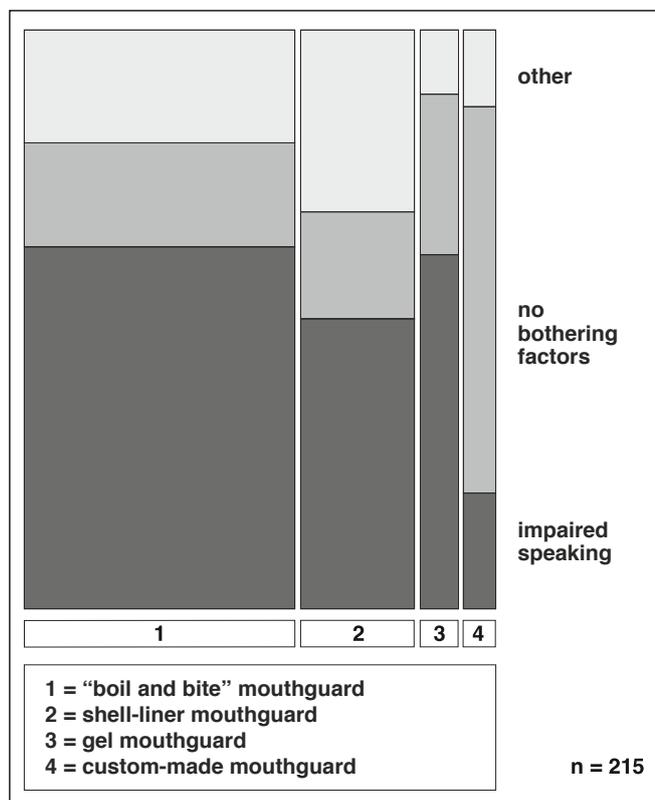


Fig. 2 Mosaic plot visualizing the relationship between the qualitative variables “bothering factors” and “mouthguard types”. Vertical bars represent relative proportions of bothering factors associated with the various mouthguard types.

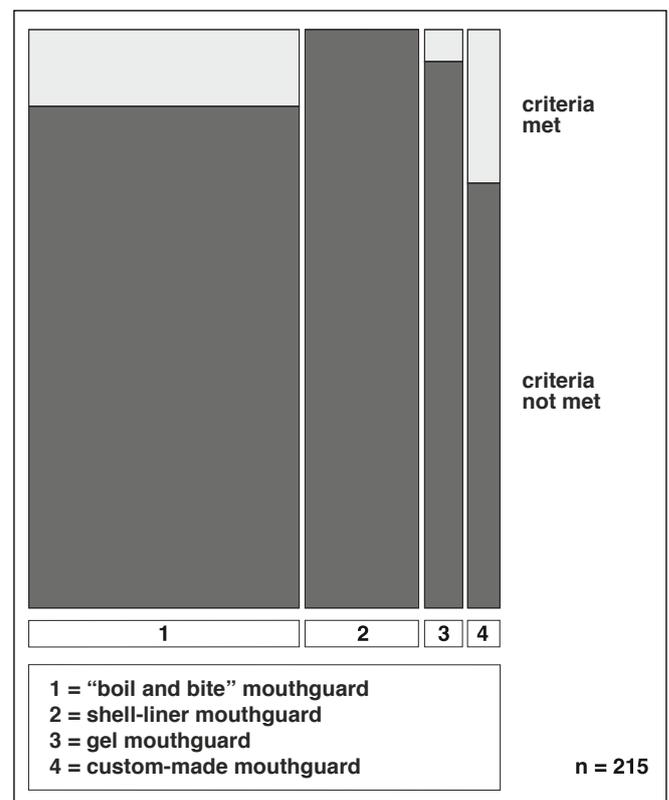


Fig. 3 The mosaic plot clearly shows that the majority of the mouthguard models examined were insufficient. The shell-liner mouthguard performed by far worst, because it was not satisfactory even with respect to the individual criteria and, therefore, exhibited the greatest overall deficiencies.

The majority of the athletes made positive comments about the effects of the mouthguard on boxing. This shows that many boxers appreciate and embrace the use of mouthguards. Compared to boxing, the acceptance of mouthguards is moderate to low in other sports (TSCHAN ET AL. 2003, PERUNSKI ET AL. 2005, LIEGER & VON ARX 2006, HERSBERGER ET AL. 2012). The majority of the boxers used a mouth-formed mouthguard. Only 47.1% of the professional and 7.1% of the amateur boxers owned a custom-made mouthguard from the dentist. These observations do not match the results from other investigations (LIEGER & VON ARX 2006, SCHILD-KNECHT ET AL. 2012), which indicate that 76.5–91% of the amateur and professional athletes used a custom-made mouthguard.

