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Effect of Masticating Chewing Gum on the Balance of Stroke Patients

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Background: Masticating is an activity that is free from temporal or spatial constraints, with an advantage that it can be combined easily with other treatment methods. While several studies have reported a positive effect of the intervention of chewing using the jaw on postural stability, only a few studies were conducted on stroke patients.
Objectives: To investigated the effects of masticating chewing gum on the static and dynamic balancing of stroke patients.
Design: Randomized cross-over study design.
Methods: Nineteen stroke patients were randomly assigned to the chewing group or control group. BT4 was used to measure the static and dynamic balancing abilities. Pre-test measurements were taken before mastication of chewing gum, and post-test measurements were taken after 2 days. The stroke patients in the chewing group were guided to sit on a chair and chew gum for 3 min, and their balancing abilities were simultaneously measured. The balancing abilities of the control group patients were measured while they sat at rest without masticating chewing gum.
Results: The chewing group showed significant increases in the measures of static balance (i.e., C90 area, trace length, X mean, and Y mean). In the between-group comparison, the measures of static balance were significantly higher in the chewing group than in the control group.
Conclusion: These findings suggest that masticating chewing gum enhanced the static balancing ability of stroke patients. Thus, gum chewing should be considered a viable clinical intervention to control posture in stroke patients.

Keywords: *Mastication; Chewing gum; Postural stability; Balance; Stroke*

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INTRODUCTION

Most stroke patients present with sensory, motor, cognitive or emotional disorders, which pose limitations on the ability to perform basic daily activities.[1] Balance is achieved by maintaining the center of gravity within the base of support,[2] and the impairment of balance control could have a substantial impact on the movement and independence of stroke patients while increasing the risk of fall.[3] For stroke patients to recover the ability to walk or to perform daily activities, proper training is necessary. The most commonly used training methods include the neurodevelopmental treatment (NDT)-bobath method and proprioceptive neuromuscular facilitation (PNF).[4]

Meanwhile, studies have reported that masticating chewing gum has a positive influence on postural stability. Kushiro et al. suggested that postural stability increased with gum chewing in healthy subjects who were standing.[5] This effect on postural stability was attributed to the improvement of the mental condition when chewing. Goto et al. measured the postural sway of subjects with chronic balance disorders as they were guided to chew a gum. The postural stability was reported to have significantly increased, which was accounted for by the effect of chewing during upright standing on the vestibular function.[6] Hellmann et al. showed a drop in the mean angular velocities and range of motion of the ankle, knee, and hip joints when healthy subjects were guided to achieve a bipedal narrow stance and a single–leg stance with submaximal biting. This was explained through the effect of submaximal biting on neuro–muscular co–contraction patterns that improved the kinematic precision.[7] As such, a chewing activity using the jaw exerts an enhancing influence on bal–ancing control for various reasons.

The chewing intervention is free from temporal or spatial constraints. It does not require an expert or a high expense. Additionally, it can advantageously be combined with other intervention methods. Nevertheless, no study has yet investigated the effects of masticating chewing gum on the balancing ability of stroke patients. Thus, this study aimed to determine the effects of gum chewing on the static and dynamic balancing of stroke patients, and to provide the basic data for the research of chewing and postural stability.

SUBJECTS AND METHODS

Subjects

The study participants included 19 chronic stroke patients diagnosed with hemiplegia, who had been receiving rehabilitation at S hospital in Cheonan–si (Table 1). All subjects submitted a voluntarily signed written consent for participation. This study was conducted with the approval of the Institutional Review Board of Namseoul University (NSUIRB–202009).

The subject inclusion criteria were as follows: (1) onset of hemiplegia secondary to stroke ≥6 months, (2) Korean version of mini–mental state examination (MMSE–K) ≥24 with an ability to communicate flu–ently, (3) ability to independently perform a 10–m gait without an assistive tool, (4) ability to perform normal deglutition, (5) normal oral cavity structure, (6) no periodontal disease, and (7) at least 24 remain–ing teeth. The exclusion criteria were as follows: (1) malocclusion, (2) facial asymmetry, (3) oro–fascial pain including trigeminal neuropathy and toothache, (4) toothache caused by periodontal disease, and (5) unstable breathing or pulse.[8,9]

