IJSAR, 8(6), 2021; 62-69

International Journal of Sciences & Applied Research

www.ijsar.in

Effect of unilateral plantar pad elevation on EMG of masticatory and superficial cervical muscles in MPP

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ABSTRACT

The paper designed to raise the sole of one side of the foot to indirectly cause body imbalance. detecting the surface electromyographic activities(SEMG) of sternocleidomastoid muscle (SCM), trapezius muscle (TR), temporal muscle(TA) and masseter muscle (MM) in mandibularpostural posture (MPP). So as to analyzed the influence of plantar afferent signal changes on the above muscle functions, and elaborated the correlation between body posture and maxillofacial and neck muscle functions. Eleven asymptomatic subjects (4 males and 7 females, ages 20-30 years) were included in this study. Disturbing the balance of body posture by lifting the one side of foot with hard boards in MPP. Recorded the SEMG of TA, MM, SCM, TR by using COMETA surface electromyography in the condition of 0.5cm, 1.0cm and 1.5cm of the planthole padded up on one side and without the planthole padded up. Analysing the changes of the average SEMG of TA, MM, SCM and TR under different plantar pad heights in MPP. In the unpadded condition, the SEMG of SCM was the most obvious, followed by TA and TR, and the SEMG of MM was the weakest. The average SEMG of left SCM and TR were significantly higher than those of right SCM and TR (P<0.05). Under the condition of respectively raising the left and right plantar, the average SEMG of the padded and non-padded TR increased gradually with the increase of the foot height step by step, which was significantly higher than that of the ipsilateral TR in the unpadded condition (P<0.05). The average SEMG of the pad side increased with the increase of the foot height (P<0.05), but not obvious on the unpad side (P>0.05). The average SEMG of the left MM decreased with the increase of the right planthar height (P<0.05), while there was no statistical difference in the average SEMG of the high side and the non-high side compared with the same side under the other high conditions (P>0.05). And the average SEMG of TA was also not significantly affected by the height of the plantar pad (P>0.05). Based on these findings, it can concluded that the body posture imbalance caused by unilateral plantar cushion can change the SEMG of sternocleidomastoid muscle, trapezius muscle, temporalis muscle and masseter muscle in mandibular posture. The sternocleidomastoid muscle and trapezius muscle have strong response to plantar cushion stimulation, so as to improve the EMG activity intensity in mandibular posture and maintain the normal position of the mandible. This study reveals that the change of body posture caused by the change of plantar afferent signal can regulate and stabilize the mandibular position through the ascending muscle chain.

Keywords: body posture, surface electromyography, temporal muscle, masseter muscle, sternocleidomastoid muscle, trapezius muscle, mandibular postural position

INTRODUCE

Body posture and the reciprocal position of the head, trunk, and limbs are maintained through a complex interrelationship between sensory information and motor commands[1] Studies have shown that the stomatognathic system is related to the body posture and postural stability. The position of the lower jaw can not only affect the postural stability of the body, but also accept the influence of changes in body balance. Thoms Myers proposed the "myofascionic chain" theory and believes that the balance regulation of the body is mainly the result of the interaction between the muscles used in the postural chain of the body. When one part of the postural chain is in disorder, other neighboring structures will make corresponding compensation to correct the change of the body posture.It may also decompensate and cause changes in body posture[2-4]. Some scholars have also proposed the "ascending chain" theory, suggesting that interference with the plantar sensation may affect posture and masticatory muscles[5].

In order to further study the influence of body posture change on the stomatognathic system and whether changing the plantar afferent signals will retrograde affect the neck muscles and masticatory muscles through the ascending muscle chain, this experiment used hard boards to step up the left and right foot soles to cause the imbalance of body posture. And investigate the influence of the position change caused by unilateral plantar pad on the EMG signals of TA, MM, SCM and TR and the correlation of the changes.

MATERIALS AND METHODS

1 Subject

Eleven asymptomatic volunteers (4 males and 7 females, ages 20-30 years) were included in this study. All subjects met the following inclusionary criteria:

① Normal dentition and occlusion, absence of prosthesis (i.e., crowns, bridges, implants or removable prosthetics); ②No history of head and neck or back problems; ③No history of signs and symptoms of TMD or orofacial pain; ④No history of orthopedic or otolaryngological diseases affecting body balance and body posture; ⑤The total score of SCL-90 symptom self-rating scale was less than 160, the number of positive items was less than 43, and the factor score was less than 2; ⑥People with general health and no systemic diseases.