Lack of information, the models that are available, and the price in particular can be regarded as reasons why boxers do not protect themselves with better quality mouthguards. Boxers largely obtained their mouthguards from their clubs (53%) or sports shops (20.7%). In boxing clubs, the “boil and bite” and shell-liner mouthguards are primarily offered and recommended. Low costs and minimal effort might be the main reasons for the preferred purchase in the clubs and sports shops, because 85.7% of the athletes pay for their mouthguards themselves. Price plays an essential role in the decision (PATRICK ET AL. 2005, BOFFANO ET AL. 2012). For many boxers, custom-made mouthguards from the dentist are too expensive at an average price of CHF 383, and from their point of view, the cheaper versions serve the purpose just as well. In addition, 88.8% of the athletes would recommend their mouthguards because they feel the cost-benefit ratio is sufficient. However, only 22.3% of the boxers were actually satisfied with their mouthguards. A majority of the athletes mainly criticized impaired speaking (56.3%), followed by breathing problems (18.1%). These findings are similar to observations in other studies (LIEGER & VON ARX 2006, BOFFANO ET AL. 2012), in which the same points of criticism were frequently mentioned.

Among the mouthguards examined in this study, 89.8% were insufficient. Shell-liner and gel mouthguards exhibited the worst results by far. The occlusal support and the intraoral fit to the dental arch and alveolar process were the main points criticized. By comparison, “boil and bite” mouthguards performed better than the other two models, although they were not completely satisfactory either because of the limited adaptability (FILIPPI & POHL 2001, LANG & FILIPPI 2003). Manufacturer’s information notwithstanding, most boxers had difficulties adapting the mouthguard to the intraoral situation. Therefore, they only adjusted the mouthguard insufficiently or completely refrained from doing so. For this reason, more than half of the mouth-formed mouthguard models exhibited unsatisfactory support of the opposing jaw in the front and posterior tooth region. As a consequence of insufficient occlusion, blows to the chin can lead to fractures of the mandible (TAKEDA ET AL. 2004, SHIMOYAMA ET AL. 2009). A further problem is the insufficient occlusal material thickness (PARK ET AL. 1994, FILIPPI & POHL 2001, LANG & FILIPPI 2003). In contact sports, the occlusal thickness should be at least 2 mm in order to ensure adequate protection (SCOTT ET AL. 1994, PATRICK ET AL. 2005). Deficiencies in this regard could be observed in all three mouth-formed mouthguard models. Thus, the three mouth-formed mouthguard models cannot be recommended for light-contact boxing, and even less so for amateur and professional boxing.

In this study, nearly three-quarters of the custom-made mouthguard models made by a dentist were insufficient. Reasons for this are presumably unsatisfactory care, wear, and a

lack of follow-up checks by the dentist. PATRICK ET AL. (2005) noted that, as a consequence of material wear, persistent use, and alterations in the dentition, a custom-made mouthguard can considerably deteriorate in terms of quality after two years, and even more so after five years. Therefore, it is important that athletes have their mouthguards checked regularly (KIRSCHNER ET AL. 2006).

A custom-made mouthguard undisputedly provides the best protection (RANALLI & DEMAS 2002), as long as it is properly manufactured and meets the requirements (PATRICK ET AL. 2005). Coaches, club members in positions of authority, and dentists should better inform athletes about the advantages and disadvantages of the different types of mouthguards (TSCHAN ET AL. 2003, PATRICK ET AL. 2005). In summary, it can be pointed out that in Swiss boxing, there are good preventive measures in place with regard to acceptance, wearing frequency, and use of a mouthguard. Despite the qualitative deficiencies of the mouthguard models examined, the prevalence of injuries was comparatively low. Irrespective of the quality, it is clear that not wearing a mouthguard in sport entails a 1.6–1.9 times higher risk of orofacial injuries (KNAPIK ET AL. 2007). Therefore, more strict measures should be taken and corresponding regulations should be drawn up for other contact sports that are associated with a high risk of dental accidents as well.

Acknowledgment

The authors thank Urs Simmen for the statistical evaluation as well as all of the athletes and coaches who participated in the study.

