Influence of occlusal splint on competitive athletes performances

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Summary
The purpose of this study was to evaluate the influence of an orthopedic oral device on the performance of competitive athletes. Seven athletes from different sports have been examined during athletic tests with and without an oral device. The athletes were examined by two calibrated gnathologic operators and with specific radiography. All of the subjects were submitted to a postural exam on an electronic platform with and without the oral device applied. All subjects underwent objective tests, performed by federal trainers in specialized centers, to evaluate the athletic performance with and without the occlusal splint. The results showed an improvement of all the tests carried out. Our findings lead us to believe that the use of a costumed oral device, it is able to optimize neuro-muscular coordination and to improve the competitive performance of athletes, while the muscular strength not respond significantly.

Key words: splint, postural balance, athletes performances.

Introduction

Clinical experience and scientific research has found that there are frequent symptomatic connections between the elements that form the postural chain (1-3), particularly between the cranial-mandibular structures and the cervical-thoracic-lumbar spine with occasional associations to the sacred girdle, the pelvic girdle, hip joints, knees and toes. The maintenance of good postural balance between all these segments allows the human body to maintain a feasible and ergonomic energy efficiency. This postural balance facilitates the dynamic functions (7), which is particularly important in the presence of structured subjects and qualitatively active persons such as high level competitive athletes.
Several studies have been proposed with the aim to highlight correlations between the dento-mandibular apparatus and the skeletal muscle system of the human body even in regions distant from the oral cavity (4,6,29,32,33).
The first scientific studies were based on dental kinesiology, which was first developed in America in the mid-nineteenth century by Daniel David Palmer (1895). Today, further insights have led to the development of applied kinesiology, which earnings precise attention to the temporomandibular joint (TMJ) (8-10).
In a work presented by Gelb in 1977 he noted an improvement in the performance of competitive athletes after the application of a special orthopedic interocclusal device which he called MORA (Mandibular Orthopedic Repositioning Appliance) (11-13).
Iwasaki in 1994 (14) investigated the forces of occlusion in athletes. He concluded that the maximum force in occlusion was significantly higher than those of normal individuals, showing a relation between the masticatory muscles involved in dental occlusion mechanism and the force developed by the spine postural muscles.
An analysis of current scientific literature reveals that there is still a limited amount of works on this topic with a little scientific reliability (16), because there are no randomized trials and/or meta-analysis that may help to clarify the relationship between occlusion, TMJ, and sports performance (36).
Some recent studies assess muscular and postural changes through kinesiology tests (26), but they are not complete nor do they provide the proven scientific validity of such tests as the *Meesserman test* or the *stomatognathic reset* (17,18,34).
On the other and, the relationship between occlusion, the mandible, posture and musculature has gained much more importance in sports (15,19,21,22,31). Since competitive at athletes require a high performance level to achieve maximum results, they exercise at the highest levels of their physical limits, and they stress the physical structure more exhaustively and rapidly allowing a more comprehensive analysis of the possible reciprocal influences of the correlations (30). Applying scientific methods to study athletes would therefore be desirable to obtain more concrete evidence of the relationship between oc-

clusion, mandible, posture and skeletal muscle system (27-28). At the same time, however, the recruitment of these subjects, and their continued commitment, does not allow constant monitoring or easy availability (20,35).
The purpose of this article is to analyze any changes in the athletic performance of national and international competitors, before and after the application of an intraoral device, such as a occlusal appliance or splint. Athletes of different sport disciplines were selected and diagnostic tools associated with scientifically verifiable postural tests to measure the performance were used.