2 Surface Electromyography Tester and electrodes

(1) Cometa Surface Electromyography Tester (Cometa, Italy)

Cometa Surface EMG Testeris mainly composed of Wave Plus data acquisition unit, wireless surface EMG sensor, EMG data acquisition and analysis software. It collects bioelectrical signals from the skin surface via disposable ECG electrodes, and the data acquisition unit was connected to the computer through the USB interface. The corresponding muscle names of eight channels were set on the supporting EMG data acquisition and analysis software provided by Cometa.

(2) Electrode bonding

Degrease the surface of the skin to which the electrode is to be attached with 75% alcohol. The surface electrodes were placed on the abdomen of the muscle under examination along the direction of muscle fibers [6], and the distance between the electrodes placed on each muscle was about 2cm[7]. The bonding sites were those stated by anatomical reference-book for the electrode placements: trapezoid muscle, the posterolateral part of the midpoint between the spinous process and the acromial peak is about 2cm; sternocleidomastoid, the midpoint of the line where the ipsateral mastoid process and the sternum meet the clavicle; masseter muscle, the most obvious part of the masseter muscle abdomen in the maxillary bite of the subject during the cusp cross position; temporalis muscle, front of the hairline, anterior temporal muscle midabdominal point, and the most obvious place of contraction during maximum bite in intersecting cusp.

3 Study design

Subjects stood with their feet shoulder-width apart and kept their mandibular postural position under seven different pad conditions: the right plantar pad was 0.5cm, 1.0cm and 1.5cm high, and the left plantar pad was 0.5cm, 1.0cm and 1.5cm high. After the researcher confirmed that their head position was stable,Surface EMG instrument eight guide at the same time record TA, MM, SCM, TR surface EMG value (μV) 20s, each state record twice, each interval of 1 minute, the average of the two times as the final measurement value.

Statistic

GraphPad Prism 8 software was used for data analysis. Data were described in the range of median and quaternary[8], and non-parametric statistical methods were used for analysis. Wilcoxon signed rank test was used to compare the changes of left and right EMG in TR, SCM, MM, TA without padding, right plantar with padding and left plantar with padding and non-padding. *P*<0.05 indicates a statistically significant difference. Friedman M test was used to compare the EMG changes of TR, SCM, MM, TA with the change of pad height on the high side of the plantar. *P*<0.05 indicates that the difference is statistically significant.

RESULTS

1 Average SEMG of TR in mandibular postural position

The average SEMG of the left TR was greater than that of the right TR (P<0.05). The average SEMG (median) of the left TR was always higher than that of the right TR regardless of the right or left plantar padding, but there was a statistical difference only between the right and left plantar padding 0.5cm and 1.0cm and 1.5cm respectively. After the foot height was raised, the SEMG of TR on both the padded and non-padded sides were higher than those on the unpadded side, and gradually increased with the step by step increase of the foot height (P<0.05).

Table 1 The Average SEMG (μV) of TR in MPP at different plantar heights (median and interquartile)

	No padding	Pad high right sole			Pad high left sole		
		0.5cm	1.0cm	1.5cm	0.5cm	1.0cm	1.5cm
RTR	4.09 (3.47-5.53)	4.14 # (3.70-6.07)	4.24 # (3.94-6.98)	4.39 # (4.17-8.20)	4.97 # (3.94-6.92)	4.08 # (3.71-6.18)	4.10 # (3.51-5.15)
LTR	4.49 * (4.38-6.78)	5.05 * # (4.63-10.86)	5.11 # (4.73-8.21)	5.45 # (4.58-11.18)	5.23 # (4.62-9.83)	5.26 * # (4.66-10.84)	5.72 * # (5.02-12.20)

* Signifificantly different from right (Wilcoxon test), P<0.05.
# Signifiant difference among various foot pad heights (Friedman test), P<0.05.

2 Average SEMG of SCM in mandibular postural position

The average SEMG of the left SCM was significantly higher than that of the right SCM when unpadded soles and raised left soles (P<0.05). The average SEMG of the pad side increased with the increase of the foot height (P<0.05), but not obvious on the unpad side (P<0.05).

