Chapter

Effect of Salivation by Facial Somatosensory Stimuli of Facial Massage and Vibrotactile Apparatus

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Abstract

We studied the effects of salivary promotion of fluid secretion after hand massage, and the apparatus of vibrotactile stimulation (89 Hz frequency, 15 min) in normal humans. Personal massage cannot be performed on handicap and stroke patients, and then giving hand massage to them for 5 min massage gives a tired feeling. So, we focused 3 min stranger massage. Salivary glands can discharge the accumulated saliva by extrusion from the acinus glands' massages as described in the recent Japanese textbook. We think that this method may not produce realistic recovery. Our aim ideas are to relieve stress and increase temperature with lightly touch massage of the skin and for a 1 cycle of 1 s. We recorded RR interval of ECG, total salivation, facial skin temperature, OxyHb of fNIRS on the frontal cortex, and amylase activity for the autonomic changes. In increased 2°C of the facial skin temperature, the hand massage had a need for 3 min and the vibrotactile stimulation for 15 min. Increase from 700 to 1000 ms of RR intervals had a need for 3 min in the hand massage and had 15 min in the vibrotactile stimulation. Although vibrotactile stimulation needs long time of 4–7 years as effective recovery, hand massage may have more effect with a repetition of day after day.

Keywords: hand massages, vibrotactile stimulation, facial skin temperature, total salivation, RR intervals of ECG, OxyHb of fNIRS, amylase activity

1. Introduction

Does somatosensory stimulation in areas of the face and oral cavity promote salivation and recovery of poor salivary glands? We studied the effects of salivary promotion after hand massage and apparatus of vibrotactile stimulation (89 Hz frequency, 9.8 μm amplitude, and 15 min) in normal humans [1]. Namely, we think that the produce of salivation needs effective changes of an autonomic system for salivation following autonomic activity. Quality of saliva is transmuted by autonomic activity of sympathetic or parasympathetic nerve. In sympathetic activity, viscid saliva functions to allow a food bolus to be easily passed from the mouth into the esophagus. Furthermore, in parasympathetic activity, it is also very important function for the sense of taste and for digestion. In particular, as the poor salivation cannot make the food bolus, dysphasia troubles are induced. On the other hand, poor salivation leads to an increase in dental caries and gingivitis. For ill-fitting dentures of deficits of oral function, massage therapists of the salivation need a rehabilitation method for encouraging salivation and orofacial function [2]. Namely, poor salivations following sickness or advanced aging may be recovered by activation of metabolism of salivary glands. We know that the method of facial traditional massage can induce salivation with increased temperature and blood flow by directly stimulating the salivary glands. However, the descriptions of salivary glands massage from the recent Japanese text will generate salivation by extrusion of accumulated salivary from the acinus glands, and approximately totally 10 pushes form at the anterior to posterior regions of the parotid glands. Furthermore, in the textbook, the submandibular gland is pressed about five times by the thumb to grip the soft parts inside the angle of the mandible, and the sublingual gland is pressed about five times by the thumb from under the chin [3]. The traditional method of saliva massages involved pressing the acinar regions depending on saliva accumulated in that region. However, the principal goal of massages is to maintain one's metabolism. Thus, we think that the real massage must maintain the metabolism of salivary glands at high levels depending on increasing the temperature of facial skin via haptic stimuli, a paratripsis, through the use of the palms of the hand [4]. The real salivary gland massages must be performed to activate the acinar regions. Functional recovery of salivation is encouraged by promotion of the metabolism of the salivary glands, and a rise in metabolism produces with increasing blood circulation in the salivary glands. This increase in circulation also elevates the temperature around the gland which may activate acinus gland cells. Initially, we examined the effect of facial somatosensory stimuli by using of the apparatus of vibrotactile stimuli [1, 5–8]. Secondly, we tried to carry out hand massages, again. So, we will report the effects of salivation in facial vibrotactile stimuli and facial hand massages.

2. Materials and methods

The Nihon University School of Dentistry provides ethical approval to conduct this pilot clinical study (approval number: 2009-5). All study participants received verbal explanations regarding measurements of hand massages and a vibrotactile apparatus and signed an informed consent. The study participants were again explained about the protection of privacy and personal information and provided the freedom to continue or withdraw their consent.

2.1 The optimum way of hand massage

We performed facial stranger or personal hand stimuli during 3 and 5 min. After performing the stranger or self-massage procedures for 3 or 5 min, we asked for degree of fatigue. We included 40 healthy subjects (age 26.7 ± 2.4; 25 males, 15 females) and examined well-suited massage time and method depending on first 5 min and then 3 min massage. However, normal subjects were always appealed for feeling of fatigue with an exercise for 5 min. Hand massage for 3 min can be divided into stranger and self-massages: own face has been massaged by other person' hand or by own hand. Personal massage is not able to treat patients with handicap and cerebral apoplexy. So, we focused at the exercise for 3 minutes and stranger massage (hand massage), as shown in **Figure 1A**.

After a stranger massage (a light touch and paratripsis massage) of the facial skin, we performed a rotation every second to increase the temperature of the skin and thus boost local blood circulation and improve the metabolism of the parotid glands and around the facial skin (**Figure 1B**).

We performed the resting and stimulating phases during insertion of cotton rolls for each 3 min between 5 and 7 pm under the circadian rhythm. We explored ECG (electrocardiogram), facial skin temperature, total salivations, OxyHb (oxidation hemoglobin) activity of f-NIRS (functional near-infrared spectroscopy) on the frontal cortex and amylase activity between resting and massage phase of the stranger hand massage. We recorded measurement of resting condition for 3 min after each cotton roll was set into the oral cavity, and then after relax of 1 min interval, new cotton roll was fitted into an oral cavity again and we did measurement of stimulating condition for 3 min. The facial skin temperature, RR intervals of ECG and f-NIRS recorded during experiments, and the observational study were measured in each measuring range. Furthermore, we recorded total salivation and saliva amylase activity after each phase of resting, hand massage, and vibrotactile stimulation.

