Y-BALANCE TEST AND STOMATOGNATHIC RECEPTOR STIMULATIONS

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Abstract. *The aim of this study was to observe whether motor control could be influenced by varying stimuli from the stomatognathic system. In particular, the Y-Balance Test was used as a scientifically validated tool to test the dynamic balance of the subjects and to observe how this changed when the stomatognathic receptor sent different inputs depending on whether the tongue was kept in a low position or with the tip in the area of the palatine spot or when cotton rolls were placed between the dental arches or the subject was asked for maximum occlusion. The study was conducted on young soccer players belonging to the junior category of four Italian Serie A professional soccer teams. A total of 61 subjects were identified in the four teams. The data of three trials correctly performed for each direction with tongue and occlusion in standard position were acquired. As regards the Tongue Group, the results show statistical significance as regards the comparison between the Standard Trial and the Spot Trial. Statistical significance was also observed in the comparison Standard Test and Low Tongue. The Occlusion Group showed statistical significance both in the Standard Trial vs Roller Trial comparison but not in the Standard Trial and Occlusion Trial comparison. However, statistical significance was still recorded in the comparison of the Roller Test and the Occlusion Test. This study examined whether changes in tongue occlusion or position could affect tonic-postural system responses in motor control during performance of the Y-Balance Test.*

Keywords: *Y-Balance Test, young football players, stomatognathic system*

Introduction

Among the various inputs of the postural tonic system, the cranio-cervical-mandibular system has a notable importance at a posturological level, but is still the subject of debate for professionals. From a postural point of view, dental occlusion is able to modify the curves of the cervical spine and consequently the entire individual posture. Angle's classification for the evaluation of the type of occlusion is related to various postures with anterior or posterior imbalance of the center of gravity which will inevitably cause muscle-fascial tensions and retractions which differ from subject to subject (Bricot, 1998).

The importance of the trigeminal nerve as a postural nerve and its subcortical connections capable of interacting with the centers of coordination of the activity of the oculomotor muscles, with the vestibular apparatus and with the descending spinal reticulum has been underlined several times. for antigravity muscle tone (Clauzade & Marty, 2008). The tongue has often been investigated in the various studies carried out with reference to its position during certain activities. It has been observed, through electromyography, that the activity of some masticatory muscles (temporal m. and masseter m.) and suprahyoid muscles was greater when the tongue was in an anterior position or under pressure against the palate than when it was left in the low resting position (Carlson, Sherman, Studts, & Bertrand, 1997).

Also during maximum voluntary clenching of the teeth, a different activity of the temporal and masseter muscles was observed depending on the position of the tongue, with a lower

activity when the tongue was left in the rest position (Valdés, Astaburuaga, Falace, Ramirex, & Manns, 2014). The role of the tongue is not limited to the modulation of the masticatory muscle activity but also extends to the regulation of postural balance having the ability to reduce the oscillations of the centre of gravity when positioned in the palatal spot (Alghadir, Zafar, & Iqbal, 2015).

As demonstrated by the studies of prof. Scoppa, the tongue, thanks to its connections with fundamental anatomical structures such as the muscles above and below the hyoid, it plays a fundamental role in the individual postural structure, being able to alter its balance, also modifying the functional scheme of swallowing with repercussions at postural recognizable in the two types of dysfunctional swallowing syndromes (Scoppa, 2005). In addition, subjects with atypical swallowing showed improvements in some stabilometric and baropodometric parameters observed when the tongue was positioned on the retro incisive papilla (palatine spot). It was observed that the elevation of the tongue against the palate was able to stimulate the structures of the central nervous system. In particular, an increase in activity was recorded in the premotor cortex, putamen, thalamus and in the cingulate gyrus of the prefrontal lobe cortex.

In addition, the study by Halata and Baumann (Halata & Baumann, 1999), who identified the presence of five exteroceptors in the area of the palatal spot, is therefore important. The movements of the tongue are also linked with the dentofacial morphology. The vertical dimensions of the intermaxillae and the shape of the dental arches are significantly correlated with the magnitude of tongue movements and with the duration of swallowing in both adults and children (Cheng, Peng, Chiou, & Tsai, 2002).

