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Effect of wearing mouthguards on the physical performance of soccer and futsal players: a randomized cross-over study

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Abstract – *Aim*: The aim of this study was to assess the influence of custom-fit mouthguards on the aerobic performance of soccer and futsal players under 17 (U-17). *Material and methods*: Forty players from 3 Brazilian clubs participated in the study. The athletes' aerobic performance was assessed through the 20-meter shuttle-run test. All athletes performed two tests with and without mouthguard. Two outcome variables were analyzed: (i) the total distance covered in the test (meters) and (ii) the maximum oxygen uptake (VO_2 max). A questionnaire assessing the level of acceptance of mouthguards considering different parameters was administered to the athletes before the delivery of the mouthguards and after 2 weeks of use. The questionnaire used a visual analogue scale (VAS). Paired *t*-test was used to compare the results obtained from the shuttle-run tests and the questionnaires. *Results*: Mouthguards did not influence the aerobic performance of the players, considering both the total distance covered in the tests and the VO_2 max. Stability was the parameter with the highest acceptance. Levels of acceptance regarding breathing ($P = 0.022$) and communication ($P = 0.002$) increased after mouthguards usage. Communication had the lowest level of acceptance considering all parameters assessed. Only 10% of the players reported receiving recommendations to use mouthguards while playing football or futsal. None of the participants reported having used mouthguards before. *Conclusions*: The use of custom-fit mouthguards does not affect the aerobic performance of soccer and futsal U-17 players. Future studies should focus on the development of appliances with maximum protection and minimum influence on communication.

Sports activities increase the risk of dental and craniofacial injuries for athletes (1). This risk is greater in full-contact sports such as boxing, American football, and rugby due to higher susceptibility to falls and blows.

Although not considered a violent sport, soccer also presents a high risk of injury for athletes, including injuries affecting the craniofacial and oral regions (2). In a recent study that analyzed 113 professional matches in the Brazilian league, 84% included at least one incident involving the craniofacial region (3). During soccer practice, dental trauma occurs mainly in disputes for the ball on the high, in head collisions, or from elbow-to-head contact (4). These types of contacts are consequences of nature of the sport, in which using the head is an essential part of game.

Mouthguards appear to be the best option for preventing dental injuries. Several studies have shown that these appliances decrease the risk of dental and craniofacial injuries to athletes (1, 5–7). There are three types of mouthguards available for athletes: (i) stock mouthguards, (ii) mouth-formed mouthguards and (iii) custom-fit mouthguards. Of these three types, custom-fit mouthguards are the most recommended by dentists and the most accepted by athletes due to superior fit and comfort (8). In addition to dental-injury prevention, mouthguards can also protect adjacent oral structures such as the gingiva, lips, tongue, and oral mucosa (9).

Despite the benefits associated with using mouthguard soccer players rarely use them (10). According to a study conducted in Israel, only 3% of athletes used mouthguards during training and matches (11). This low rate of use could be related to discomfort caused by the appliances. The main reasons cited for non-utilization are difficulties with breathing and communication during play (12, 13). The effect that mouthguards might have on respiratory function—and consequently oxygen uptake—is a major concern (14), especially for elite athletes in sports with high aerobic demands, such as soccer.

This study aimed to assess the influence of custom-fit mouthguard use on the aerobic capability of U-17

soccer and futsal players. The null hypothesis was that using mouthguard would not affect the aerobic capability of the players.

Methods

This interventional study was performed on a homogeneous group of 45 soccer and 13 futsal players from 3 clubs in the city of Pelotas, located in Southern Brazil. All participants were boys aged 15–17 years who trained approximately 16 h per week. All tests were performed at the clubs' installations.

Ethical issues

All study participants and their parents were informed about the study protocol and the potential risks and benefits. All parents gave written consent allowing their children to participate. The study protocol was approved by the Local Ethics Committee of the Federal University of Pelotas.

Sample-size calculation

The sample-size calculation considered a study by Bangsbo et al. (15) on U-20 players. The following parameters were used: (i) the total distance covered in the 20-meter shuttle-run test, equal to 2115 meters, without a mouthguard, (ii) a reduction of 40 meters on the total distance covered using a mouthguard, (iii) a standard deviation of 52 meters, (iv) $\alpha = 5\%$ and (v) power of 80%. Considering a repeated-measure study, the required sample size was 36 players. Ten percent was added to the final sample to consider possible losses and refusals, creating a total sample size of 40 players.