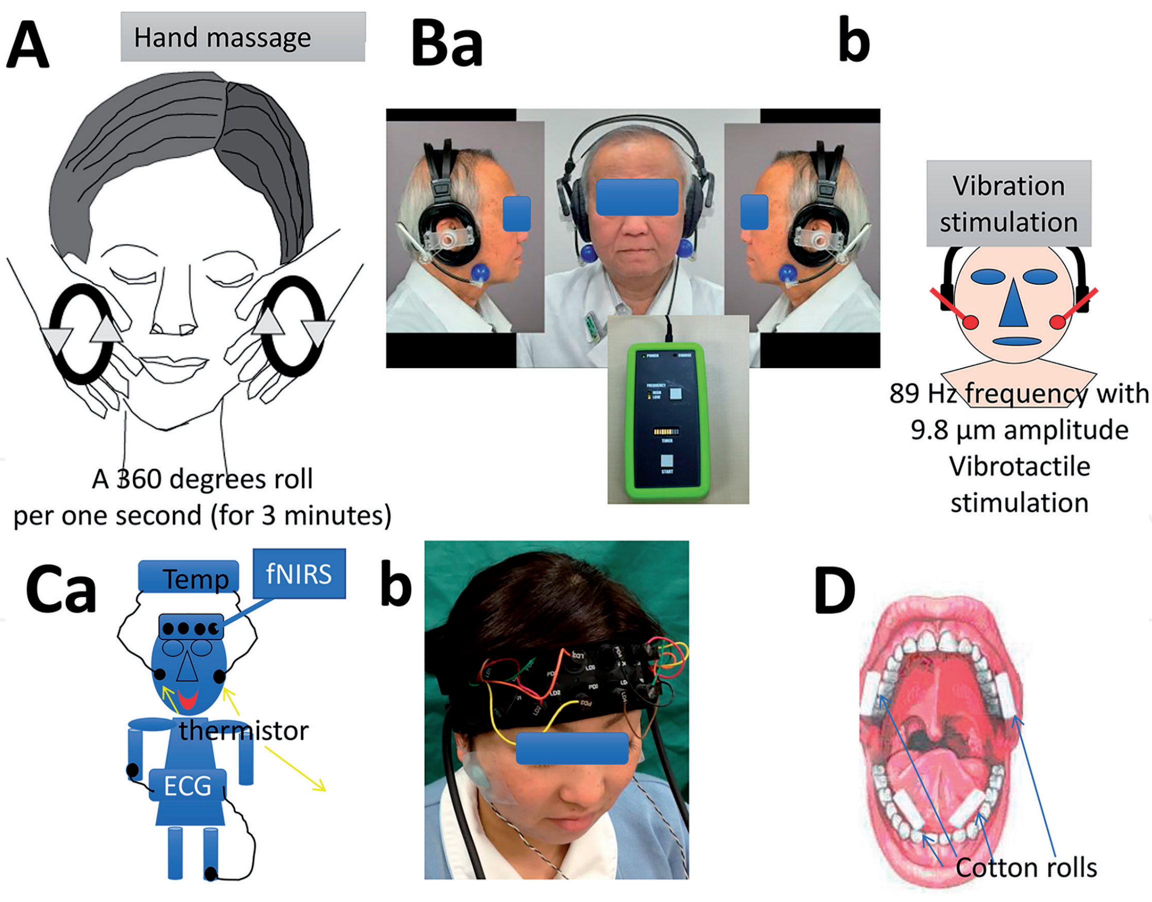

Figure 1.
Experimental method. (A) Stranger hand massages performed at 360° roll per 1 s for 3 min. (B-a and -b) 89 Hz and 9.8 μm amplitude vibrotactile stimulation. (C-a) Thermometers on the facial skin, electrodes of electrocardiogram (ECG), and electrical poles of functional near-infrared spectroscopy (fNIRS) in the frontal cortex and the position of electrodes of ECG. (C-b) Photograph of electrical poles of fNIRS and thermistors. (D) The position of cotton rolls into the intraoral cavity. Cotton rolls under the tongue were recorded salivations of the submandibular and lingual glands and cotton rolls on the buccal mucosa of the upper jaw were recorded salivations of the parotid glands.

2.2 The optimum frequency of vibrotactile apparatus

Apparatus of 89 Hz frequency and 9.8 μm amplitude vibrotactile stimulation was chosen by data of the previous papers [1, 5–8], as shown in **Figure 1B-a**, -**b**. We tried three vibrotactile stimuli, (89, 114, and 180 Hz, and others all of 9.8 μm amplitude), and the best salivation was 89 Hz frequency in comparison with others, as shown in **Figure 2**. This apparatus was used by poor salivation patients (especially, Sjogrens's syndrome and so on) and about 50% of patients showed the effect [1]. Stranger hand massage had a limit time to do massage for physical fatigue, so we tried the 89 Hz frequency vibrotactile apparatus for long time of facial stimulation. Furthermore, we recorded facial skin temperature, total salivation, RR intervals of ECG, and saliva amylase activity, too.

We explored the facial skin temperature, ECG recording, and fNIRS on the frontal cortex for the comparison with resting for 3 min, stranger massage for 3 min, and vibrotactile apparatus for 15 min.

2.3 Analysis of facial skin temperature

Facial skin temperature was measured by thermistor-pots (BioResarch Co.) located on the facial skin of parotid glands of both sides with adhesive tape, as shown in **Figure 1C-a**, -**b**. We recorded the temperature through the experiment and analyzed 3 min from start to finish during resting phase, 3 min from start to finish during stranger hand massage, and 15 min from start to finish during the vibrotactile stimulation.