Résumé

En raison des nombreux coups et des chocs violents au niveau de la tête auxquels sont exposés les boxeurs, ce sport présente un risque élevé de traumatismes dentaires. C’est la raison pour laquelle le port d’un protège-dents est obligatoire. La présente étude visait à évaluer la fréquence des traumatismes dentaires, l’utilité et la qualité des protège-dents dans les clubs de boxe suisses. Les données se rapportant à 217 boxeurs et à leur protège-dents ont été collectées au moyen de questionnaires et analysées à des fins statistiques. Sur 217 boxeurs, 75 (34,6%) avaient subi jusqu’à présent un traumatisme dentaire, mais seulement 8 (10,7%) dans le cadre de leur activité sportive. Les boxeurs professionnels étaient les plus affectés ($p=0,001$). Dans cette enquête, les fractures coronaires étaient les plus fréquentes, avant les dislocations. Toutes les personnes interrogées possédaient un protège-dents qu’elles portaient plus régulièrement pour le «sparring full-contact» que lors des entraînements avec partenaire. La majorité des boxeurs utilisaient un protège-dents fabriqué en série et adaptable, notamment le modèle «Boil and Bite». La plupart des athlètes achetaient leur protège-dents par l’intermédiaire du club de boxe. Les problèmes les plus fréquemment mentionnés concernaient les difficultés à parler avec un protège-dents. En matière de confort, le protège-dents fabriqué sur mesure par le dentiste avait le plus de succès ($p=0,002$). La qualité du protège-dents a été évaluée sur la base des critères suivants: l’aspect bucco-labial, l’occlusion, l’épaisseur occlusale et les bords arrondis. Sur 215 modèles examinés, 193 (89,8%) se sont avérés insuffisants ($p=0,002$). En dépit des défauts relevés, seuls quelques athlètes avaient subi un traumatisme dentaire lors d’un combat de boxe. L’étude révèle que les approches préventives existent dans la boxe suisse, mais qu’elles doivent être améliorées par l’éducation et l’information.

