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A preliminary examination of effect of massage and aroma oil massage in foot care nursing

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Abstract

Foot care nursing is attracting attention as a medically effective treatment for the foot lesions caused by such problems as diabetes or aging. In this study, we experimentally examined how aromatherapy affects human brain functions during foot care nursing using near-infrared spectroscopy (NIRS). 11 subjects received both foot care nursing massages and aroma oil massages. We analyzed the changes in their oxygenated hemoglobin (oxy-Hb) concentrations based on their brain activity by t-tests, and the t-test results showed significant differences between two kinds of massages in both the somatosensory and prefrontal association areas. The oxy-Hb concentration in both massages with and without aroma oil also showed a tendency to decrease with time. Our questionnaire results showed that our subjects felt more comfortable and relaxed while receiving foot care nursing with aroma oils. These results suggest that aroma oil massages are an effective foot care nursing tool and that foot care nursing is a medically effective treatment.

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Keywords: foot care nursing, aroma oil massage, near-infrared spectroscopy, oxygenated hemoglobin concentrations

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1. Introduction

As a countermeasure against foot lesions caused by aging and diabetes, interest in foot care nursing is growing as an effective medical treatment, especially by combining aromatherapy with foot care nursing^{1,2}. Aroma oils relax the mind and the body and increase the intrinsic self-healing power of humans³. In this study, we measured the influence of the blood flow in the human brain during foot care nursing with aroma oils using a near-infrared spectroscopy (NIRS) device to confirm the relaxation caused by aroma oils. This NIRS device measured the relative changes in the oxygenated hemoglobin (oxy-Hb), in the deoxygenated hemoglobin (deoxy-Hb), and the total hemoglobin (total Hb) in the blood flow in the human brain and specified which part is being activated⁴.

Previous studies reported the stimulation effects caused by smell using NIRS on the human brain whose orbitofrontal cortex corresponds to activation^{5,6}. Differences have also been reported in the quality of the smell and the activated state of the human brain⁷. However, since little research has examined the effect of foot care nursing using aroma oils, we measured the effect of aroma oils by NIRS and the changes of the blood flow within the brain during aroma oil massages and analyzed the results.

2. Experiment

In our experiments, three female nurses who specialize in foot care nursing performed two sets of foot care nursing: massages with and without aroma oil. Our subjects were six females and five males over the age of 65. We obtained aroma oils from essential oils by blending *Lavandula angustifolia*, Tea tree, Ravensara, Palmarosa, and Chamomile. We measured the prefrontal association area (from the 1st to 22nd channels) and the somatosensory association area (from the 23rd to 44th channels). We used the NIRS system developed by Hitachi (ETG-4000, 44 channels) to observe and record the hemoglobin concentrations in every subject's brain.

The probe holder included 44 optical source-detector channels to monitor the relative changes in the hemoglobin concentration in the brains of the subjects. The channels covered both the brain's prefrontal and somatosensory association areas. To assess the activation of the human brain functions in these areas, we observed the blood hemoglobin concentration of each subject from the massage's beginning to its end. The relative changes in the oxy-Hb, deoxy-Hb, and total-Hb concentrations from the 44 channel points were simultaneously measured and recorded for each subject. After finishing the measurements, the subjects completed questionnaires on a five-point scale (where 1 = very good and 5 = no good) to determine relaxation levels and feelings about the massage's comfort.

2.1. Experimental design

Our experiment used the block design shown in Fig. 1. In a previous study by Eto and Yamazaki et al.⁸, the massage time was 60 seconds to focus on its effect; in our study, the time was 180 seconds. Nothing is done in Rest 1 (rest) (20 seconds), and Task 1 is just touching the subject's foot (60 seconds). Task 2 is a massage of the subject's foot (180 seconds). Case A is a left foot massage without aroma oil. Case B is a right foot massage without aroma oil. Case C is a left foot massage with aroma oil. Case D is a right foot massage with aroma oil.

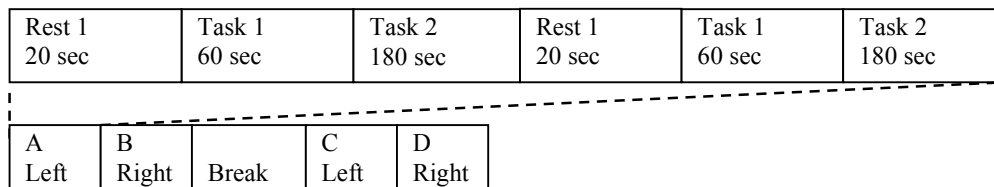


Fig. 1 Block design of experiment

3. Result

3.1. Two-dimensional images of brains

The numerical data obtained in our experiment were visualized to two dimensions. Fig. 2 shows a left foot, and Fig. 3 shows a right foot.