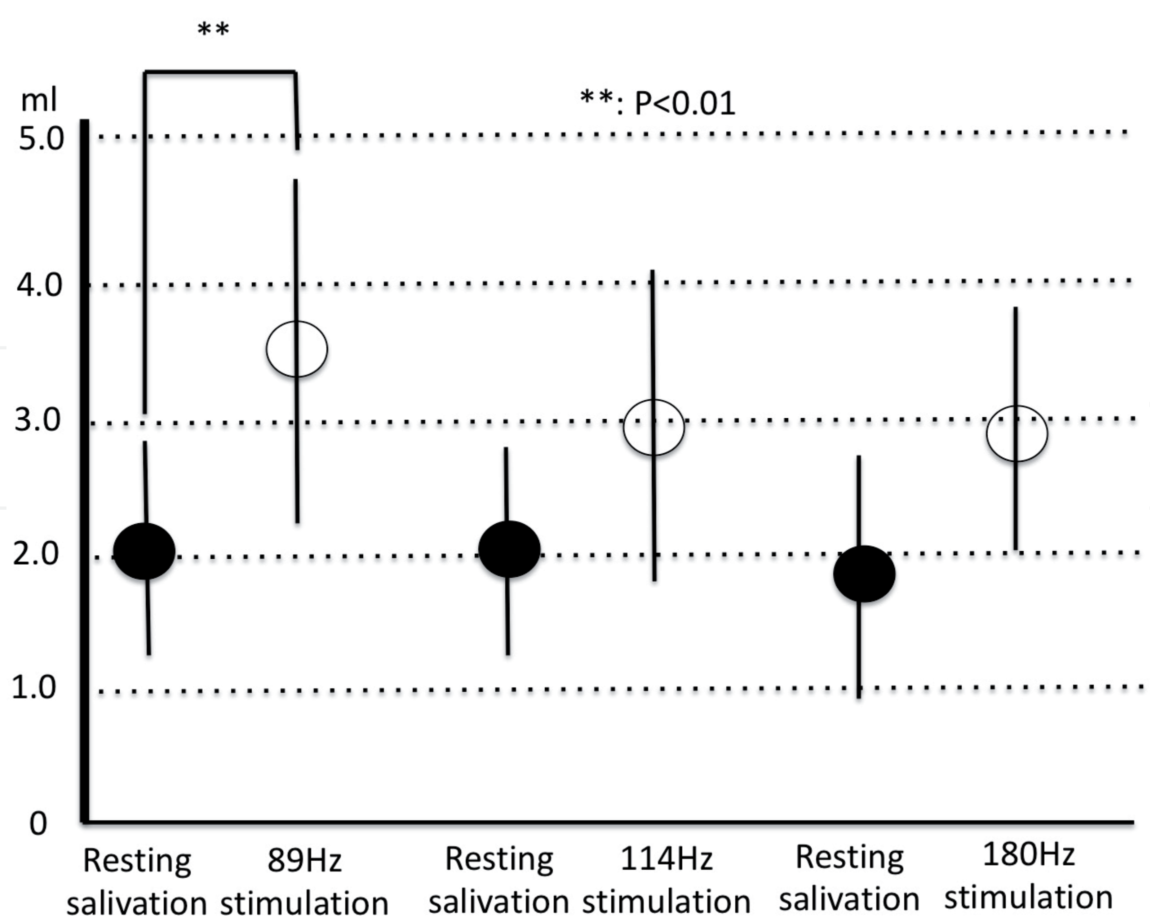

Figure 2.
Total salivation in resting salivation and vibrotactile stimuli (89, 114, and 180 Hz frequency). p < 0.01, t-test.

2.4 Analysis of RR intervals of ECG

The electrocardiogram (ECG) recording was induced by the standard limb lead. The heart rate was measured by the RR interval rate (time between R and R) and was analyzed by the variance plot and frequency distribution, as shown in **Figure 1C-a**. On the other hand, in the distribution of frequency measured by RR interval rate, we decided a mean RR interval value in order to show almost mono-modal peaks [9].

2.5 Analysis of total salivation

The mouths of each subject were fitted with rolls of cotton placed on both sides of the mouth at the following sites on the duct openings of the parotid glands of the buccal mucosa near the second upper molar teeth, and under the tongue to collect saliva from the sublingual and submandibular glands for a measurement of total salivation, as shown in **Figure 1D**. The total salivations indicate the sum of four cotton rolls (both sides of parotid, and submandibular and sublingual glands), as shown in **Figure 1D**. We measured the resting salivation for 3 min and after a relaxing interval of a minute, we did stranger hand massages salivation for 3 min again. Furthermore, we measured total salivations of the 15 min vibrotactile stimulation after 5 min resting interval of the massage.

2.6 Analysis of an OxyHb of fNIRS on the frontal cortex

The recording was conducted using a functional near-infrared spectroscopy (fNIRS) OEG16 instrument (SpectraTech, Inc., Shelton, CT, USA) from the frontal cortex. As shown in **Figure 1C-a**, -**b**, the fNIRS probe assembly consisted of six LEDs as light sources, each of which emitted two kind of wavelengths, 770 and 840 nm, and six photodiodes as detectors. The sources and detectors were symmetrically arranged in an area of 3.0–14.0 cm, with the nearest source-detector separation of 2.0 cm, and measurement points were at 16 points on a frontal cortex. During scanning, a velcro band held the probe assembly securely to the forehead of subjects and extended from ear to ear horizontally and from hairline to eyebrows vertically. Each of the LEDs was turned on in sequence, and the diffuse NIR light from each source was acquired through the cortical region at the nearest detector. Thus, 16 source-detector pairs (channels) in total were measured (**Figure 1C-a**, -**b**). The sampling rate across all 16 channels was 0.76 Hz. In particular, we showed a 16-channel computerized analysis (as shown in the previous papers [5–7]) and the original waves of four channel recording areas in the central parts. Analysis of amount of OxyHb of fNIRS on the frontal cortex is examined by the program of fNIRS Data Viewer, and we explored channels 4, 7, 10, and 13 of the central part of the frontal cortex. Data recorded by the experiment measured the value of integral of four channels in the center frontal cortex, and we calculated mean value of integral of four waves [5, 6, 10, 11].

2.7 Analysis of salivary amylase activity

A salivary amylase (α-amylase) activity was measured by salivary amylase monitor (Nipro Co.) provided for chips of salivary amylase monitor. Measurements of saliva amylase activities were recorded after resting, stranger hand massage, and vibrotactile stimulation phases.