Repercussions of the position of the tongue are consequently had on the position of the teeth, causing over-bite phenomena when the position of the tongue at rest is below the occlusal plane and open-bite phenomena when instead it is located above the lower incisors with the mandible in the resting position. A recent study has shown that dropping the palatal spot with the tongue has scientifically significant effects on both power and acceleration when performing isokinetic knee tests. Improvements were recorded in both low (90°/s) and high (180°/s) angular velocity exercises during knee flexion/extension of the dominant leg compared to when the tongue was in the low rest position or on the surface lingual of the incisors (Di Vico, Ardigò, Salernitano, Chamari, & Padulo, 2013).

From these evaluations we evaluated the possibilities of the tongue and malocclusions to interfere in postural balance, with repercussions both at a pathological level due to the different distribution of loads at the joint level, and at a performance level due to a limitation of dynamic balance performance with the possibility of increase the likelihood of musculoskeletal injuries. Therefore, the tongue can be considered a trait d'union between the anterior and posterior kinetic chains. The palatine spot is reached by the palatine nose nerve belonging to the II branch of the trigeminal nerve.

At the neurophysiological level, this nerve has direct connections with the thalamus at the same point where the podalic information arrives. In addition to the request to put the tongue on the palatine spot, there is a greater activation of the cerebellum. The direct connections between trigeminal-vestibule, trigeminal-oculomotor nuclei and trigeminal-vestibule-hypoglossal should also be highlighted. Considering the anatomical and neurophysiological

relationships between the nuclei of the cranial nerves and the connections to the subcortical centers, can a stimulation of the palatal spot also have a significant influence on dynamic postural control? Does a correction of any malocclusions affect dynamic postural control performance? These are the questions that gave birth to this project. An activation of the spot would increase the activation of the cerebellum, of the descending pathways for maintaining balance and of the ascending pathways through tactile and breech proprioceptive information.

The correction of malocclusions or altered kinetics of the temporomandibular joint could recreate a correct joint balance with repercussions on all the fascial muscle chains, as well as a correct afferent signal to the brain structures. Correction of some malocclusion conditions and stimulation of the palatal spot can modulate dynamic postural control performance with repercussions in terms of increased performance and prevention of musculoskeletal injuries.

To verify these hypotheses we made use of the Y-Balance Test dynamic postural control measurement tool, born in the U.S.A from the studies of Dr. Phil Plisky (Plisky, et al., 2009) (Plisky, Rauh, Kaminski, & Underwood, 2006) is now used worldwide as a screening for assessments of postural control asymmetries which have highlighted a significant increase in the likelihood of incurring musculoskeletal injuries in various sports subjects during the sports season. The test involves the execution of monopodalic squats in 3 different directions with the aim of maintaining the center of gravity within the base of the foot in support while the opposite foot moves a detection bar along the directional trajectory established by the test. At the end of each test, the cm reached in the three directions for each lower limb are measured.

Experimental study

The aim of this study was to observe whether motor control could be influenced by varying stimuli from the stomatognathic system. In particular, the Y-Balance Test was used as a scientifically validated tool to test the dynamic balance of the subjects and to observe how this changed when the stomatognathic receptor sent different inputs depending on whether the tongue was kept in a low position or with the tip in the area of the palatine spot or when cotton rolls were placed between the dental arches or the subject was asked for maximum occlusion.

Subjects

The study was conducted on young football players belonging to the junior category (Under 17) of four Italian professional football teams in Serie A (Fig. 1). A total of 61 subjects were identified in the four teams. The exclusion criteria from the study were: 1) ongoing stomatognathic operations; 2) musculoskeletal surgeries; 3) injuries in the last six months. Based on the exclusion criteria, 50 subjects were subsequently randomized into two groups: Tongue Group (n=24, age=16.08 ± 0.28, height=181.22 ± 5.19 cm, weight=72.11 ± 5.57 kg, lower limb length=93.96± 4.52 cm) and Occlusion Group (n=26, age=16.04 ± 0.20, height=176.96 ± 6.08 cm, weight= 69.15 ± 8.78 kg, lower limb length = 93.08 ± 5.22 cm).