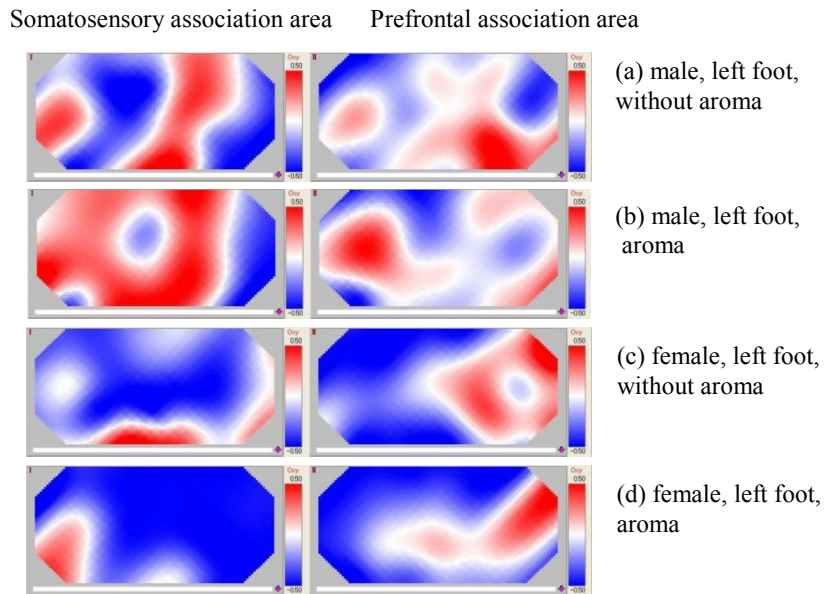


Fig. 2 Two-dimensional image of left foot

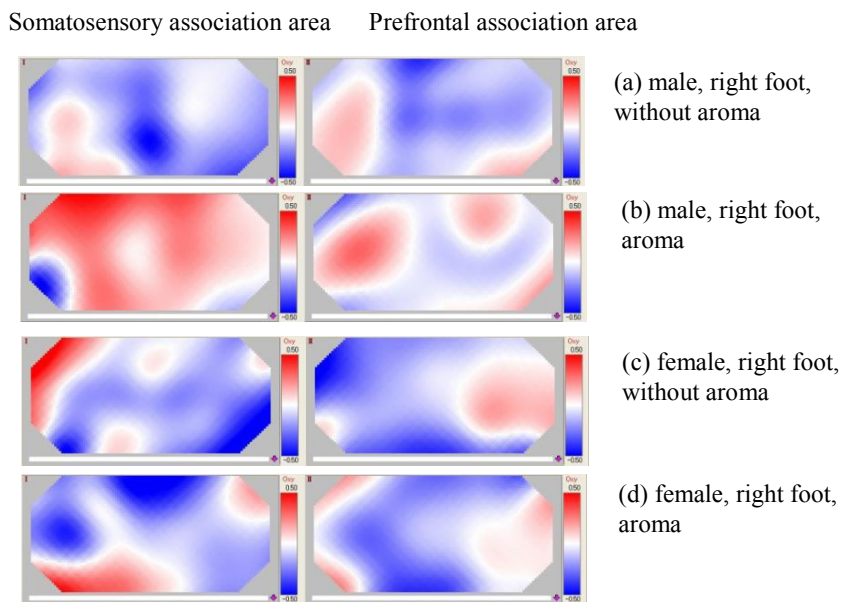


Fig. 3 Two-dimensional image of right foot

The oxy-Hb concentration is increasing in the red area. Deox-Hb is increasing in the blue area. As shown in Fig. 2, in case (a), the increases and decreases of oxy-Hb in the somatosensory association area are large. In case (b), the oxy-Hb increases are large in the somatosensory association area. In case (c), the oxy-Hb increases are not large in the somatosensory and prefrontal association areas. In case (d), the deox-Hb increases in the somatosensory association area are large.

In Fig. 3, in case (a), deox-Hb increased in both the somatosensory and prefrontal association areas. In case (b), oxy-Hb increased in the somatosensory association area. In case (c), deoxy-Hb increased in both the somatosensory and prefrontal association areas. In case (d), deoxy-Hb increased in the prefrontal association area. As a whole, oxy-Hb concentration increased in males, and deoxy-Hb concentration tended to increase in females. Both the changes in the oxy-Hb and deoxy-Hb concentrations were also larger in the left foot than in the right foot.