3. Results

We examined the effect of salivation in resting and stimulating stages between the stranger hand massage and vibrotactile apparatus. We focused on a 3 min stranger massage, because a self-massage could not be performed for treating patients with handicap and stroke, and 5 min massage evoked the tired feeling.

3.1 Facial skin temperature

In 5 min hand massages, facial skin temperature increased about 2–3°C in both hand massages (stranger and personal). On the other hand, in 3 min stimuli, facial skin temperature increased about 1.5–2.0°C. The tendency of increased facial skin temperature in 3 and 5 min stimuli was almost same; namely, the ratio of increased temperature was dependent on stimulus time. On the other hand, in performance of stranger hand massages for 5 min, each operator complained with feeling of fatigue, and sometimes showed overflowing of salivation in the cotton rolls of the oral cavity. From this result, we abandoned this experiment of 5 min stimulation depending on using of five subjects. Furthermore, the 5 min massage procedure elicited the sure fatigue. So, we focused to 3 min stranger hand massage.

In loading, facial skin temperature showed about 33°C in the insert of cotton rolls in an oral cavity, as shown in **Figure 3**. This skin temperature may be stimulated by a foreign substance, because facial skin temperature was decreased up to about 32°C in the resting phase after loading. After a resting phase of 3 min stranger massage stage, facial skin temperature in the stranger massage increased from 32.0 to 34.5°C, as shown in **Figure 3**; namely, stranger massage showed the increase of facial skin temperature from 32.0 to 34.5 in 3 min stimulation.

On the other hand, the apparatus of 89 Hz frequency and 9.8 μm amplitude vibrotactile stimulation was chosen by data of the previous papers [1, 5–8], as shown in **Figure 1**. This vibrotactile stimulation was the best salivation in comparison with others, as shown in **Figure 2**. In the resting phase, facial skin temperature showed about 32°C. Furthermore, the start of 89 Hz vibrotactile stimulation showed about 33°C and after 15 min, it did 34°C; namely, an increase of 1°C spent due to 15 min vibrotactile stimulation, as shown in **Figure 3**.

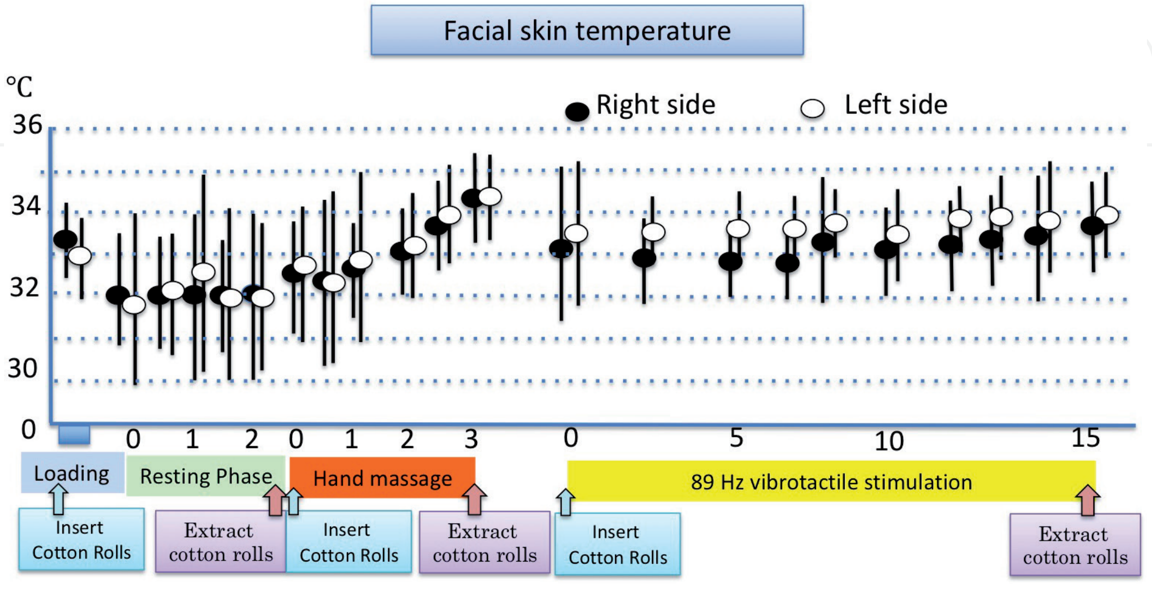

Figure 3.
Changes in temperatures on facial skin before and after 3 min resting phase, 3 min stranger massage, and 15 min vibrotactile stimulation. Black circle is right side and white circle is left side.

3.2 RR interval of ECG and total salivation

First, we examined the difference between stranger and self-massages of the RR intervals of ECG. However, there were no differences between the RR intervals of ECG of stranger and self-massages. Especially, the RR intervals in 3 min stranger massage had a tendency to decrease (increase of heart rate), and there was a $p < 0.01$ significance (T-test), as shown in **Figure 4A**. Namely, for 3 min of stranger massage, RR intervals increased from about 700 to 1000 ms, and it evoked feeling of sleepy in everybody, as shown in **Figure 4A**. However, a 89 Hz vibrotactile stimulation was spent for 15 min to increase from about 700 to 1000 ms of RR interval, as shown in **Figure 4A**. Especially, immediately after the insert of cotton rolls, RR intervals showed about 700 ms and then after a few min increased up to about 900–1000 ms, as shown in **Figure 4A**. In particular, hand massages are effective to increase temperature and RR intervals. However, no change of total salivation did not show the effect of the autonomic system in 3 min hand massage.

However, hand massages, especially stranger one, will evoke sleepiness by the increased temperature, and metabolism will decrease getting sleepy with the non-increased salivation. Especially, hand massage is needed to countermeasure the effectiveness of fight falling asleep.