Figure 1 - Under 17 Italian professional football player

Materials and methods

For each subject, the anthropometric values of weight and height were acquired as well as the length of the right lower limb (as required by the YBT protocol).
Subsequently, each subject performed the test six times to gain familiarity in the following order:

- Front right;
- Front left;
- Right posteromedial;
- Left posteromedial;
- Right posterolateral;
- Left posterolateral;

After the familiarity phase, data from three correctly performed trials were acquired for both groups, with the same sequence, for each direction with tongue and occlusion in the standard position. After the execution of the Standard test, the Tongue Group performed three tests with the tip of the tongue in the palatal spot area and subsequently another three tests with the tongue in a low position.

Similarly, the Occlusion Group performed, after the Standard test, three tests with cotton rolls between the dental arches and finally the data of three tests performed with maximum dental occlusion were recorded.

Statistical analysis

Statistical analysis was performed using Software R. All data are expressed as mean and standard deviation (mean ± SD). After verifying the normality of the samples, the One Way ANOVA test with repeated measures was performed with Bonferroni's correction for multiple comparisons and the significance level was set at $p < 0.05$. As regards the Tongue Test, a nonparametic comparison was initially performed for the right limb test since the Gaussian curve did not have a normal distribution. Finally, the non-parametric Wilcoxon test was

performed both for the data relating to the tests performed with the right limb and for those performed with the left limb.

Results

As regards the Tongue Group, the results show statistical significance as regards the comparison between the Standard Trial and the Spot Trial performed with the right limb (Standard dx vs spot dx: 104.83% ± 16.09% vs 108, 77% ± 21.28%; p=0.012) as well as with the left limb (standard left vs spot left: 105.02% ± 17.21% vs 109.94% ± 21.42%; p=0.002) . Statistical significance was also observed in the comparison Standard Test and Low Tongue both on the right (standard dx vs low Tongue dx: 104.83% ± 16.09% vs 103.63% ± 15.51%; p=0.001) and on the left (standard left vs low tongue left: 105.02% ± 17.21% vs 104.21% ± 16.06%; p=0.013) as well as in the Spot and low Tongue Test (Spot right vs low Tongue right : 108.77% ± 21.28% vs 103.63% ± 15.51%; p=0.003 and left Spot vs left Low Tongue: 109.94% ± 21.42% vs 104.21% ± 16.06 %; p=0.002) (Fig. 2, Tab. 1).