Fabrication of mouthguards

Upper-jaw impressions were taken by standard trays using alginate impression material and were poured with dental stone to produce working models. Before the models were confected, the impressions were disinfected using 1% sodium hypochlorite. Ethyl vinyl acetate (EVA) sheets 3.0 mm thick (FGM, SC, Brazil) were used to fabricate the mouthguards. Sheets were placed in a thermal forming machine. They were softened for approximately 2 min and then formed on the models. The sheets were cooled at room temperature to avoid deformation during removal from the model. The design of the mouthguards took into consideration the following limits: (i) labially to within 2 mm of the vestibular reflection, rounded at the buccal peripheries, (ii) about 4 mm from the cervical margin in the palatal limit, tapered at the edges and (iii) enclosing the maxillary teeth to the distal surface of the first molars. The adaptation, stability, and retention of the mouthguards were checked when delivering them to athletes. Adjustments were performed when necessary. All mouthguards remained with the athletes after the end of the study. To produce better adaptation, the athletes used the mouthguards for 1 week before the tests were conducted.

Primary outcomes

The primary outcomes consisted of the results of the 20-meter shuttle-run test performed by the athletes (16). The test was performed on a flat soccer field or futsal court with lanes marked by cones separated 20 meters from each other. The test consisted of running back and forth on the course and around the 20-meter line; at the same time, a sound signal was emitted from a prerecorded tape to mark the rhythm of the test. The frequency of the sound signal was increased by 0.5 km h^{-1} each minute from a starting speed of 8.5 km h^{-1}. Subjects were given verbal encouragement throughout the test. They continued until they could not reach the cones two consecutive times after the beep sounded.

The test results were measured in two ways: (i) the total distance covered in the test (meters) and (ii) the maximum oxygen uptake (VO_2 max). The values for VO_2 max were obtained using the equation described by Léger and Lambert (16) for athletes younger than 18 years of age:

$$VO_2\text{max} = 31.025 + 3.238 \times (\text{speed}) - 3.248 \times (\text{age}) + 0.1536 \times (\text{speed}) \times (\text{age})$$

Speed means the running speed at the moment the athlete gave up the test, and *age* means the age of the athlete.

Secondary outcomes

Two questionnaires were used in this study. The first contained seven questions concerning each player's knowledge of mouthguards use in soccer and futsal; it was administered before the delivery of the mouthguards. In addition to this instrument, another questionnaire evaluated the acceptance of mouthguards with regard to breathing, communication, oral dryness, stability, and overall evaluation. A visual analogue scale (VAS) was used for this purpose. Each athlete assessed the mouthguard by drawing a line on a 10-cm-long scale for each parameter, with 0 meaning 'very bad' and 10 meaning 'very good.' This information was quantified for the analysis by measuring the distance between the 0 point and the point where the player crossed the line with a ruler with 0.1 mm of precision. To compare evaluations for before and after using the mouthguard, the second questionnaire was administered on two occasions: (i) with the first questionnaire before delivering the mouthguards and (ii) after the second application of the shuttle-run test.

Fieldwork

Two shuttle-run tests were performed on the players, one with the mouthguard and the other without. A crossover design was adopted to avoid a possible performance increase in the second test, which could bias the results. Figure 1 shows the flowchart of the study. Players were randomized by a simple draw; one half of the sample performed the first test using mouthguards, and the other half performed without mouthguard. In

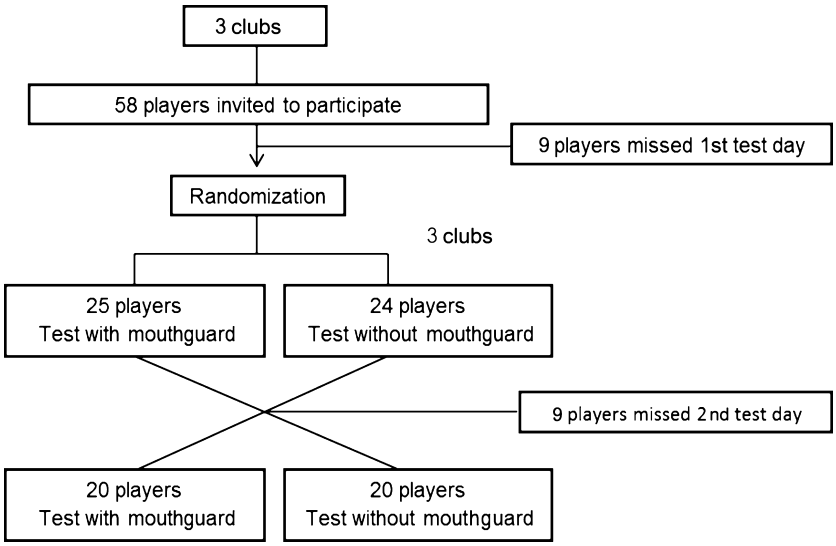

Fig. 1. Flowchart of the study.

the second test, players who had performed the first test with a mouthguard did not use the appliance and vice versa. The period between tests was set to be 1 week. Due to the request of one of the clubs, however, the interval in this club was 3 weeks. Although no interventions were made to the clubs' training routines, the researchers requested that the training loads on the day before the tests be similar with light intensity of effort. The weather conditions on test days were also similar, with temperatures ranging from 18 to 25 degrees Celsius.