On the other hand, total salivation showed about 1.2 ml in resting phase during 3 min, 0.5 ml in stranger massage during 3 min, 1.0 ml in self massage during 3 min, and 3.5 ml in 89 Hz vibrotactile stimulation during 15 min, as shown in **Figure 4B**. Although 3 min hand massages did not show the effect of autonomic activity, 15 min vibrotactile stimulation did it.

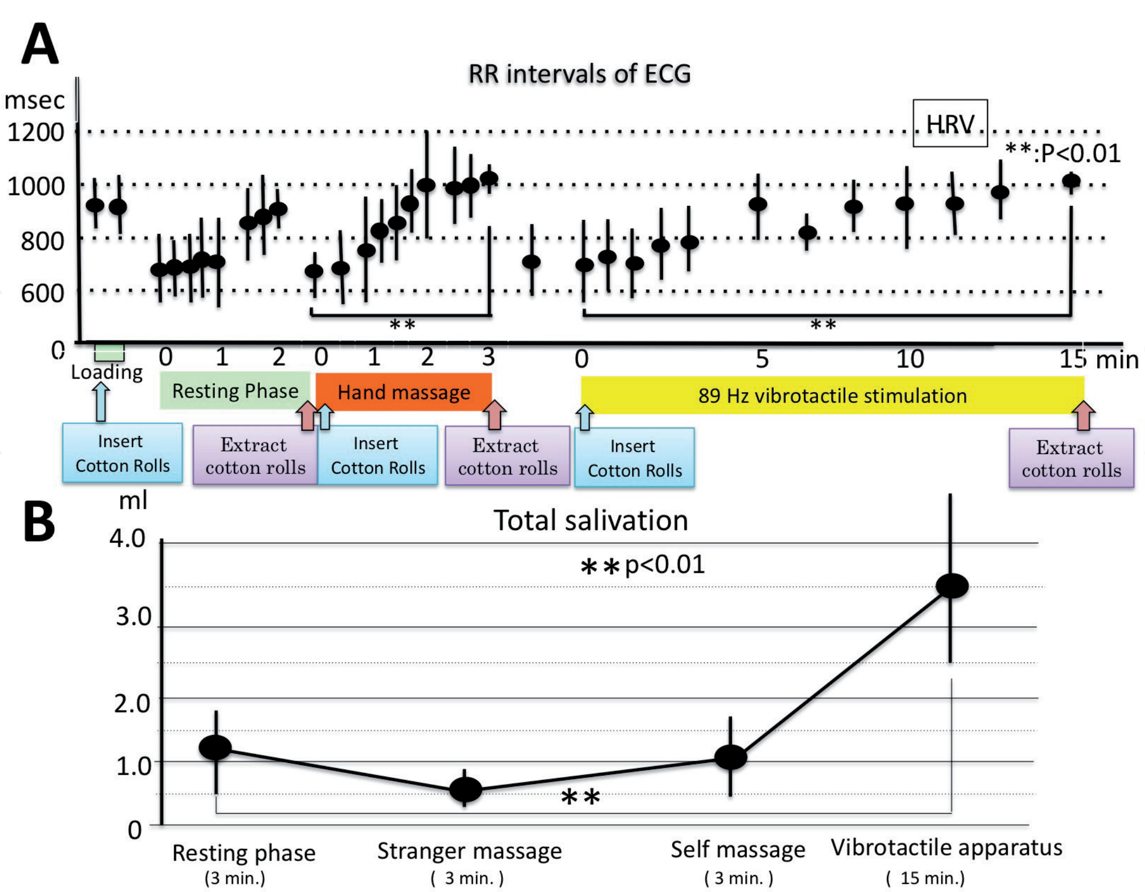

Figure 4.
RR intervals of ECG (A) and total salivation (B) before and after 3 min hand (stranger and self-massage) massage.

3.3 Measurement of OxyHb of fNIRS on the frontal cortex

The increase toward plus direction of OxyHb is associated with neuronal activities, but when we become sleepy, it is decreased toward below zero [12, 13]. On the other hand, the zero level of OxyHb of fNIRS showed parasympathetic activity from our data [5–7]. According to the amount of OxyHb of fNIRS, OxyHb in the stranger massage showed the decrease below zero, as shown in **Figure 5**. The results may be sleepy with decreased OxyHb during the stranger massage. According to analysis of OxyHb activity of fNIRS, during the resting phase and hand stimulation, subjects showed the nonzero number, and during the second half stimulation of 89 Hz vibrotactile apparatus, they showed the zero level. In particular, the below zero level of OxyHb activity coincided with the inducing of sleepy in the stranger massage. We think that the nonzero number is the decreased metabolism with getting sleepy, and the zero level is the parasympathetic activity (2–15 min in 89 Hz vibrotactile stimulation), as shown in **Figure 5** and the previous papers [5–8]; namely, the stranger massage will produce an early excitation (0–2 min) and a late relaxation (3 min), as shown in **Figure 5**.

3.4 Measurement of amylase activity

In the previous studies [10, 11, 14], measured values with salivary amylase monitor (Nipro Co.) showed the increased value depending on the sympathetic activity; namely, the value of amylase activity measured by salivary amylase monitor is shown as an increase of value following increased sympathetic activity. The results showed that the minimum value was before hand massage (about 15 KIU/L) and then the maximum value was after stranger massage (about 40 KIU/L) and vibrotactile apparatus (about 42 KIU/L), as shown in **Figure 6**. These findings show that subjects (patients) may be excited (decreased RR intervals, as shown in **Figure 4A**) by stranger's hand touching (**Figure 4B**). Furthermore, it may be related to an amount of amylase.