3.2. Differences between massages with and without aroma oil

(1) T-test of differences between massages with and without aroma oil

We conducted a t-test ($p < 0.05$) to examine the significance of the differences between massages with and without aroma oil and examined the left and right feet of all subjects. The examination results are shown in Tables 1 and 2.

Table 1 Examination results of t-tests in somatosensory association area

| | Somatosensory association area | | | | | |
|------|--------------------------------|-------|-----------|------------|-------------|--------------|
| | Left | Right | Male left | Male right | Female left | Female right |
| CH1 | - | - | - | - | + | - |
| CH2 | - | + | - | + | + | - |
| CH3 | + | + | + | + | + | - |
| CH4 | + | - | + | - | + | - |
| CH5 | - | + | - | - | - | + |
| CH6 | - | - | - | - | - | - |
| CH7 | - | - | - | - | - | - |
| CH8 | - | - | + | - | - | + |
| CH9 | | + | | + | - | |
| CH10 | - | + | - | + | - | + |
| CH11 | - | + | - | + | + | - |
| CH12 | - | + | - | - | + | + |
| CH13 | - | + | - | + | + | + |
| CH14 | - | - | - | - | - | - |
| CH15 | - | + | - | + | - | + |
| CH16 | - | - | - | - | - | - |
| CH17 | - | + | - | + | + | + |
| CH18 | - | - | - | - | + | + |
| CH19 | - | - | - | - | - | - |
| CH20 | - | + | - | + | - | + |
| CH21 | - | + | - | + | - | - |
| CH22 | + | + | | + | + | + |

+ significant difference, Sample mean is + value

- significant difference, Sample mean is - value

blank No significant difference

In the table, + shows a significant difference, and the aroma oil massage indicates higher concentrations of oxy-Hb than massages without aroma oil. The - sign shows a significant difference, and the aroma oil massage indicates low concentrations of oxy-Hb.

In Table 1, in the somatosensory association area, we observed significant differences between massages with and without aroma oil in the left and right feet of all subjects. The change in the oxy-Hb concentration in the left foot showed a decreasing trend and an increasing trend in the right foot. In males, the change in the oxy-Hb concentration showed almost the same tendency as in the case of all participants. In females, the change in the oxy-Hb concentration showed the same tendency with either foot except CH 1 to CH 4.

Table 2 Result of examination of t-test in prefrontal associate area

| | Prefrontal association area | | | | | |
|------|-----------------------------|-------|-----------|------------|-------------|--------------|
| | Left | Right | Male left | Male right | Female left | Female right |
| CH1 | - | - | - | - | - | + |
| CH2 | + | + | + | + | - | + |
| CH3 | - | - | + | - | - | + |
| CH4 | - | - | - | - | - | - |
| CH5 | - | - | - | - | - | - |
| CH6 | - | - | - | - | - | - |
| CH7 | + | - | + | - | - | + |
| CH8 | + | - | + | - | + | + |
| CH9 | - | - | - | - | - | - |
| CH10 | - | - | - | - | - | + |
| CH11 | - | + | + | - | - | + |
| CH12 | - | + | - | - | - | + |
| CH13 | - | - | - | - | + | - |
| CH14 | - | + | - | - | - | + |
| CH15 | - | - | - | - | - | + |
| CH16 | - | - | - | - | - | - |
| CH17 | - | - | - | - | + | + |
| CH18 | - | - | - | - | - | - |
| CH19 | - | - | - | - | - | - |
| CH20 | - | - | - | - | - | - |
| CH21 | - | - | - | - | - | - |
| CH22 | - | - | + | - | - | + |

+ significant difference, Sample mean is + value
 - significant difference, Sample mean is - value
 blank No significant difference

In Table 2, in the prefrontal association area, we observed significant differences between massages with and without aroma oil in the left and right feet of all subjects. The changes in the oxy-Hb concentration showed a trend to decrease in the left and right feet, except CH 2, CH 7, and CH 8 in the left foot and CH 2, CH 11, CH 12, and CH 14 in the right foot. In the men, the change in the ox-Hb concentration showed a larger decreasing trend in the right foot than in the left foot. In the women, the change in the oxy-Hb concentration showed a tendency where the right foot increased more than the left foot.