Data analysis

Data were double entered in an Epi Info 6.04 database to avoid errors. Statistical analysis was performed using Stata 11.0. Answers to knowledge questionnaires were submitted to descriptive analysis. Data obtained in the shuttle-run tests with and without mouthguard were compared using a paired *t*-test. A paired *t*-test was also used to compare the results of the acceptance questionnaire before and after using the mouthguard. The data used in the *t*-test passed normality tests. The significance level was set to 5%.

Results

Of the 58 players selected for the study, 18 were excluded. The exclusions were due to absence on one of the test days (14 players) or muscle injuries (four players). All 40 players who completed the study were boys aged 15–17 years (mean = 16.2; SD = 0.55).

Table 1 shows a descriptive analysis of the players' knowledge of mouthguards use in soccer and futsal. None of the players indicated having used mouthguards before, and only 10.0% had been advised to use them. Of those participating in the study, 67.5% believed that dentists were responsible for recommending the use of mouthguards.

Table 2 shows a comparison between the players' perception of the parameters before and after using of mouthguards. Stability obtained the best evaluation. The worst evaluation could be observed in communication. However, the evaluation of this criterion increased

Table 1. Descriptive analysis of questions related to knowledge of U-17 soccer and futsal players about mouthguards ($N = 40$)

Question	Answer	*N*	%
Do you know mouthguards?	Yes	30	75.0
	No	10	25.0
Which types of mouthguard do you know?	Stock	12	40.0
	'Boil and Bite'	6	20.0
	'Custom-made'	3	10.0
	Not know the type	9	30.0
Do you use mouthguard during soccer/futsal practice?	Yes	0	00.0
	No	40	100.0
Have you ever seen a soccer/futsal player using mouthguard to play?	Yes	29	72.5
	No	11	27.5
Did you receive recommendation to use mouthguard during soccer/futsal practice?	Yes	4	10.0
	No	36	90.0
In your opinion, who is the main responsible for this recommendation?	Parents	3	7.5
	Clubs	9	22.5
	Dentist	27	67.5
	Federations	1	2.5
Do you think that mouthguards usage should be mandatory in soccer/futsal?	Yes	22	55.0
	No	18	45.0

Table 2. Comparative analysis of the level of acceptance of mouthguards considering different parameters before and after the use ($N = 40$)

	Scale Mean (SD)		
Criteria	Before	After	*P* value
Breath	5.63 (2.52)	6.80 (2.56)	0.022
Communication	2.12 (1.55)	3.83 (2.50)	0.002
Oral dryness	5.15 (2.93)	4.72 (3.10)	0.589
Stability	7.14 (1.93)	7.23 (2.40)	0.839
Overall	6.78 (2.30)	6.65 (2.47)	0.751

significantly ($P = 0.002$) after the use of mouthguards (3.83) when compared with the observation before using them (2.12). Breathing evaluation also increased significantly after the use of mouthguards ($P = 0.022$) with a mean of 5.63 before usage compared to 6.80 after usage.

To the question, 'Would you use a mouthguard during soccer/futsal practice?' 92.5% of the players answered yes prior to using mouthguard. After 2 weeks of use, this percentage dropped to 80.0%.

Table 3 shows the results of the comparison between tests with and without mouthguards. For both outcomes, there were no statistical differences between tests. The results were similar considering total distance covered and VO_2 max.

Discussion

The main aim of this study was to assess the influence of custom-fit mouthguards on the VO_2 max of U-17 soccer and futsal players. Our findings show that mouthguard use does not jeopardize the aerobic performance of athletes, affirming the proposed null hypothesis. Despite the fact that existing studies corroborated our findings, this was the first interventional study evaluating the influence of mouthguards on the respiratory performance of soccer and futsal players (17–19).

Several studies identified breathing difficulty as one of the main reasons for not using mouthguards (6, 12–14, 20). Our findings disagree with this assumption considering both aspects evaluated: aerobic performance and individual acceptance, which was satisfactory with a significant improvement after using the mouthguards. Similar results were observed in other studies (18, 21). Conversely, Amis et al. (22) evaluated the influence of mouthguards in the dynamics of airflow during oral breathing, observing an increase in the strength of airflow expired at rest. However, the authors said it was unlikely that mouthguards would have the same influence in the face of highly taxing ventilation, as during sports play.