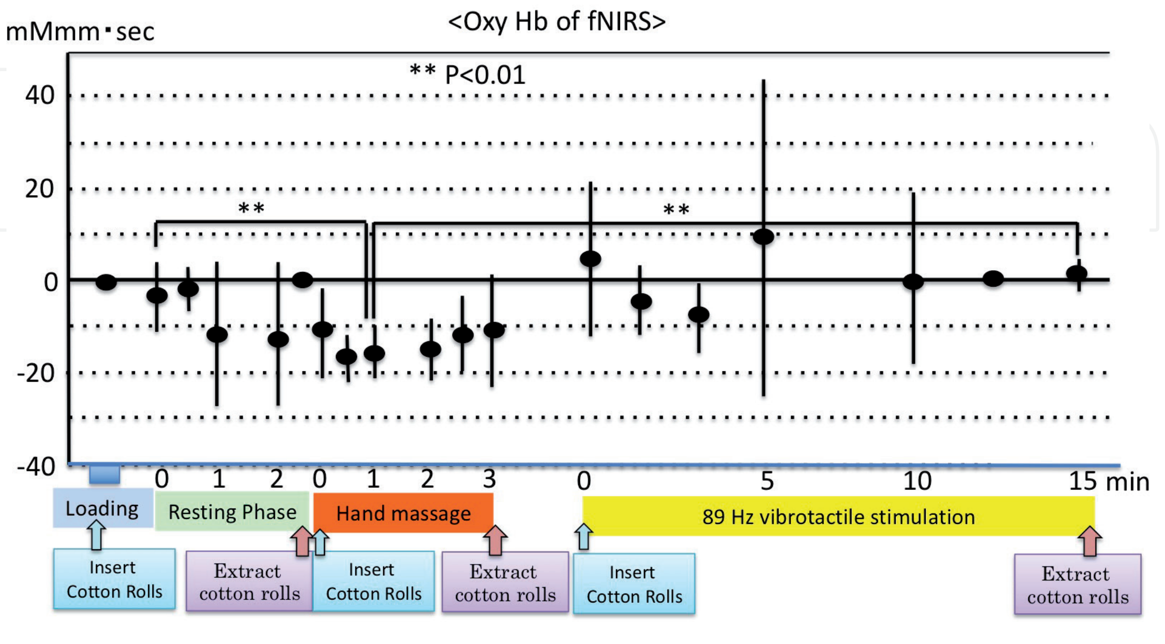

Figure 5.
Changes in OxyHb of fNIRS of resting and stranger massage for 3 min, and vibrotactile stimulation of 89 Hz frequency and 9.8 μm amplitude for 15 min. p < 0.01, p < 0.05, t-test.

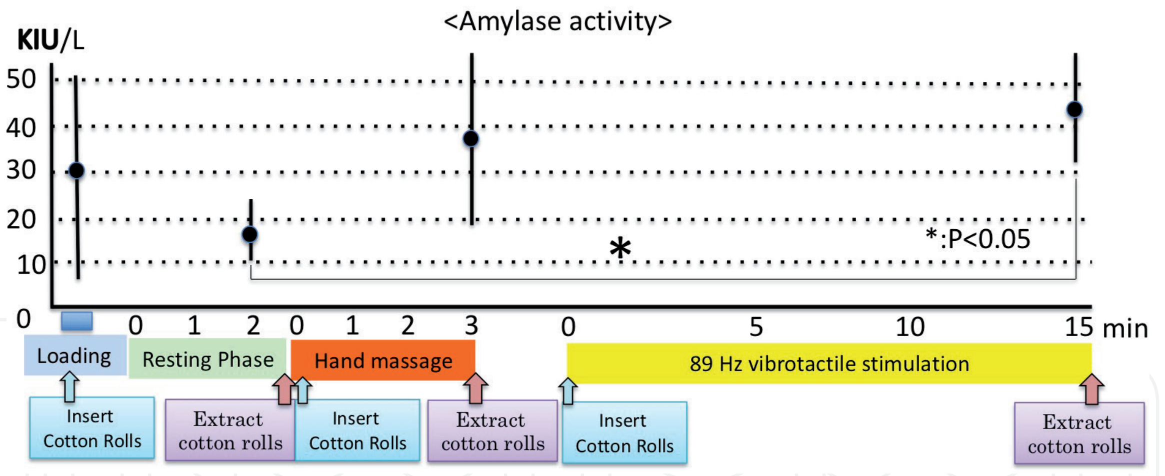

Figure 6.
Changes in amylase activities of loading, resting phase, and hand stranger massage for 3 min, and vibrotactile stimulation of 89 Hz frequency and 9.8 μm amplitude for 15 min.

4. Discussion

4.1 Facial skin temperature

Firstly, although we tried to perform 5 min massage, there were three bad deficits: in 5 min massage, operators complained about being very tired and they cannot handle patients with handicaps and stroke. Furthermore, we performed by the measurement of salivation with the cotton roll method. When we measured the amount salivation of a cotton roll, subjects of 5 min stimulation with heavy salivation often leaked from a cotton roll [8]. So, we focused to 3 min stranger hand massage, and we measured facial skin temperatures after 3 min resting phase and after 3 min stranger hand stimulation phase. In 3 min stranger hand stimulation, facial skin temperature increased about 2.0°C, as shown in **Figure 3**. In particular, in comparison with before and after facial skin temperatures between resting and hand massage, although the resting phase increased as little as possible, the hand massage showed a big increase in temperature. On the other hand, a 89 Hz vibrotactile stimulation was spent for about 15 min to increase temperature (about 1.0°C), as shown in **Figure 3**. The finding showed that the stranger hand massage was especially effective in facial skin temperatures. As shown in **Figure 3**, a 89 Hz vibrotactile stimulation was spent for 15 min for an increase of 1°C [5–8]. However, hand massages are adequate with 2–3 min for an increase of 1°C, as shown in **Figure 3**. Although a 89 Hz vibrotactile stimulation needs long time of 4–7 years as effective recovery, hand massage for 3 min may have more effect with a repetition of day after day, as shown in the previous paper [1]. A 89 Hz vibrotactile stimulation was spent for 15 min time for an increase of 1°C, and this apparatus got effective by using at morning and night. However, as hand massage was necessary for 1–2 min, we may get effect by doing at morning and night; namely, an effective increase in facial skin temperature may be elicited by a good metabolism for recovery [18].