Table 1. General characteristics of the subjects

General characteristics	n = 19
Sex (male/female)	11 / 8
Age (years)	61.58 ± 12.27
Height (cm)	168.63 ± 5.47
Weight (kg)	67.63 ± 7.20
Stroke type (n) Ischemic/Hemorrhagic	12 / 7
Affected side (n) Left/Right	9 / 10
Time since stroke (month)	21.67 ± 15.10
MMSE–K (score)	26.55 ± 2.14
Brunnstrom (stage)	4.23 ± .57

MMSE–K: Korean version of mini–mental state examination

Methods

This study was conducted with a randomized crossover design on 19 subjects. The procedures in Goto et al.[6] were modified and applied in this study. The gum was Xylitol from Lotte Corporation (Korea). Balancing ability was assessed in two conditions, namely, during gum chewing and without gum chewing. On Day 1, the subjects were randomly divided into two groups. The chewing group was guided to sit on a chair and to chew a gum continu–ously for 3 min while static and dynamic balancing were measured on the force plate of BT4 (Hurlabs, Finland). In contrast, the control group was guided to sit on a chair with a gum in the mouth but without chewing for 3 min while static and dynamic balancing were measured. For wash–out, the second measure–ments were taken 2 days later. The intervention and measurement were performed as in Day 1, although the intervention was switched between the groups (Figure 1).

Outcome Measurement

The balancing ability of the subjects was measured using the BT4 (Hurlabs, Finland). The romberg test and limit of stability (LOS) were used for static and dynamic balancing, respectively. On the BT4 plat–form, each subject was guided to position the feet at 15° while staring forward at a point 2 m away, with eyes open for 1 min. This was to perform the romberg test for the measurement of postural sway based on the center of pressure (COP). For the COP variables,

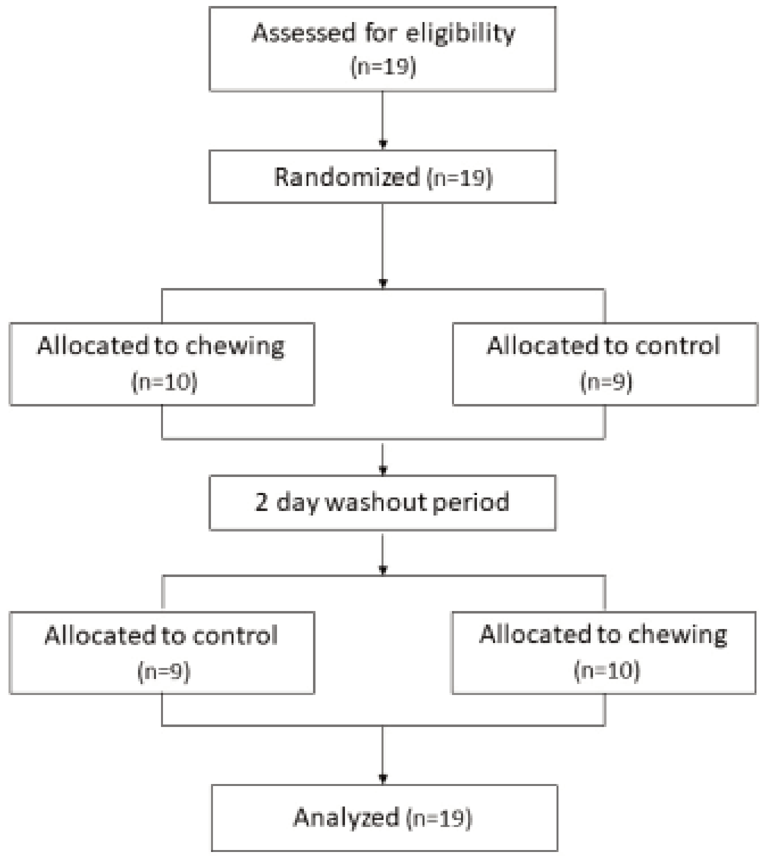

Figure 1. Flowchart of the study

the C90 area, trace length, X mean, and Y mean were selected. C90 area is the area of COP shift from the center, and trace length is the path of the COP shift. X mean is the medial–lateral average displacement, and Y mean is the anterior–posterior average displacement. All four COP variables indicated a good static balancing ability when the values were low, as they implied minimal postural sway. For LOS, the subject was guided to stand straight and to position the feet at 15° on the BT4 platform; then, the body was tilted maximally for 8 s in four directions, namely, front, back, left, and right. The sum of all four tilted angles was selected as the LOS variable, and higher values indicated higher dynamic balancing abilities.