Materials and methods

The sample selection involved the search for competitive athletes who had an high level activity inserted into a nationally and internationally recognized federation, therefore those who had already followed standardized exercise protocols.
The athletes were selected according to the authors' ability to contact the offices of sports training facilities and the positive response to the project by the company. The sports selected were: swimming, boxing, rugby.
The second stage of selection was directly related to the availability of competitive athletes. Among the subjects chosen were those with residence in Rome and surrounding for practical and logistical reasons. The initial sample was 21 athletes.
From this initial screening all subjects underwent a specialist visit to assess the exclusion criteria, which was applied to reduce the influence of occlusion and to determine the health of the TMJ and masticatory muscles. This was done following the diagnostic criteria codified by the Unit of Gnathology of the Department of Oral and Maxillofacial Sciences of University of Rome which are based on integrating the international Rdc/Tmd. The exclusion criteria included: having undergone previous ortognatodontic treatments; presence of prosthetic restorations; cervical, dorsal, lumbar or temporomandibular pain; worst in general health; taking medication; no more than two missing teeth for emi jaw, including third molars. The occlusal class was not considered as a valid selection criterion. All these criteria were evaluated clinically by 2 specialists previously calibrated.
Therefore, according to the subjective willingness of the athletes to join the study and the characteristics required by the selection criteria, the study was conducted on a total of seven athletes: two swimmers, a boxer, four rugby players (Tab. 1).
They were all of national and international competitive level, with many victories under their belts and well aware of their potential maximum, accredited to federations and followed by federal coaches. The athletes were six male and a female with mean age of 25 years. They were contacted by their respective sport's federation, their individual coaches, and through individual contacts for the direct management and recording of clinical and instrumental data.
Each athlete was subjected to the following collection of records:

- extraoral and Intraoral photographs;
- orthopanoramic and individualized tomographic study of TMJ.

To test the hypothesis of the study, we recorded changes in competitive results as a result of changes in the occlusal proprioceptions, with a removable interocclusal device applied to all subjects.

	Sport	Sex	Age	N. dental elements missing
Athlete 1	Swimming	F	26	4
Athlete 2	Swimming	M	24	0
Athlete 3	Boxing	M	27	5
Athlete 4	Rugby	M	23	4
Athlete 5	Rugby	M	23	0
Athlete 6	Rugby	M	24	0
Athlete 7	Rugby	M	32	0

Table 1.

The appliance used in the study needed to be a device which had to facilitate easy insertion and extraction. It had to place minimal stress on the teeth, and to be as small as possible in the mouth. It also had to have good dimensional stability, well-polished contact surfaces with boundaries that would comply with the gums and mucous membranes. It had to have rounded edges to prevent disturbance to the tongue, and it had to allow for easy swallowing and breathing. Finally, it could not be fitted with metal anchors, but constructed to be stabilized by using natural undercuts. The material used had to be biocompatible, non-toxic, non-allergenic, odorless, and tasteless. We therefore chose an elastomer, SBS (styrene-butadiene-styrene). In addition to the above mentioned requirements we also added the following clinical requirements: a defined occlusal stability, a valid condyle-disc-fossa relationship and a repeatable and efficient neuromotor pattern.

The choice fell on oral devices with functional orthopedic repositioning that allowed for a joint occlusal-defined position and to be guided and easily modified by the control data performed by instrumental examinations. Furthermore, the splint was considered as the occlusal device best suitable for the study in question since it is bound to the jaw and is best able to express the physical exertion of the subject. It was applied to the upper arch during competitive activities of the athletes to evaluate the influence of occlusion on the physical activity and its effect on skeletal muscle performance.

The dental plate was constructed with the indirect method of using the die casting technique. The impressions were first taken with alginate and from these plaster casts were derived. Individual custom trays were then designed for a second cast of precision silicone. The models were then placed in the articulator and the centric relation was detected by recording the wax occlusal position of the mandible. The flasking model was then made and ran the injection cycle:

- melting temperature: 165 °C;
- holding time above the melting point: 20 minutes;
- cooling time under pressure: 20 minutes;
- injection pressure: 4 bar.

After building the plates, they were tested for each athlete in order to customize the features and to clinically evaluate, through instrumental examination, the effective global postural balance prior to their use during the active competitive phase. The stabilometric platform was performed with the purpose of evaluating the postural balance of the subject and the eventual changes when the oral device was used. And then it was repeated after the agonistic performance to check for any changes.

All measurements were performed 10 times each in total, with and without the oral splint, at 30 day intervals.

The training sessions were organized in consecutive days as follows:

- the first day workout without bite;
- second day: training with bite;

Each athlete carried out the exercise in their own specific discipline.

For the two swimmers (swimmer 1: dolphin style; swimmer 2: freestyle) the average time for each session were calculated. Each athlete was subjected to:

- stabilometric platform with and without bite;
- detection performance with professional timing made by federal coaches.

For the boxer and four rugby players instead, where we could not have seen the results on the track type of training, they were submitted to:

- stabilometric platform with and without bite;
- mognoni Test;
- lactate PRO ARKRAY test.

