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Wearability and physiological effects of custom-fitted vs self-adapted mouthguards

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Abstract – *Objectives*: The purpose of this study was to measure the comfort, wearability, physiological effects and its influence on athletes' physical performance, of custom-fitted compared with self-adapted mouthguards (MGs). *Methods*: Eleven rugby players were put under specific efforts similar to those of the competition. Each player made three consecutive tests randomly wearing a commercially available 'boil-and-bite' self-adapted mouthguard (MG2), a custom-fitted mouthguard (MG3), and no mouthguard (reference). Forced expiratory air volume at 1 s (FEV_1), expiratory flow rates peak (PEF), forced vital capacity (FVC), rebound (RB) jump 15 s, and counter-movement jump (CMJ) were measured on each player before and after the training exercise tests. Subjective evaluations by means of a visual analog scale (VAS) questionnaire took place. Comforts, adaptability, stability, tiredness, thirst, oral dryness, nausea, ability to talk, breathe, and drink were evaluated. *Results*: The wearing of the self-adapted MG showed significant improvement in PEF ($P < 0.05$). There were no statistically significance differences regarding the others spirometer parameters. In CMJ, there were no differences between both the MGs. On RB power was similar with both MGs and control. However, RB height reduced significantly wearing MGs. MG3 showed superior properties in comfort, adaptability, stability, and ability to talk and to breathe. *Conclusions*: MG3 showed the smallest range of changes in players' performance, suggesting improved fit, comfort, and acceptation compared with MG2. Furthermore, its greatest advantage is the individualized design according to the proper anatomy of the oral cavity. Greater efforts must be made to improve the comfort of MGs if their use is to be increased.

As sports have become more competitive in recent years and as there is a strong encouragement to participate in them from an early age, sporting injuries to the maxillofacial region and dental structures have become more common. Within this, rugby is a contact sport that presents a high risk. The face, especially maxillary anterior teeth are the commonest injuries sustained (1).

Dentistry applied to sports is in charge of the study, revision, prevention, and treatment of oral–facial traumatology, as well as the maintenance of sportsman dental health and in spreading information and new knowledge related with sports oral health.

The dental injuries are often irreversible and can lead to functional, aesthetic, and psychological problems. For this reason, prevention of orofacial injury during sports is one of the biggest preoccupations in sports dentistry (2–4). An essential element to achieve this goal is the mouthguard (MG), a device that placed inside the mouth prevents and reduces possible oral injuries, specially of the teeth and surrounding structures. The MG acts on absorbing and dissipating very important part of the energy in the impact zone. Its main functions are reduction in the incidence of orofacial injuries, soft tissue lacerations, temporomandibular joint damage, concussion, and mandible fractures (1, 5–12).

Protective MGs were first developed at about the turn of the century and consisted of a piece of rubber suitably trimmed and hollowed out (13). This development has undoubtedly effected a major reduction in the incidence of sports-related oral trauma.

MGs are successfully used in minimizing sports injuries. Opinion is unanimous, wearing MG while playing high-risk sports, such as rugby, hockey, boxing, basketball or soccer, helps to reduce the frequency and severity of orofacial injuries (7, 9, 13–22). Although sportsmen attitude to MG is generally positive, players found it difficult to wear because of oral dryness, nausea, instability, difficulties in breathing and speaking (3, 4, 6, 7, 9, 18, 20–23).

There are three general types of MGs: MG1 (stock mouthguard), ready-made and simply placed over the upper teeth of the player; MG2 (self-adapted mouthguard), molded directly over the upper arch in the mouth of the player; and MG3 (custom-fitted MG), made over an impression of the upper dental arch of the player (24).

The hypothesis is that MG3 has a lower influence on athletes' performance. The purposes of the present study were to measure the physical performance, physiological effects and, players' attitude of custom-made compared with self-adapted MGs, from the standpoint of comfort, wearability, fit, retention, protection, effect on speech and breathing.

Methods

Subjects

The subject group consisted of a homogeneously population of 10 healthy rugby players, all of the masculine sex, aged between 21 and 23 years, mean weight and height of 84 kg and 175 cm, respectively. All players had a similar training level; more than seven weekly training hours and a minimum 3 years of competition.

After explaining and giving a written study information paper to players, written informed consent was obtained from each subject. Our research activities were covered by the Ethic Committee of Clinical Investigation, Clínica Odontológica Universitaria, University of Barcelona.