Data and Statistical Analysis

All statistical analyses were performed using the IBM SPSS Statistics (ver. 23.0; IBM Corp., Armonk, USA) to obtain the mean and standard deviation. The data normality was tested by the Shapiro–Wilk test. To test the homogeneity of general characteristics, the Chi–square test and independent t–test were performed. To examine the pre–test and post–test intervention effects in each group, a paired t–test was performed. For the between–group comparison, an independent t–test was performed. The significance level was set to $P<.05$.

RESULTS

A significant increase in the values of the static balance parameters (i.e., C90 area, trace length, X mean, and Y mean) was found between the pre–test and post–test scores of the chewing group. The static balance parameter values were similarly increased in the chewing group compared with the control group (Table 2).

Table 2. Effect of masticating chewing gum on static (C90 area, trace length, X mean, and Y mean) and dynamic (LOS) balance

Variables	Group	Pre–test	Post–test	*P*	t	*P*
LOS [mm2]	Chewing group	3.18 ± .61	4.67 ± .51	.08	–0.42	.23
	Control group	3.97 ± 1.02	4.02 ± .85	.68		
C90 area (EO) [mm2]	Chewing group	290.26 ± 64.73	265.48 ± 30.85	.02*	–2.59	.01*
	Control group	284.26 ± 47.32	299.32 ± 55.18	.10		
Trace length [mm2]	Chewing group	961.89 ± 204.78	747.69 ± 254.82	.04*	2.63	.01*
	Control group	928.57 ± 226.54	907.08 ± 208.44	.44		
X mean [mm]	Chewing group	21.98 ± 17.50	16.25 ± 12.49	.04*	4.09	.00*
	Control group	21.80 ± 19.24	17.89 ± 11.17	.34		
Y mean [mm]	Chewing group	17.65 ± 14.41	22.21 ± 15.80	.00*	–6.18	.00v
	Control group	15.67 ± 13.47	16.27 ± 15.30	.21		

*P〈.05

LOS: Limit of stability, C90 area (EO): C90 area (Eyes open), Trace length: Area of the 95% confidence ellipse

Y mean: Anterior posterior average displacement, X mean: Medial lateral average displacement static balance evaluation items using romberg 30s test among BT4 protocols

DISCUSSION

This study was conducted with a randomized crossover design on 19 stroke patients to estimate the balancing ability in two conditions, with and without gum chewing. The results are as follows.

In the group that received the chewing intervention, there was a significant difference in the pre–test and post–test measurements of static balance (i.e., C90 area, trace length, X mean, and Y mean). Similarly, the chewing group also showed higher values of the static balancing parameters than the control group.

To maintain the center of gravity in the base of support, continuous efforts are made in the human body. In the case of static posture stability, an intri–cate control of posture through the neuromuscular system is necessary. As the posture control system is complex and pluralistic, the proprioceptive system, different vestibular and neck reflexes, and the vestibulo–ocular system are required. The control of static balance comes from an elaborate set of neuro–muscular interactions based on sensory motor path–ways, with postural stability and directionality as the main functional goals.[10] Thus, the sensory data from the somatosensory, vestibular, and vision systems are merged together and relatively loaded according to the purpose and environment of a given task.

Hellmann et al. examined the electromyography (EMG) activity of the lower extremity muscles under the influence of force–controlled biting in relation to the ankle, knee, and hip joint kinematics, and in bipedal gait and single leg positions. The range of motion and angular velocity of the ankle, knee, and hip joints were reported to have significantly decreased in the unipedal and bipedal postures when submaximal biting was applied.[7] Takada et al. reported that voluntary teeth clenching caused irre–versible facilitation of the ankle extensor and flexor, but reduced the reciprocal Ia inhibition of the soleus muscle. The study also claimed that voluntary force–controlled biting contributed to the enhancement of postural stability rather than the agility of move–ments.[11]

Buisseret–Delmas et al. and Cuccurazzu et al. demonstrated the reciprocal connection of the trigeminal nerve and auditory nerve.[12,13] Park et al. showed that chewing in patients with vertigo or nys–tagmus could significantly improve the symptoms and claimed, based on the results, that the human vestibular system could be controlled by the trigemi–nal system.[14] Boroojerdi et al. and Miyahara et al. reported a facilitation effect of teeth clenching on reflex control and the lower extremities.[15,16]

Thus, the findings of this study are consistent with those of previous studies, in which a significant increase in static balancing was found in the group that received the chewing intervention. This may be attributed to the constant stimulus on the vestibular system from chewing, which induced a lower extremity reflex and a muscular facilitation.