The performance evaluation for the boxer and rugby players was performed using the Mognoni test for the calculation of instantaneous spot heart rate and ending heart rate, and the Lactate PRO ARKRAY test for the measurement of lactic acid produced during the exercise. In the Mognoni test every athletes had to perform 1350 meters in 6 minutes while maintaining a constant speed of 13.5 Km / h. To make the test accurate and reliable, pins were positioned on the path at regular intervals (every 50 m) so that athletes could get an audio signal when they passed over a pin. The Lactate PRO ARKRAY test allowed us to measure with extreme easy and precision the blood lactate level and a precise volume of blood (5 microliters).

Results

The results showed how one of the most important parameters of the evaluation carried out on the postural stabilometric platform, i.e. the percentage of load divided into the two supports breech, is modified with and without the occlusal splint insertion. In fact, the variation of the percentage of load varies from a maximum of 6% (rugby player 4) to a minimum of 1% (boxer), with a single case of neutrality (rugby player 2). Therefore an average variation of 3% in static load between the values with and without the oral plate were obtained.

The performance time of the two swimmers were as follows:

Swimmer 1:

- 100 meter dolphin style: the average time without the bite was between 1 minute and 28 seconds and 1 minute and 32 seconds, while with the bite a constant average of 1 minute and 25 seconds were obtained.

Swimmer 2:

- 100 meters freestyle: the average time without the bite was 1 minute and 16 seconds, with the bite the average was 1 minute and 14 seconds.

  The boxer and the four rugby players reported the following heart rate values expressed in bpm and relative values of lactic acid produced expressed in millimoles (ml/mol) checked one minute after the end of the Mognoni test with (Tab. 2) and without the splint (Tab. 3).

	Heart rate	Bpm 1' after end of test	Lactic Acid in ml/mol
Boxer	After 1' 146 bpm 3' 151 bpm 5' 158 bpm 6' 164 bpm	140	2,7
Rugby player 1	After 1' 167 bpm 3' 180 bpm 5' 186 bpm 6' 189 bpm	165	11,6
Rugby player 2	After 1' 160 bpm 3' 173 bpm 5' 178 bpm 6' 182 bpm	151	5,3
Rugby player 3	After 1' 160 bpm 3' 168 bpm 5' 171 bpm 6' 181 bpm	169	8,7
Rugby player 4	After 1' 163 bpm 3' 171 bpm 5' 178 bpm 6' 179 bpm	174	10,1

Table 2.

	Heart rate	Bpm 1' after end of test	Lactic Acid in ml/mol
Boxer	After 1' 144 bpm 3' 150 bpm 5' 156 bpm 6' 156 bpm	119	2,4
Rugby player 1	After 1' 158 bpm 3' 173 bpm 5' 174 bpm 6' 178 bpm	148	10,8
Rugby player 2	After 1' 159 bpm 3' 168 bpm 5' 174 bpm 6' 176 bpm	137	8,1
Rugby player 3	After 1' 150 bpm 3' 167 bpm 5' 169 bpm 6' 173 bpm	154	6,7
Rugby player 4	After 1' 155 bpm 3' 163 bpm 5' 165 bpm 6' 168 bpm	105	8,4

Table 3.

Discussion

The purpose of this study was to assess any changes that could occur with the application of an occlusal splint in the athletic performance of national and international competitive athletes.
The sample of competitive athletes had been selected so as to be free of dysfunctional problems, and that would meet the above requirements. All athletes were subjected to the stabilometric platform to evaluate postural muscle, and from this we saw a change in the distribution of the load resting on both feet, and therefore posture.