References

- AIBA INTERNATIONAL BOXING ASSOCIATION (2012):** Technical and Competition Rules. www.aiba.org/documents/site1/docs/technical_and_competition_rules_201207018.pdf [accessed August 15, 2012]
- ANDRADE R A, EVANS P L, ALMEIDA A L, DA SILVA J DE J, GUEDES A M, GUEDES F R, RANALLI D N, MODESTO A, TINOCO E M:** Prevalence of dental trauma in Pan American Games athletes. *Dent Traumatol* 26: 248–253 (2010)
- BLED SOE G H, LI G, LEVY F:** Injury risk in professional boxing. *South Med J* 98: 994–998 (2005)
- BOFFANO P, BOFFANO M, GALLESIO C, ROCCIA F, CIGNETTI R, PIANA R:** Rugby athletes' awareness and compliance in the use of mouthguards in the North West of Italy. *Dent Traumatol* 28: 210–213 (2012)
- CHACONAS S J, CAPUTO A A, BAKKE N K:** A comparison of athletic mouthguard materials. *Am J Sports Med* 13: 193–197 (1985)
- EBU EUROPEAN BOXING UNION (2012):** Boxing Rules. www.boxebu.com/ebuboxingrulesNEW.htm [accessed August 19, 2012]
- ELLWANGER S, ELLWANGER U:** Boxen basics. Training – Technik – Taktik. Pietsch Verlag, Stuttgart (2008)
- EMERICH K, NADOLSKA-GAZDA E:** Dental trauma, prevention and knowledge concerning dental first-aid among Polish amateur boxers. *J Sci Med Sport* 16: 297–301 (2013)
- FDI FEDERATION DENTAIRE INTERNATIONALE:** Commission on dental products. Working party No. 7 (1990)
- FERRARI C H, FERREIRA DE MEDEIROS J M:** Dental trauma and level of information: mouthguard use in different contact sports. *Dent Traumatol* 18: 144–147 (2002)
- FILIPPI A, POHL Y:** Der Zahnschutz: Prävention von Zahnunfällen im Sport. *Schweiz Monatsschr Zahnmed* 111: 1075–1085 (2001)
- FILIPPI A:** Traumatologie bleibender Zähne. In: Lambrecht J T (Ed.): *Zahnärztliche Operationen*. Quintessenz Verlag, Berlin, pp 169–223 (2008)
- FÖRSTL H, HAASS C, HEMMER B, MEYER B, HALLE M:** Boxing – acute complications and late sequelae: from concussion to dementia. *Dtsch Arztebl Int* 107: 835–839 (2010)
- HERSBERGER S, KRASTL G, KÜHL S, FILIPPI A:** Dental injuries in water polo, a survey of players in Switzerland. *Dent Traumatol* 28: 287–290 (2012)
- KÄSER S:** Integrationsmöglichkeiten für das Boxen im Schweizer Schulsport. GRIN Verlag, Munich (2003)
- KIRSCHNER H, POHL Y, FILIPPI A, EBELESEDER K:** Unfallverletzungen der Zähne. Vorbeugen – Retten – Behandeln. 2nd ed., Elsevier, Urban & Fischer Verlag, Munich (2006)
- KNAPIK J J, MARSHALL S W, LEE R B, DARAKJY S S, JONES S B, MITCHENER T A, DELA CRUZ G G, JONES B H:** Mouthguards in sport activities: history, physical properties and injury prevention effectiveness. *Sports Med* 37: 117–144 (2007)
- LANG B, FILIPPI A:** Der Zahnschutz im Sport – Funktion, Herstellung, Design. *Endodontie* 12: 39–51 (2003)
- LEVIN L, FRIEDLANDER L D, GEIGER S B:** Dental and oral trauma and mouthguard use during sport activities in Israel. *Dent Traumatol* 19: 237–242 (2003)
- LIEGER O, VON ARX T:** Orofacial/cerebral injuries and the use of mouthguards by professional athletes in Switzerland. *Dent Traumatol* 22: 1–6 (2006)
- MAEDA Y, KUMAMOTO D, YAGI K, IKEBE K:** Effectiveness and fabrication of mouthguards. *Dent Traumatol* 25: 556–564 (2009)
- NEWSOME P R, TRAN D C, COOKE M S:** The role of the mouthguard in the prevention of sports-related dental injuries: a review. *Int J Paediatr Dent* 11: 396–404 (2001)
- PARK J B, SHAULL K L, OVERTON B, DONLY K J:** Improving mouth guards. *J Prosthet Dent* 72: 373–380 (1994)
- PATRICK D G, VAN NOORT R, FOUND M S:** Scale of protection and the various types of sports mouthguard. *Br J Sports Med* 39: 278–281 (2005)
- PERUNSKI S, LANG B, POHL Y, FILIPPI A:** Level of information concerning dental injuries and their prevention in Swiss basketball – a survey among players and coaches. *Dent Traumatol* 21: 195–200 (2005)
- POTTER M R, SNYDER A J, SMITH G A:** Boxing injuries presenting to U.S. emergency departments, 1990–2008. *Am J Prev Med* 40: 462–467 (2011)
- RANALLI D N, DEMAS P N:** Orofacial injuries from sport: preventive measures for sports medicine. *Sports Med* 32: 409–418 (2002)
- R DEVELOPMENT CORE TEAM (2011):** R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3–900051–07–0, www.R-project.org.
- SCHILDKNECHT S, KRASTL G, KÜHL S, FILIPPI A:** Dental injury and its prevention in Swiss rugby. *Dent Traumatol* 28: 465–469 (2012)
- SCOTT J, BURKE F J, WATTS D C:** A review of dental injuries and the use of mouthguards in contact team sports. *Br Dent J* 176: 310–314 (1994)
- SHIMOYAMA T, MASUDA I, NUMA T, HORIE N:** Mandibular fracture with a mouth formed mouthguard in kickboxing. *Dent Traumatol* 25: 242–244 (2009)
- SHIRANI G, KALANTAR MOTAMEDI M H, ASHURI A, ESHKEVARI P S:** Prevalence and patterns of combat sport related maxillofacial injuries. *J Emerg Trauma Shock* 3: 314–317 (2010)
- SONNENBERG H:** Boxen. Fechten mit der Faust. 22nd ed., Verlag Weinmann, Berlin (2009)
- SWISS BOXING FEDERATION (2012):** SwissBoxing/Verband. www.swissboxing.ch/index.php?ID=55 [accessed August 10, 2012]
- TAKEDA T, ISHIGAMI K, OGAWA T, NAKAJIMA K, SHIBUSAWA M, SHIMADA A, REGNER C W:** Are all mouthguards the same and safe to use? The influence of occlusal supporting mouthguards in decreasing bone distortion and fractures. *Dent Traumatol* 20: 150–156 (2004)
- TSCHAN J D, RÖTHLISBERGER B, HEGG L, VON ARX T:** Häufigkeit und Art von Frontzahnverletzungen und Gebrauch eines Zahnschutzes in Berner Sportclubs. *Schweiz Monatsschr Zahnmed* 113: 20–26 (2003)
- TULUNOGLU I, ÖZBEK M:** Oral trauma, mouthguard awareness, and use in two contact sports in Turkey. *Dent Traumatol* 22: 242–246 (2006)
- WALILKO T J, VIANO D C, BIR C A:** Biomechanics of the head for Olympic boxer punches to the face. *Br J Sports Med* 39: 710–719 (2005)
- ZAZRYN T R, FINCH C F, MCCRORY P:** A 16 year study of injuries to professional boxers in the state of Victoria, Australia. *Br J Sports Med* 37: 321–324 (2003)
- ZAZRYN T, CAMERON P, MCCRORY P:** A prospective cohort study of injury in amateur and professional boxing. *Br J Sports Med* 40: 670–674 (2006)