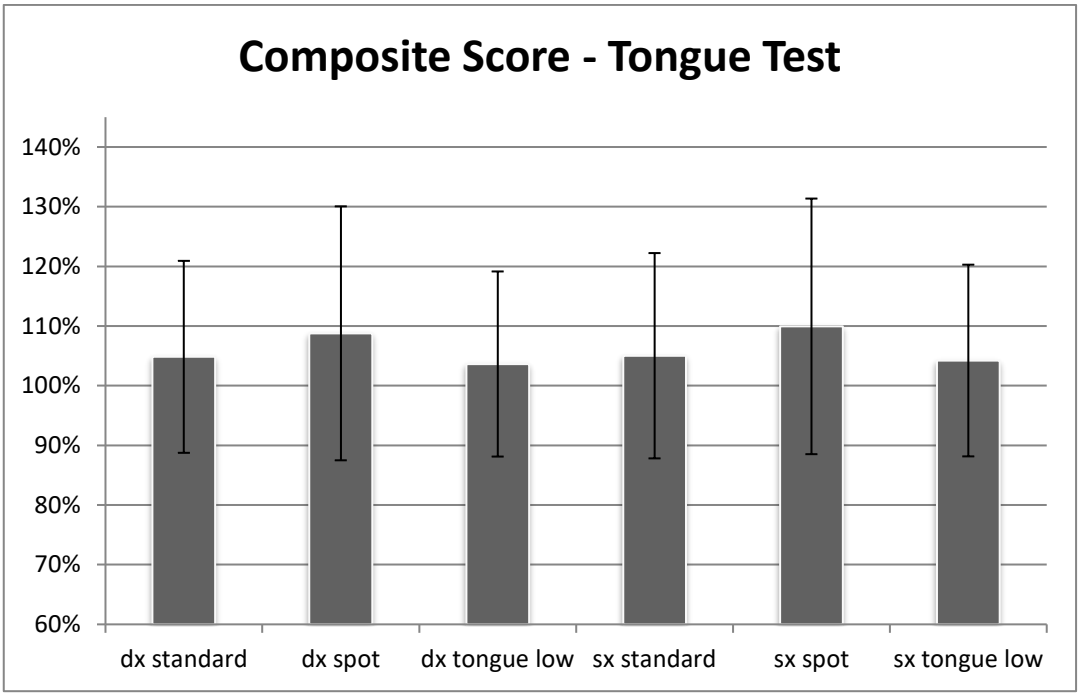

Figure 2 - Composite Score Test Tongue

Test Tongue	Right	Left
Standard vs Spot	p=0,012	p=0,002
Standard vs Tongue low	p=0,001	p=0,013
Spot vs Tongue low	p=0,003	p=0,002

Tab. 1 - Test Tongue significance values.

The Occlusion Group showed statistical significance both on the right (right Standard vs right Rollers: 97% ± 5.61% vs 100.20% ± 8.41%; p=0.02) and left (left Standard vs left Rollers: 97.96% ± 6, 40% vs 100.91% ± 8.40%; p=0.02) in the Standard Trial vs Roller Trial comparison but not in the Standard Trial and Occlusion Trial comparison, recording significance values higher than 0.05 in the test performed with the right lower limb (right

Standard vs right Occlusion: 97% ± 5.61% vs 97.46% ± 5.99%; p=0.643) and in the test performed with the left lower limb Standard vs left Occlusion: 97.96% ± 6.40% vs 98.53% ± 6%; p=0.451). On the other hand, statistical significance was still recorded in the comparison of the Roller Test and the Occlusion Test both for the right test (Right Roller vs Right Occlusion: 100.20% ± 8.41% vs 97.46% ± 5.99%; p=0.013) and for the one on the left (left Roller vs left Occlusion: 100.91% ± 8.40% vs 98.53% ± 6%; p=0.049) (Fig. 3, Tab. 2).