Table 2 The Average SEMG(μV) of SCM in MPP at different plantar heights(median and interquartile)

	No padding	Pad high right sole			Pad high left sole		
		0.5cm	1.0cm	1.5cm	0.5cm	1.0cm	1.5cm
RSCM	5.65 (5.25-6.36)	5.71 # (5.33-6.55)	5.74 # (5.42-6.96)	5.89 # (5.50-7.47)	5.78 (5.31-6.37)	5.79 (5.31-6.36)	5.79 (5.51-6.02(
LSCM	6.42 * (5.93-7.36)	6.78 * (6.15-7.39)	6.88 (5.99-7.55)	6.75 (6.04-7.67)	6.71 * # (6.06-7.66)	6.83 * # (6.14-7.78)	7.28 * # (6.21-8.09)

* Signifificantly different from right (Wilcoxon test), P<0.05.
# Signifiant difference among various foot pad heights (Friedman test), P<0.05.

3 Average SEMG of MM in mandibular postural position

The average SEMG of the left MM decreased with the increase of the right plantplate height (P<0.05), and there was no significant difference in the average SEMG In the rest of the plantar pad high state.

Table 3 The Average SEMG(μV) of MM in MPP at different plantar heights (median and interquartile)

	No padding	Pad high right sole			Pad high left sole		
		0.5cm	1.0cm	1.5cm	0.5cm	1.0cm	1.5cm
RMM	3.14 (3.05-3.50)	3.25 (2.77-3.74)	2.98 (2.76-3.47)	3.00 (2.83-3.75)	2.99 (2.87-3.38)	3.27 (2.85-3.43)	3.05 (2.87-3.20)
LMM	3.08 (2.88-3.39)	2.93 # (2.87-3.70)	2.96 # (2.83-3.32)	2.94 # (2.81-3.25)	3.04 (2.86-3.25)	2.98 (2.82-3.41)	2.89 (2.78-3.35)

Signifiant difference among various foot pad heights (Friedman test), P<0.05.

4 Average SEMG of TA in mandibular postural position

With the increase of the height of the sole, the average SEMG of TA on the pad side and the non-pad side did not change significantly (P>0.05).

Table 4 The Average SEMG (μV) of TA in MPP at different plantar heights (median and interquartile)

	No padding	Pad high right sole			Pad high left sole		
		0.5cm	1.0cm	1.5cm	0.5cm	1.0cm	1.5cm
RTA	4.94 (4.54-8.18)	4.80 (4.25-10.39)	4.54 (4.21-9.70)	4.44 (4.12-8.67)	4.74 (4.36-8.88)	4.68 (4.20-8.20)	4.85 (4.34-7.11)
LTA	6.06 (3.60-7.74)	5.31 (4.06-8.39)	4.67 (3.60-7.97)	4.73 (3.25-8.24)	5.38 (3.83-8.55)	5.36 (4.05-7.38)	5.12 (4.17-7.57)

5 Correlation of average SEMG of TR, SCM, MM and TA in MPP

In MPP, the average SEMG of SCM was the largest, followed by TA and TR, and the SEMG of MM was the weakest. The average SEMG of TR and SCM increased gradually with the foot height increasing, and there was a positive correlation between them and the foot height. The average SEMG of MM and TA on the pad side were negatively correlated with the pad height.