The generalizability of these results is subject to certain limitations. First, there was a small study population; therefore, the results may not be applicable to all stroke patients . Second, only a single-session intervention was administered and monitored. Further studies should be conducted to assess the long-term effect of masticating chewing gum on the balance of stroke patients.

CONCLUSION

Our findings corroborate previous studies and suggest that mastication can modulate balancing control mechanisms. In particular, masticating chewing gum can enhance static and dynamic balancing in stroke patients. Our results could be considered in the treatment and rehabilitation planning for patients with postural instability.

REFERENCES

1. Hochstenbach J, Donders R, Mulder T, Van Limbeek J, Schoonderwaldt H. Long-term outcome after stroke: a disability-orientated approach. *Int J Rehabil Res*. 1996;19(3):189-200.
2. A Shumway-Cook A, Woollacott M. Attentional demands and postural control: the effect of sensory context. *J Gerontol A Biol Sci Med Sci*. 2000;55(1):M10-16.
3. Mackintosh SF, Hill KD, Dodd KJ, Goldie PA, Culham EG. Balance score and a history of falls in hospital predict recurrent falls in the 6 months following stroke rehabilitation. *Arch Phys Med Rehabil*. 2006;87(12):1583-1589.
4. Bonan IV, Marquer A, Eskiizmirliler S, Yelnik AP, Vidal P-P. Sensory reweighting in controls and stroke patients. *Clin Neurophysiol*. 2013;124(4):713-722.
5. Kushiro K, Goto F. Effect of masticating chewing gum on postural stability during upright standing. *Neurosci Lett*. 2011;487(2):196-198.
6. Goto F, Kushiro K, Tsutsumi T. Effect of chewing gum on static posturography in patients with balance disorders. *Acta Otolaryngol*. 2011;131(11):1187-1192.
7. Hellmann D, Stein T, Potthast W, Rammelsberg P, Schindler HJ, Ringhof S. The effect of force-controlled biting on human posture control. *Hum Mov Sci*. 2015;43:125-137.
8. Gim MN, Lee SB, Yoo KT, Bae JY, Kim MK, Choi JH. The effect of olfactory stimuli on the balance ability of stroke patients. *J Phys Ther Sci*. 2015;27(1):109-113.
9. Kim MJ, Hong JY, Lee GH, et al. Effects of chewing exercises on the occlusal force and masseter muscle thickness in community-dwelling Koreans aged 65 years and older: A randomised assessor-blind trial. *J Oral Rehabil*. 2020;47(9):1103-1109.
10. Horak FB, Henry SM, Shumway-Cook A. Postural perturbations: new insights for treatment of balance disorders. *Phys Ther*. 1997;77(5):517-33.
11. Takada Y, Miyahara T, Tanaka T, Ohyama T, Nakamura Y. Modulation of H reflex of pretibial muscles and reciprocal Ia inhibition of soleus muscle during voluntary teeth clenching in humans. *J Neurophysiol*. 2000;83(4):2063-2070.
12. Buisseret-Delmas C, Compoint C, Delfini C, Buisseret P. Organisation of reciprocal connections between trigeminal and vestibular nuclei in the rat. *J Comp Neurol*. 1999;409:153-168.
13. Cuccurazzu B, Deriu F, Tolu E, Yates BJ, Billig I. A monosynaptic pathway links the vestibular nuclei and masseter muscle motoneurons in rats. *Exp Brain Res*. 2007;176:665-671.
14. Park SH, Kim HJ, Kim JS, et al. Mastication-induced vertigo and nystagmus. *J Neurol*. 2014;261:480-489.
15. Boroojerdi B, Battaglia F, Muellbacher W, Cohen LG. Voluntary teeth clenching facilitates human motor system excitability. *Clin Neurophysiol*. 2000;111(6):988-993.
16. Miyahara T, Hagiya N, Ohyama T, Nakamura Y. Modulation of human soleus H reflex in association with voluntary clenching of the teeth. *J Neurophysiol*. 1996;76(3):2033-2041.