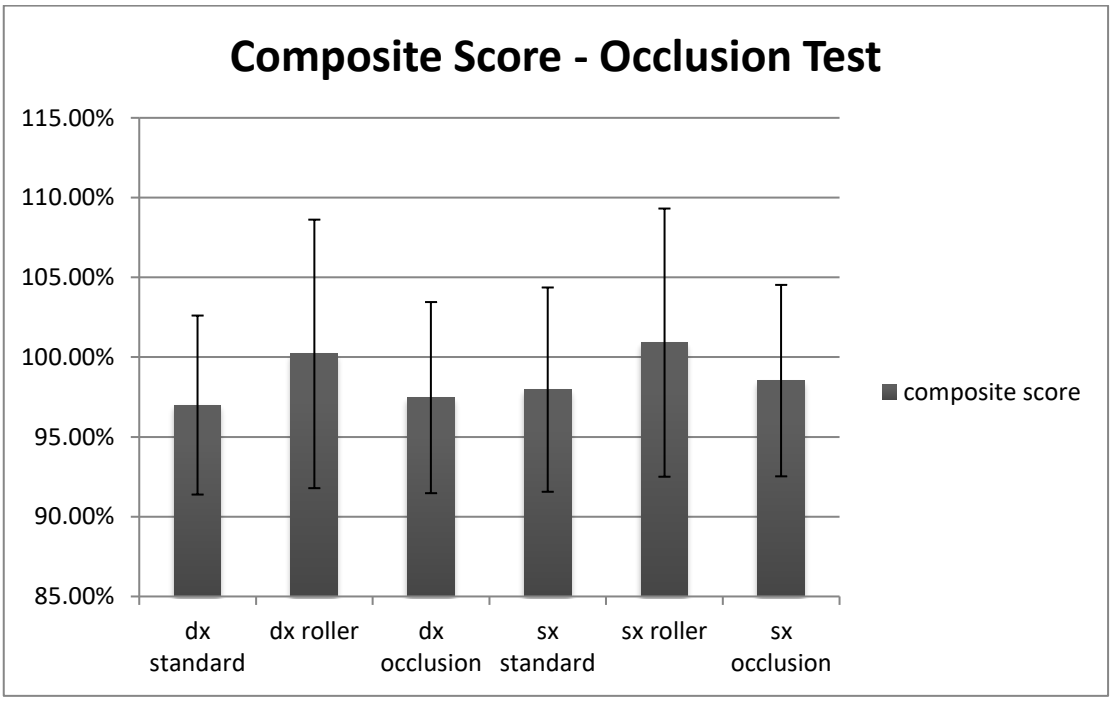

Figure 3 - Composite Score Occlusion Test

Occlusion Test	Right	Left
Standard vs Roller	p=0,02	p=0,02
Standard vs Occlusion	p=0,634	p=0,451
Roller vs Occlusion	p=0,013	p=0,049

Tab. 2 - Occlusion Test significance values.

Discussion

The link between the stomatognathic system and posture has not been sufficiently investigated in the literature. There are studies that have taken into consideration the ability of tongue and occlusion to modify the activity of individual muscles or a small group of them. This study examined whether changes in tongue occlusion or position could affect tonic-postural system responses in motor control during performance of the Y-Balance Test.

Significance values were observed when the values obtained from the standard test were compared with those obtained from the test with the tip of the tongue touching the palatal spot area (p=0.012 on the right and p=0.002 on the left) and when the tongue was in the low position (p=0.001 right and p=0.013 left). The result obtained from the comparison of the tests performed with the tongue on the spot and in a low position was also interesting. Also in this

case the statistical analysis produced significance values (p=0.003 on the right and p=0.002 on the left).

It was observed that the data relating to the three tests showed higher average values for the executions carried out with the tongue on the spot, while the data relating to the tests with the tongue in the low position were those with lower averages. The fact that in the three analyzes statistical significance has always been found, suggests to the authors of this study that the position of the tongue is strongly capable of perturbing the tonic-postural system and its motor control as hypothesized. When the tongue pushes against the area between the interincisive papilla and the first palatine wrinkles, it is able to stimulate the sensory branches of the trigeminal nerve which end in the region of the palatine spot, thus sending inputs to the trigeminal sensory nuclei located in the trunk of the brain. This reading of the statistical results relating to the spot test would also allow us to understand the meaning of the lowest averages obtained from the test with the tongue in a low position. Since this position is non-physiological, we recall that in resting conditions the tongue should already be with the tip of the tongue in the area of the palatal spot, the tongue sends incorrect information to the brain areas which are not, however, the same ones that are activated when this is in the physiological position. It has also been observed that modifications of the occlusion performed with the interposition of cotton rolls between the dental arches or the position in maximum dental occlusion is able to disturb the motor control during the execution of a dynamic equilibrium movement (Y- Balance Test). The comparison between the standard test and the roller test produced significance values in the non-parametric Wilcoxon test (p=0.02 both during execution with the right lower limb and during execution with the left lower limb) as well as statistical significance was observed in the comparison between the roller test and the occlusion test (p=0.013 for the right limb and p=0.049 for the left limb). Non-statistically significant values were instead observed in the comparison between the standard test and the test in which a maximum occlusion was performed (p=0.634 on the right and p=.451 for the left limb).