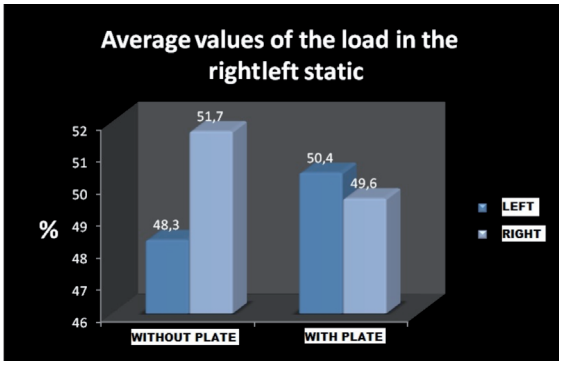

Fig. 1

With the bite inserted, the percentage values of the load distribution were more likely to approach the ideal balance, i.e. 50% of load resting on the right foot and 50% of resting on the left foot.
Figure 1 shows the mean values of the load distribution on both sides, right and left, and displays how with the bite inserted these values tend to be closer to an equitable sharing of the percentages. In fact, starting from an average load distribution of 48.3% on the left and right of 51.7% without support of the bite we get to a distribution load value of 50.4% on the left and 49.6% on the right with the bite inserted.
The variation from an ideal condition (50% of load support for both sides) without the repositioning bite is 1.7%, while with mandibular bite in place it is 0.4%.
The swimmers found a decrease in time at 100 meters for their own style. Swimmer 1 without the bite took 1 minute and 29 seconds on average; while with the bite in place, Swimmer 1's time improved by about 4 seconds on average, down to 1 minute and 25 seconds constants. The same goes for the Swimmer 2, which had improved time of approximately 2 seconds passing from 1 minute and 16 seconds to 1 minute and 14 seconds.
The boxer and the four rugby players, in addition to the improvement of the values recorded with stabilometric platform, recorded a decrease in the production of lactic acid when they practiced the exercise test with a bite and how the intra-oral device had also impacted the heart rate values.
This means that, with bite, there is a decrease in muscular effort. This made be due to the drop of the production of lactic acid and heart rate leadind to a better recovery time after muscular effort.
The cronometric values, the results obtained from computer platforms, the heart rate values and the Lactate PRO ARUPAY test, all significantly changed in a positive way with the application of a bite. It would seem that the mechanical receptive stimulus created by changing the ratio of occlusal-mandibular posture is able to influence the work of the muscles and of the neuromuscular component.
The results of our study are consistent with those presented by Edwards (22,23), which showed that the occlusal relationships can interfere with both the body posture and neuromuscular balance.
The most important limits of our study are in the number of samples examined and the diversity of sports investigated. Then, the data obtained is numerically small and the comparison of that does not allow for more than a descriptive analysis of the base and not a statistical observation. Considering these limits, the results still seem to indicate that the presence of an occlusal splint can lead to greater control of neuromotor coordination, resulting in improved efficiency and effectiveness of competitive sports performance.
A study conducted on high-level professional athletes can analyze the change of body patterns and the neuromuscular dynamics but not the change in dysfunctional symptoms (24,25). These subjects express dynamic movement of the entire body at the highest levels of stress to neuro-musculo-articular relationships and may therefore represent the best individuals to be studied to evaluate these relationships.

Conclusions

The study showed, in the subjects examined, a positive influence that a stimulus balancing occlusal device seems to have on the sporting performance of national and international competitive athletes. Restoring a better balance in the occlusal receptor could allow an improvement of the neuro-muscular dynamic and to learn more effective motor patterns. These observations are sequential changes in a positive sense of the competitive performance of athletes who were involved in this preliminary analysis.
In all of the athletes of this study, the application of a mandibular bite resulted in a better balanced redistribution of the load between the two sides of the body, demonstrating the role that the dental occlusion has in posture through the neuromuscular system, and that these are such as to influence the muscular work itself.
In the fact, with the bite, the two swimmers improved the water resilience, achieved a greater resistance to fatigue, and enhanced the performance during the training sessions. In addition they have obtained excellent competitive performance that saw Swimmer 1 qualify for the first time in tenth place in the World Championship 2006 Masters Champion and she became Italian Champion in the 50 meters dolphin style.
Worthy of note also are the results of the boxer who won the title of the European Union Welterweight. Finally, for the latter as for the four rugby players, instrumental values, confirmed by heart rates and those of lactate produced, showed that the changes of the neuro-musculo-joint mediated by mandibular repositioning bite have a

positive impact on the work of the body's muscles, leading to better muscle performance and to less fatigue.
The final results are therefore auspicious. The setting of scientific and clinical studies are desireable when validated and found to allow for standardization of protocols. As with Formula 1 racing where technological developments are later adopted by the broader market, the opportunity to benefit from the availability of athletes at this level should be managed so that the results which emerge from the research could lead to developments that can lead to possible positive effects on the daily life of each individual.

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