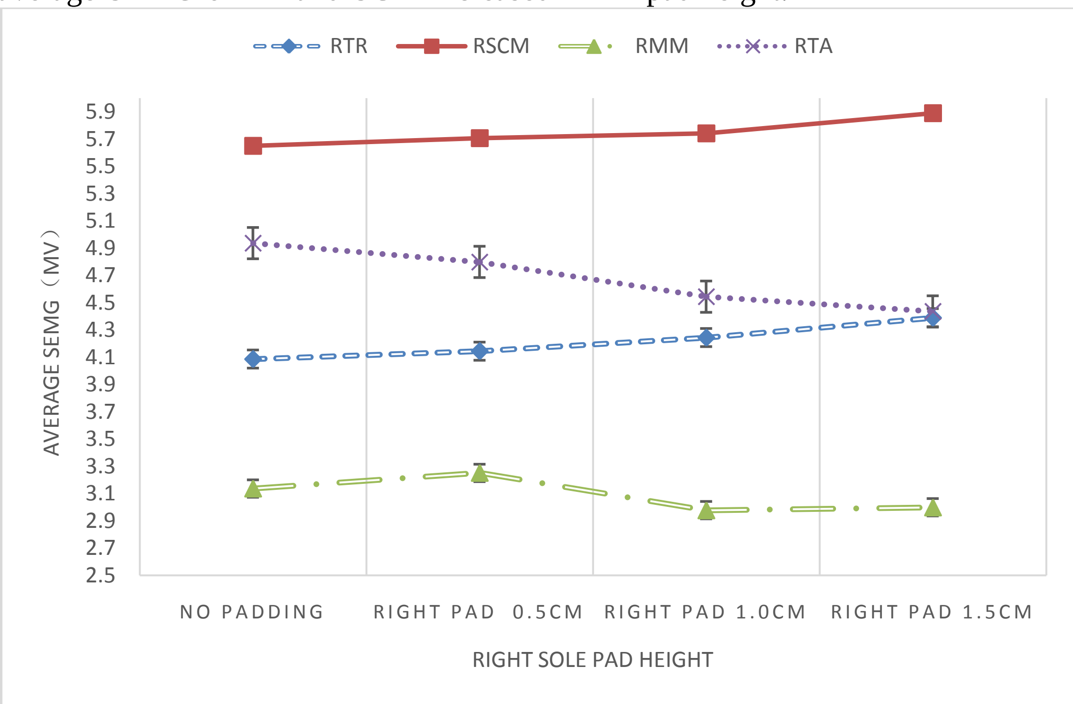

Figure 1 Average SEMG of RTR, RSCM, RMM and RTA on the right plantar in MPP (median)

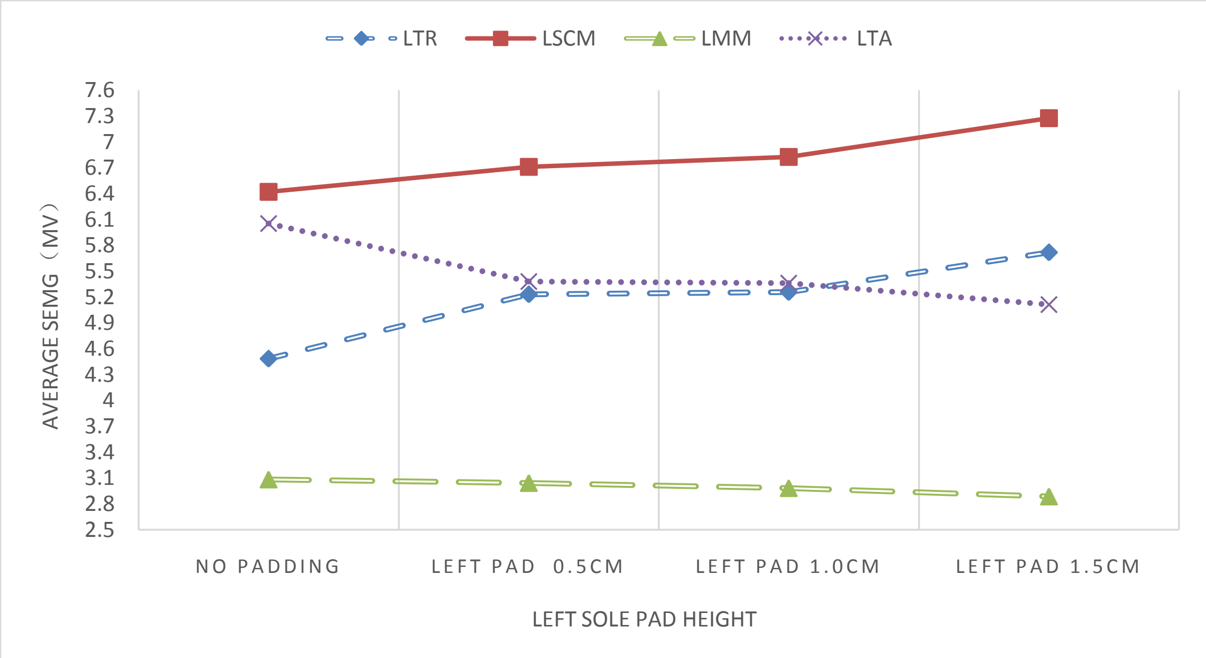

Figure 2 Average SEMG of LTR, LSCM, LMM and LTA on the left plantar in MPP (median)