Mouthguards

Twenty-two MGs were used, two for each player. Eleven were commercially available 'boil-and-bite' self-adapted MGs (MG2) and the rest were custom-fitted MGs (MG3). The MG2 used were boil-and-bite MGs purchased at a sporting goods store (Fig. 1). The MG3 were pressure-laminated MG (Fig. 2). Fabrication technique was similar to the one previously described (24). The gum shield consisted of ethylene vinyl acetate. The machine used for the confection of the laminated MG was the Dreve Drufomat® (Dreve-Dentamid GmbH, Unna, Germany) at 6 bar. MG3 fabrication and mouth adaptation was performed in the School of Dentistry, University of Barcelona, Barcelona (Spain).

Study design

A randomly crossover study was designed. Each player made a weekly effort randomly using a self-adapted MG (MG2), a custom-fitted MG (MG3), and without MG (negative control). The three necessary effort tests, one for each MG, were made on three consecutive weeks. They were performed at Instituto Nacional de Educación Física de Cataluña (INEFC), Barcelona. It was related with specific rugby training and consisted of changes of direction for 5 s, maximum 10 m short duration race and moderate maintained aerobic work for 6 s.

Performance test was evaluated by counter-movement jump (CMJ) and rebound (RB) jumps of 15 s using a contact platform (Ergojump Bosco System, Bosco C, 1980) as previously described by Bosco (Fig. 3) (25). It was considered, before and after the effort, the height,

Fig. 1. Commercially available 'boil-and-bite' self-adapted mouthguards (MG2).

Fig. 2. Custom-fitted mouthguard (MG3).

Fig. 3. Rebound jumps 15 s.

number of repetitions and the average power. A Discovery Spirometer® (Futuremed, Granada Hills, CA, USA) was also used before and after the effort on each subject. Forced vital capacity (FVC), forced expiratory air volume at 1 s (FEV_1), peak expiratory flow (PEF) rates, FEV_1 divided by FVC (FEV_1/FVC), and mid-expiratory flow ($MEF_{25\%-75\%}$) were recorded wearing either no MG, MG2, or MG3 (21). The subjects then completed a 10-point visual analog scale (VAS) questionnaire for each MG concerning breathing, oral dryness, tiredness, thirsty, speaking, taste, nausea, difficulty in drinking, adaptability, and comfortability. Those evaluated items represent the most frequent problems described in wearing MG (4). All data were recorded on a specially designed study protocol.

Statistical analysis

The collected data were analyzed using version 11.5 of the Statistical Package for the Social Sciences (SPSS) (SSPN Inc.; Chicago, IL, USA). The Wilcoxon test was used for the questionnaire variables. An ANOVA of repeated measures was used in spirometer test, CMJ and RB jumps 15 s. Differences were considered statistically significant when $P < 0.05$.

Results

Questionnaire

The survey was completed correctly by all rugby players. MG3 interferes less in breathing, speaking, and oral dryness ($P < 0.05$). Wearing type 3 MG players refer better adaptability, comfort, less nauseas, that is more easy to drink ($P < 0.05$). They also refer less thirst and bad taste compared with MG2 but this result is not statistically significant ($P > 0.05$; Fig. 4).

Most of the players do not take out the MG2 or MG3 to drink. Those who do take out the MG2 reported that it is impossible to drink while wearing it, and those who take out the MG3 reported that they have never tried to drink while using it. All the players reported that, to wear the MG2, they needed to close their mouth, whereas only one player reported doing so when wearing the MG3.

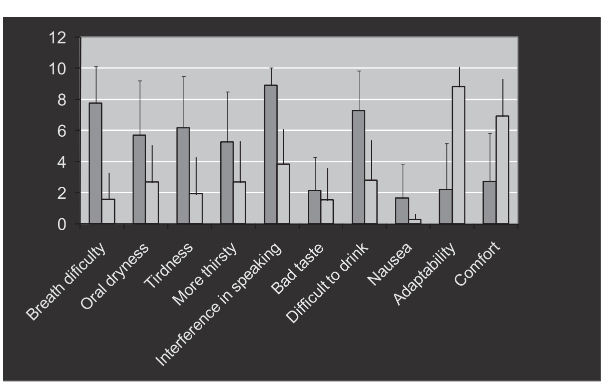

Fig. 4. Visual analog scale questionnaire (median and SD of MG2 vs MG3).