Turning, once again, a look at the anatomy and physiology of the stomatognathic apparatus, the authors hypothesize that an incorrect occlusion of the subjects is to be attributed as responsible for interpreting the significance observed in the test performed with cotton rolls between the dental arches. As extensively described previously in the chapter "occlusion and posture", an incorrect occlusion results in incorrect information from the articular, periodontal and muscular receptors of the stomatognathic apparatus to the sensory nuclei of the facial, trigeminal and hypoglossal. Consequently, the interposition of cotton rolls between the dental arches was able to remedy the mandibular dislocation by correctly repositioning the temporomandibular joint and canceling the avoidance reflex with consequent sending of physiologically correct information to the sensory nuclei. This allowed a statistically significant improvement in the performance of the Y-Balance Test.

Conclusions

The knowledge and evaluation of the postural tonic system is not a simple and immediate job. Each individual represents a reality in itself, with his experience, his traumas, his emotions, his daily habits (work, physical activity, nutrition, neurovegetative functions, sleep quality). These factors contribute to creating the individual's posture which, taking these aspects into

consideration, can be interpreted according to a neurophysiological model, a biomechanical model and a psychosomatic model. Evaluating posture and its control means dealing with a fine system that does not respond to cause-and-effect logics but rather tends to assume a non-linear dynamic. This means that small stimuli induced to the system are able to produce large effects over time and space. Our investigation wanted to explore a field in continuous experimentation. Studying the postural behavior of the human body in a dynamic condition by altering the incoming information of the stomatognathic receptor means, at a neurophysiological level, considering the innumerable subcortical connections between the various systems that govern the visual, vestibular, occlusal and swallowing functions. Admitting the existence of an interdependent work between these systems means taking a step forward in the clinical analysis of the healthy or pathological person who is thus evaluated as a whole.

From the results obtained in this experimental study we can state that the initial hypotheses have been confirmed. As far as the position of the tongue is concerned: correct lingual positioning on the palatal spot can have repercussions on dynamic postural control due to a greater increase in direct afferents to the cerebellum, an organ responsible for controlling movement and balance, greater activation of the prefrontal cortex and better intermuscular coordination (α and γ motor neurons). It is reflected in a descending way up to the foot, a "sensory" organ which adapts its response to maintain the body's center of gravity within the support base and thus inform the superior centers, with an ascending feedback mechanism, in such a way by modulating muscle tone and regulating balance.

Therefore a possible explanation of this phenomenon would admit that the tongue at the spot activates the trigeminal pathway which exchanges information with what is perceived by the vestibular system (otolithic organs and semicircular canals) and the cerebellum (ascending info from the sole of the foot that reaches the vestibular nuclei and subsequently the 'archicerebellum) to organize a better motor response, i.e. more effective for what is required by the environment.

As far as occlusion is concerned, we can think that the introduction of symmetrical elements between the dental arches such as cotton rolls can both remodify the ATM kinetics and the trigeminal afferents coming from the periodontal receptors, so that they inform the higher centers in more efficient way. It should be considered that the ATM can be both considered primary interference and therefore directly responsible for postural dysfunction, and secondary interference, i.e. it adapts in dislocation as a defense mechanism against altered incoming trigeminal afferents (e.g. precontacts).

These evaluations make us inclined to the idea that a better dynamic postural control is of fundamental importance within the sports world for the prevention of seasonal musculoskeletal injuries. It is no coincidence that studies conducted using the Y-Balance test have shown an increased risk of joint injury in different classes of athletes belonging to different sports with low levels of the composite score so as to establish a specific cut-off value. This is why we can think that the assessment of the pre-season postural tonic system is useful for investigating what the athlete's possible limitations are in order to guarantee maximum efficiency. These neurophysiological and biomechanical aspects should be taken into consideration in order to carry out increasingly accurate studies.

Although the sample was very selected, it is legitimate to conduct the study on a larger number of subjects. Furthermore, it would be useful to evaluate several selected samples diagnosed with tongue dysfunction or temporomandibular dysfunction and observe how dynamic postural control performance changes within these groups

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