4.2 Effect of autonomic activity

The effect of autonomic activity can directly be studied by changes in RR intervals of ECG and total salivation. The RR interval and salivation are controlled by an autonomic activation, and the increased RR intervals (decrease of heart rate) and a great deal of serous salivation are parasympathetic activity and the decreased ones (increase of heart rate) and a little mucus salivation are sympathetic activity [15, 16]. In the experimental room, the RR interval showed about 700 ms in the resting phase between 0 and 1, and after the resting phase of the latter half, it arrived in about 900 ms, as shown in **Figure 4A**. This insert of cotton rolls was activated by sympathetic nerve, and the RR intervals were decreased. Furthermore, in the resting phase of the latter half, it became naturalized, and the RR intervals increased, as shown in **Figure 4A**; namely, it showed the adaptation to the environment in latter resting phase. On the other hand, total salivation was decreased before and after hand massages, as shown in **Figure 4B**. This decrease may be activated by sympathetic nerve. Three minutes hand massages may be a small amount for the effective autonomic activity and an adequate massage times may produce an effective effort of the autonomic nerve. In the 3 min hand stimulation, they showed the increased rate in average values, and they showed significant differences (T-test, $p < 0.01$) in RR intervals. However, in total salivation, the hand massage may not show the effect of the autonomic nerves as 3 min stimulation. Although this finding may be an effective treatment, we thought inadequate recovery of a function for salivation. We reported the increased salivation depending on the 89 Hz vibrotactile stimulation on the facial skin [1, 5–7]. Namely, autonomic changes of stranger massage may be produced by an adequate stimulation time. However, the stranger hand massage did not show the total salivation, and always caused sleepiness after the experiments. We think increased temperature will show a good increased metabolism in stranger massage, but all of subjects are set to sue for sleepiness in the stranger massage. Namely, it is important to get not to sleep for prevention of a decline in metabolism.

4.3 Analysis of OxyHb of fNIRS on the frontal cortex

We have studied an analysis of OxyHb of fNIRS (a functional near-infrared spectroscopy) on the frontal cortex during vibrotactile stimuli, as shown in the previous papers [1, 5–8]. As a result, we reported that the zero level of the OxyHb of fNIRS showed the parasympathetic activity (**Figure 5**), and total salivation in the vibrotactile stimulation of the 89 Hz frequency and 9.8 μm amplitude were the most effective.

Facial skin temperature increased from 32 to 34°C spend 3 min in the hand massage, and did 15 min in 89 Hz vibrotactile stimulation. Although 3 min stranger massage did not show the effective effect of total salivation, RR intervals increased from 670 to 1000 ms. However, over 3 min massage evoked the fatigue feeling. So, we tried 15 min 89 Hz vibrotactile stimulation. To increase RR intervals, we spent 3 min in the hand massage, but 15 min was spent in the 89 Hz vibrotactile stimulation; namely, an increase of facial skin temperature and RR interval will be effective in the 3 min hand massage.

We measured facial skin temperature and fNIRS on the frontal cortex during 3 min hand stimulation and during 3 and 15 min 89 Hz vibratory stimulation. We reported that the vibrotactile stimuli on the facial skin showed the near zero level of values of OxyHb, DeoxyHb, and TotalHb in fNIRS [1, 5–8]. The OxyHb and DeoxyHb of brain circulation in the frontal cortex were reported to parallel the neuronal activity [2]. The finding is showed by the increased parasympathetic activity [1, 5–8]. On the other hand, the decreased OxyHb (under zero level) showed the decreased neuronal activity with the decreased consumption of oxygen and metabolism, and the drowsy and sleepy conditions were shown by the decreased OxyHb during hand massages [13]. According to OxyHb activities of fNIRS on the frontal cortex, effects between stranger massage and resting condition are almost the same under zero level. Hand stimulation for 3 min may not show the increase of total salivation, except for the increase of facial skin temperatures, RR intervals of ECG and saliva amylase. However, RR interval and salivation were effective effort on 15 min 89 Hz vibrotactile stimulation, as shown in **Figure 4B** and the previous paper [5]. As over 3 min massage produced the fatigue feeling, we thought that repetitious stimuli may change the autonomic system and during hand massage, we tried hard not to get sleepy by talking. However, in the subject, this active feeling was decreased immediately and the subject felt sleepy.

4.4 Changes in an activity of saliva amylase

A stress is activated by the activation of sympathetic nerve, and an activity of saliva amylase is increased by a self-preservation response of a body; namely, the activity of amylase shows the activity of sympathetic nerve [14]. However, we may relate to amount of amylase because of their mass production after 15 min vibrotactile stimulation, as shown in **Figure 6**. The results showed the increased activation of saliva amylase related to amount of amylase, too. So, the increased saliva amylase was exhibited by about increase 2.5 times in 3 min hand stimulation and 89 Hz vibrotactile stimulation showed three times, as shown in **Figure 6**. This finding shows that subjects may be excited by stranger's hand touching and then decrease of RR intervals **Figure 4B**). On the other hand, it may be related to increase of amylase activity and amount of saliva in the 89 Hz vibrotactile stimulation, too.

5. Conclusion

Generally, a massage is an immediate recovery of reducing stress with warm feeling by a light touch. An explanation in Japanese textbook of "salivation glands massage" was caused by extrusion of accumulated salivary from the acinus glands. However, this method of salivation massage was not encouraged by shakeout of poor glands, we thought. Traditional idea of massage shows immediate recovery of reduced stress with warm feeling. Namely, traditional massage on the facial skin shows immediate reaction, and deactivated salivary glands will be a recovery with an improvement of circulating blood by the increased temperature [17]. The increasing temperature by hand stimuli brings forward metabolism in the facial skin and saliva glands, and deactivated saliva glands as a recovery will be a good tendency. We focused on 3 min hand stranger massage, because 5 min massage was provoked by feeling of fatigue, and self-massage could not treat in handicap and stroke patients. However, we were performed by a hand stranger massage for 3 min, because of operator's fatigue over 3 min massage. In the effect of automatic nerve system, the hand stranger massage for 3 min increased RR intervals of ECG, did not increase salivation, and increased the amylase activity. However, the hand stranger massage was the best effectiveness of the increased facial skin temperature. On the other hand, hand massages will evoke sleepiness by the increased temperature, and metabolism will decrease getting sleepy with the non-increased salivation. Furthermore, OxyHb of fNIRS on the frontal cortex showed values below zero during hand stimulation. Values below zero in OxyHb of fNIRS show the sleepiness. This reason may suggest that hand massage is effective not only due to increased temperature and metabolism but also non-increased salivation and heart rates. In particular, during hand massage, we must try not to get sleepy by talking. However, the vibrotactile stimulus apparatus for 15 min showed changes in the RR interval of ECG and salivation. On the other hand, repetitious stimuli may change the autonomic system, but the most suitable time of repetitious intervals is necessary for further experiments. As shown in **Figure 4A-a**, **-b**, a 89 Hz vibrotactile stimulation is spent for 15 min for an increase