DISCUSSION

1Average SEMG of TR, SCM, TA and MM under unpadded high sole condition

It was found that in the upright mandibular postural position, TA, MM, SCM and TR maintained the mandibular position with weak muscle force. The SEMG of SCM was the most obvious, followed by TA and TR, and the SEMG of MM was the weakest. However, several scholars reported that TA has the highest SEMG in the mandibular postural position[9, 10]. It may be because the subjects in the previous studies were in the sitting position, while the present study was conducted in the upright state, indicating that SCM plays a key role in the maintenance of the upright mandibular position. In addition, the average SEMG of the left TR and SCM at MPP were significantly higher than those of the right TR and SCM. As the main muscles for balancing the head posture, the asymmetrical contraction of TR and SCM was related to the deviation of the head and neck position. This may be related to the subjects were selected from oral physician groups, long time maintain work under the state of a certain position and posture, bad postures and gestures for a long time can cause spinal deformity and shoulders imbalance. Epidemiological survey has shown that 62% of oral physicians had axial syndrom[11]. This reminds stomatologists that in the process of clinical operation, more attention should be pay to the norms of body position and posture, and take a proper rest after a long time of operation to relieve neck and shoulder fatigue.

2 Average SEMG changes in TR, SCM, TA and MM with unilateral plantar pad elevation

In this study, it was found that the average SEMG of TR and SCM on the pad side were higher than those on the same side without pad, and were positively correlated with the height of the pad. Although the average SEMG of TA and MM have a downward trend, the change difference is not obvious, which is consistent with the "ascending chain" theory proposed by some scholars[12, 13]. Fabio et al. found that the muscles in the upper part of the body would respond after changing the input signals of the planthole with experimental insoles[14]. Simona's study believed that the injury of the ACL would affect the electromyography activity of the head and neck muscles and trunk muscles[15]. It has been found that the difference of leg length will affect body posture and tooth occlusion[16]. These studies all indicate that the interference of feet or legs may affect the whole body posture and the stomatognathic system.

3 Influence mechanism of unilateral plantar pad height on SEMG of TR, SCM, TA, MM

The mechanism of the association between foot stimulation and stomatognathic system is not clear. Based on the existing literature and the experimental results, we prefer to use the theory of “Muscle balance reflection” to explain, that is, the regulation of body posture is the result of comprehensive reflex after the central nervous system processes the input of sensorimotor signals at different levels[3]. In this study, a hard wooden board was used to pad one side of the plantar, the plantar skin receptors transmitted the signals of inconsistent plantar pressure on both sides to the nerve center. After fine regulation by the central nervous system, the information was transmitted to the muscular system, and the posture was adjusted by muscle contraction and corresponding displacement of bones.

According to the theory of myofascial chain by Thomas Myers, all the bones and muscles of the human body are connected together through continuous fascia to form the integrity of human function. When the signal is exerted on the musculoskeletal system, all the muscles of the postural muscle chain of the body respond together to participate in the stability and maintenance of the postural position. The changes of the trunk and limbs not only affect the structure of adjacent tissues, but also the skeletal muscles in distant areas, such as the head and neck muscles, The joint muvement of muscles maintains the balance body posture. TR and SCM are the main muscles that maintain head position, so when the body changes position, these two muscles are the first to compensate for the balance of the body, and their EMG signals are active. TA and MM are more likely to play roles in mandibular functional movement, so the signal of EMG is basically unchanged in the process of posteual muscle response. What’s more, since the adjacent muscles are overactive in the stress state, which weakens the role of TA and MM in the pose muscle chain, and the EMG signal is slightly weakened.

CONCLUSION

TA, MM, SCM and TR maintained the normal upright mandibular postures with lower muscle tension levels. TR and SCM, as the main muscles of head and neck posture, were affected by the myofascial chain and had a strong response to the stimulation of unilateral plantar pad, which enhanced the EMG activity intensity to maintain the mandibular position.

ACKNOWLEDGMENT

Authors gratefully acknowledge the members of the 1st Affiliated Hospital of Jinan University and Jinan Universityfor their valuable help.

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