(2) Graph of moving averages

We calculated five-second moving averages to smooth the data. The graph in Fig. 4 shows the moving averages of the measurement results of the left and right feet by gender in the somatosensory association area. The graph in Fig. 5 shows the moving average of the measurement results of the left and right feet by gender in the prefrontal association area.

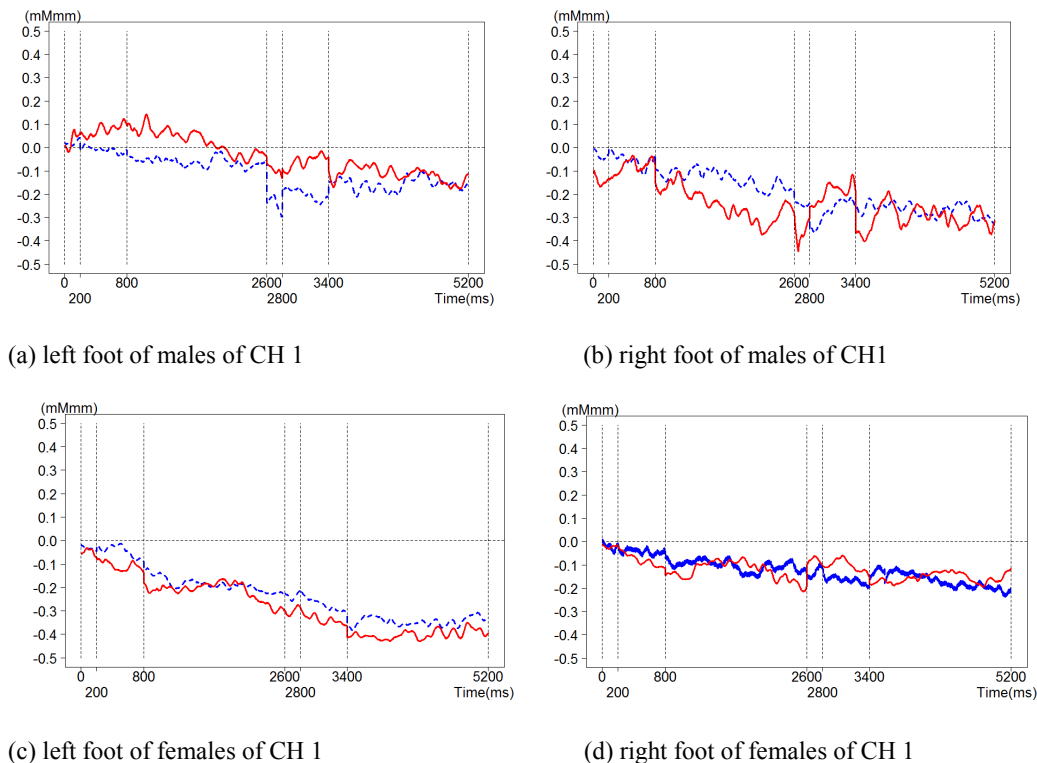
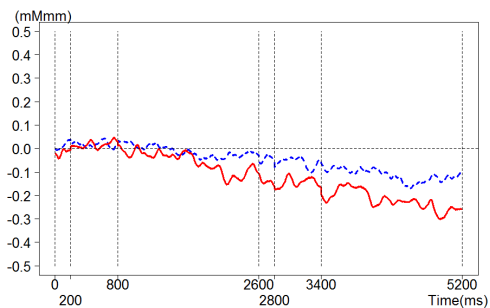


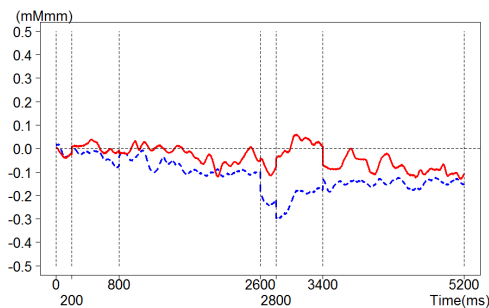
Fig. 4 Somatosensory association area

In the aroma oil massages, the oxy-Hb concentration gradually increased in the first half, and a downward tendency appeared in the second half (Fig. 4(a)). The oxy-Hb concentration in the aroma oil massages exceeded the oxy-Hb concentration in the massages without aroma oil. In the aroma oil massages, the oxy-Hb concentration greatly decreased in the first half, and the degree of reduction was comparatively small in the second half (Fig. 4(b)). The change of the oxy-Hb concentration in the aroma oil massages was higher than in the massages without aroma oil.