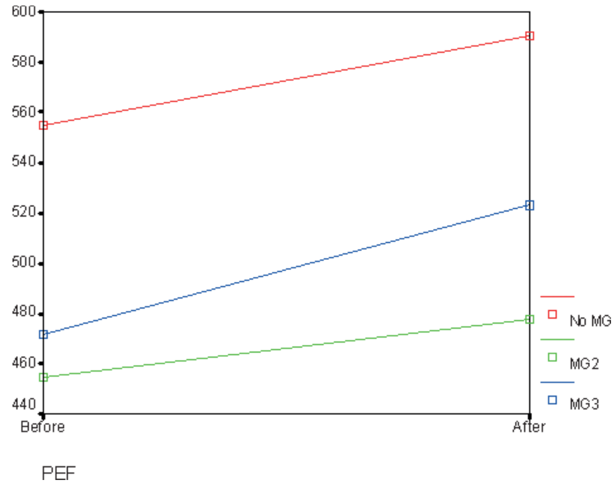

Fig. 5. PEF results before and after the effort tests.

Performance test

There are statistically significant differences in CMJ before and after the effort. Initial CMJ is between 0.71 and 3.59 cm (95% CI) smaller than after the effort. There are no statistically significant differences in CMJ between MG2 and MG3.

In the 15-s RB jumps (RB 15 s), there are no statistically significant differences in players' power between MGs ($P > 0.05$), but before the effort, RB 15 s result is between 0.01 and 1.74 W (95% CI) smaller than at the end. In players' height, there are no significant differences before and after the effort, but there are statistically significant differences ($P < 0.05$) between not wearing MG and using type 3 MG. Not wearing MG gives values between 0 and 8 cm higher.

Spirometry

There was no significantly change in FEV_1 by the wearing of both the MGs. PEF rates were significantly reduced by both MGs ($P < 0.05$). MG2 reduced PEF with a 31.10–181.78 l min^{-1} (95% CI) and MG3 with a 25.01–124.87 l min^{-1} (95% CI; Fig. 5). In FVC, there was no significantly change by the use of MGs. However, wearing MG2 shows a tendency to reduce FVC. In FEV 1%, MEF 50, and MEF 75, the wearing of different MGs did not significantly change oxygen consumption (VO_2), whereas after the effort VO_2 was significantly reduced ($P < 0.05$).

Discussion

Acceptance of MG is generally positive among the athletes, and most of the coaches felt that it should be worn all the time (during practices and competitions) (26). Our results support that the MG3 compared with MG2, interferes less with speech, breath, and oral dryness. It is more comfortable, better adapted and causes less nausea. For these reasons, MG3 are the favorite and have the highest level of acceptance for most of the players (2, 7, 13, 24, 27, 28). On the contrary, they are the less used because of their cost (10, 27).

MG3 is the most effective and recommendable to avoid sports injuries. It is the best type of MG from the standpoint of fit, retention, comfort, and speech (27). In addition, they present the advantage of an individualized design according to players' needs and allow the dentist to examine the athlete's mouth for any conditions that may affect his or her health. MG2, because of their instability and irregularity in material distribution, does not offer a sufficient prevention for sports orofacial injuries (13, 15, 24, 27, 29). However, MG2 are relatively comfortable and if properly fitted, it can be worn with a fixed intraoral appliance (27).

As well as benefiting physically from wearing the MG, sports participants may experience a significant improvement in their self-confidence and performance (1). However, our results of RB 15 s (a sensible parameter to the adaptations introduced in training) showed a tendency to be inferior with the wear of MG, suggesting an influence in player's performance.

Regarding the physiological breathing effect during exercise, our study showed that MG might be uncomfortable and restrict forced expiratory air flow. Although other authors think that they could be beneficial in prolonging exercise by improving ventilation and economy (21). The pressure-laminated MG3 used in our study showed the smallest range of changes comparing with the control, suggesting potentially improved fit and comfort.

Besides the training, dentists devote only marginal attention to the prevention of dental trauma caused by sports activities. Sports participation and activity should become standard questions on all health and dental histories. Additionally, the dental profession should emphasize the use of MG during sports. Future researches are needed to obtain guidelines for improving the usefulness and developing the MG. Furthermore, greater efforts and effective strategies must be carried out in promotion and increase of MG wear.

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