To evaluate the aerobic functioning of the players, the 20-meter shuttle-run test was used. This test was developed by Léger and Lambert (16), presenting as the principal result the estimated maximum oxygen uptake (VO_2 max) for each athlete. This test is widely used by scientists and coaches to monitor players' cardiorespiratory fitness (17, 23). In addition to VO_2 max estimation, the athletes' performance was also evaluated by the total distance covered. This variable allows a more sensitive analysis of a player's performance considering that a difference of 120 meters can exist in the same stage of the test. Thus, a significant difference in the distance cannot be detected when only considering the results for VO_2 max (24).

Table 3. Comparison between tests with and without mouthguard in U-17 soccer and futsal players. Paired *t*-test ($N = 40$)

Outcome	Group – Mean (SD)		
	With mouthguard	Without mouthguard	*P* value
Total Distance Covered (m)	1727.5 (271.2)	1705.5 (243.3)	0.43
VO_2 máx (ml Kg^{-1} per min)	50.45 (3.64)	50.42 (3.62)	0.93

For this type of physical test, an interval of 48 h between tests is considered a good pattern. Club planning and scheduling, however, prevented us from applying this interval. In two clubs, therefore, an interval of 1 week was adopted, and in the other, the interval was 3 weeks. Other concerns were addressed to minimize bias, including similar weather conditions, the intensity of training on the day before the test, and the crossover design. It should also be noted that this was the first study to present sample-size calculation, conferring power to our results.

A visual analogue scale (VAS) was used to assess the players' acceptance of mouthguards usage. This instrument has good reliability, it is easily interpreted by the subjects, and it is often used in health research (18, 21, 25, 26). Administering the instrument before and after (at least 2 weeks) the delivery of mouth guards allowed for the assessment of variation in the players' acceptance of the mouthguards at these different times.

The lowest value obtained in the level of acceptance was for communication. However, a significant increase in the evaluation was observed for this parameter. This finding agrees with the study of Von Arx et al. (18) that used a similar methodology. In a study performed in Turkey, almost 50% of players who wore mouthguards related difficulties with communication (1). On the other hand, Eroglu et al. (21) analyzed by VAS the satisfaction of tae kwon do athletes who wore mouthguards, presenting a high degree of satisfaction with communication. It is necessary to keep in mind that soccer and futsal are team sports that require a lot of oral communication between players during the matches. Athletes in these sports are, therefore, probably more demanding in this regard, which justifies our findings. Another possible explanation is the palatal extension used in the fabrication of the mouthguards. While our study adopted a distance of 4 mm from the gingival margin, a recent study showed that a margin set at the gingival line is recommended to obtain better pronunciation of sibilant sounds/s/, while maintaining the same level of protection (27).

Acceptance in relation to oral dryness presented the second-lowest performance with no significant changes after using the mouthguards. With tae kwon do athletes, this parameter was the one with the worst evaluation (21). The thickness of the mouthguard limits a proper closing of the mouth. The athlete experiences oral dryness because of heavy exercise and stress during competition. Drinking water at frequent intervals can help minimize this feeling.

Stability and overall acceptance of the mouthguards were well rated by the players. This can be explained by the use of custom-fit mouthguards that provide optimal adaptation, stability, and comfort (8, 28). A recent study showed that custom-fit mouthguards were better evaluated after 4 weeks of use (18). Consequently, we believe that the final levels of acceptance

observed in our study would have been higher if the period of evaluation had been increased. Considering communication as a key factor for soccer and futsal athletes—and considering the other related advantages of custom-fit mouthguards in relation to mouth-formed ones—negative controls (without the mouthguard) were chosen for comparison in the study design.

Analysis of the players' knowledge about mouthguards showed that—despite the majority of them knowing about mouthguards and being willing to use them—very few had received recommendations to use mouthguards, and none had ever used them. In addition, most players believed that dentists should be responsible for making the recommendation. In spite of the increased importance of sports dentistry over the last years (5), the presence of dentists in Brazilian soccer clubs is still deficient (2). Those responsible for the health departments of the premier soccer clubs in Brazil lack knowledge about the prevention and conducts adopted in face of dental injuries (2). To change this situation, the inclusion of dentistry in the health departments of Brazilian professional soccer clubs should be mandatory—not only for the prevention and treatment of dental injuries, but also for maintenance of the players' oral health.

Conclusions

Our findings show that the use of custom-fit mouthguards does not affect the aerobic performance of U-17 soccer and futsal players. Regarding wearability, the mouthguards were generally well received by the athletes. Communication, however, appears to be the major problem to be solved in terms of overall acceptance and use of mouthguards. Finally, strategies should be designed to encourage young players to use mouthguards.

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