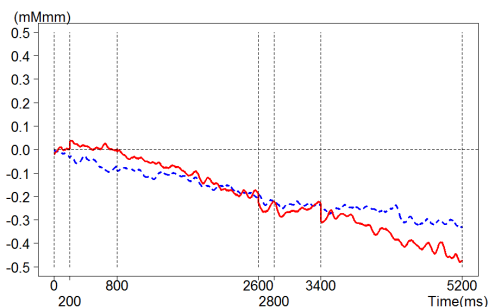
The oxy-Hb concentration showed the same change in the massages with and without aroma oil, but the oxy-Hb concentration in the aroma oil massages was lower in the massages without aroma oil (Fig. 4(c)). In the aroma oil massages, the oxy-Hb concentration showed a gradual downward trend and the same change in the massages with and without aroma oil (Fig. 4(d)). Both had only slight changes of oxy-Hb concentration.



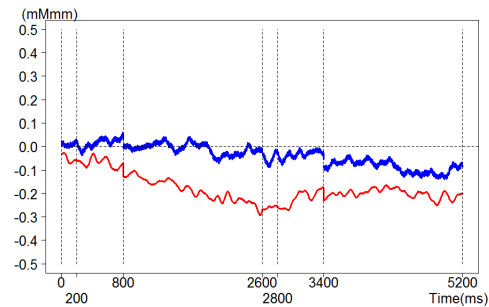
(a) left foot of males of CH 21



(b) right foot of males of CH 21



(c) left foot of females of CH21



(d) right foot of females of CH 21

Fig. 5 Prefrontal association area

In Fig. 5(a), in the aroma oil massages, the oxy-Hb concentration had a slightly larger reduction than in the massages without aroma oil. In Fig. 5(b), in the aroma oil massages, the oxy-Hb concentration showed a slightly smaller reduction than in the massages without aroma oil. In Fig. 5(c), in the aroma oil massages, the oxy-Hb concentration showed the same downward tendency as the massages without aroma oil, but a slightly larger reduction in the second half of the massage. In Fig. 5(d), in the aroma oil massages, the oxy-Hb concentration showed a larger reduction than in the massages without aroma oil in the first half and an upward tendency in the second half.

As seen from the above description, the oxy-Hb concentration in the somatosensory association area in both massages with and without aroma oil showed a tendency to decrease in the second half. Males showed a tendency for larger changes of ox-Hb concentration than females. In the prefrontal association area, the oxy-Hb concentration only showed a slightly different trend in the massages with and without aroma oil. On the other hand, in the somatosensory association area, females showed a larger tendency for changes of oxy-HB concentration than males.

4. Questionnaire results

We summarized the questionnaire results of our investigation as follows.

(1) Smell of aroma oil:

Nine of our eleven subjects answered that aroma oil smelled either very good or good. They had good feelings about aroma oil.

(2) Massages in foot care nursing:

Ten subjects described the massages as either very comfortable or comfortable. These results suggest that the aroma oil and the massages helped our subjects relax during foot care nursing.

5. Discussion and conclusion

In this study, we examined the effect of both massages with and without aroma oil in foot care nursing using NIRS and obtained the following results.

(1) Two-dimensional images of brains:

Oxy-Hb concentration increased in males, and deoxy-Hb concentration tended to increase in females. In the left foot, changes in the oxy-Hb and deoxy-Hb concentrations were larger than in the right foot.

(2) T-test of differences between massages without and aroma oil:

In the somatosensory association area, we observed significant differences between massages with and without aroma oil in the left and right feet of all the subjects. The changes in the oxy-Hb concentration in the left feet showed a decreasing trend and an increasing trend in the right feet. In the prefrontal association area, we observed significant differences between the massages with and without aroma oil in the left and right feet of all subjects. The change in the oxy-Hb concentration showed a decreasing trend in the left and right feet.

(3) Graph of moving averages:

In the prefrontal association area, the oxy-Hb concentration only showed a slightly different trend in the massages with and without aroma oil. On the other hand, in the somatosensory association area, the females showed a tendency for a larger change of the oxy-Hb concentration than the males. The oxy-Hb concentration in both the massages with and without aroma oil showed a tendency to decrease with time.

These results suggest that aroma oil massages had a larger relaxation effect than massages without aroma oil. Foot care nursing influences relaxation. We visualized the effect of foot care nursing with massages with and without aroma oil by determining the concentration of the oxy-Hb changes in the blood in human brains by NIRS. In future work, we plan to increase the number of subjects and develop a method to scrutinize the experiment data.

Acknowledgements

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