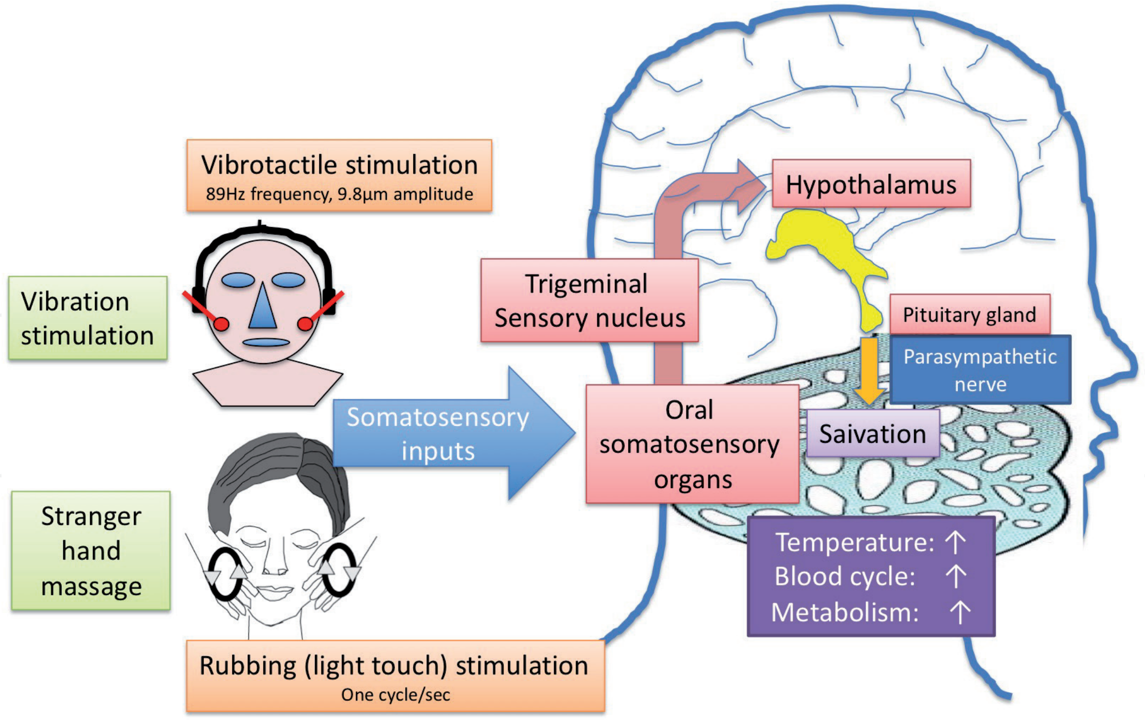

Figure 7.
Our idea about effects in salivation of facial somatosensory inputs. In summary, we showed our idea of salivation by facial somatosensory stimuli, hand stranger massage, and vibrotactile stimulation. Facial somatosensory sense was excited by oral somatosensory inputs with the 89 Hz vibrotactile stimulation or hand massage. Vibrotactile inputs arrived at the hypothalamus via the trigeminal somatosensory nucleus, and then parasympathetic nerves were activated and produced salivation. So, vibrotactile stimulation will be slowly recovered with the increase of facial skin temperature. Although vibrotactile stimulation spent many time for recovery of glands, hand massage might do a short time for recovery. In particular, the hand stranger massage rapidly increased the produced facial skin temperature and reducing stress. Furthermore, it will recover circulation and metabolism. This massage may be early recovered by a repetitious performing in comparison with a recovery period of the vibrotactile apparatus.

of 1°C [5–8]. However, hand massages are adequate with 2–3 min for an increase of 1°C, as shown in **Figure 2A** and **B**. Although the 89 Hz vibrotactile stimulation needs long time of 4–7 years for effective recovery, hand massage for 3 min may have more effect with a repetition of day after day. Namely, an effective increase of facial skin temperature may be elicited by a good metabolism for recovery.

In summary, we showed our idea of salivation by facial somatosensory stimuli, hand massage, and vibrotactile stimulation as shown in **Figure 7**. Facial somatosensory sense was excited by oral somatosensory inputs with the 89 Hz vibrotactile stimulation or hand massage. Vibrotactile inputs arrived at the hypothalamus via the trigeminal somatosensory nucleus, and then parasympathetic nerves were activated and produced salivation. So, vibrotactile stimulation will be slowly recovered with the increase of facial skin temperature. Although vibrotactile stimulation spends many time for recovery of glands, hand massage might do a short time for recovery. In particular, the hand massage rapidly increased the produced facial skin temperature and reduced the stress. Furthermore, it will recover circulation and metabolism. This massage may be early recovered by a repetitious performing in comparison with a recovery period of the vibrotactile apparatus.

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Conflict of interest

None of the authors report any conflict of interest.

Ethical approval

The Nihon University School of Dentistry provides ethical approval to conduct this pilot clinical study (approval number: 2009-5). All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This chapter does not contain any studies with animals performed by any of the authors.

Informed consent

Informed consent was obtained from all individual participants included in the study.

A. Appendices and nomenclatures

Obey dysphasia rehabilitation society.

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