Effects of Far-infrared Radiation on Lactation

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Massage and warm compresses to the breast have been commonly used for stimulating and/or increasing blood flow to the breasts, and for enhancing lactation consequently. However, more effective and easier remedies seem to be necessary.

The vasodilating and warming effects of ceramics far-infrared radiation were studied. Based on the results obtained, the effect of a ceramic disc on lactation, attached to the breast skin, was evaluated in 27 puerperal women who had had poor lactation previously and in 36 with currently poor lactation monthly until weaning. Approximately 3/4 of these puerperal women enhanced lactation significantly one month after attachment and 1/2 of the women were able to breast-feed until weaning.

Thus, we found that ceramics far-infrared radiation may be an effective remedy for enhancing lactation.

**Key words**: Far-infrared radiation, Lactation, Breast feeding

Practically all mammalian newborns reach for a breast to suck soon after birth. Stimulation of the nipple by sucking induces the secretion of oxytocin from the pituitary gland to enhance uterine contraction and recovery (Kobayashi, N., 1989). The secretion of prolactin is also stimulated, resulting in enhancement of the production of breast milk (Tyson, J., 1972).

The colostrum contains large quantities of substances involved in immunity, including secretory IgG, anti-inflammatory agents and protectors against infection and large numbers of cellular components such as macrophages and lymphocytes (Ogra and Ogra, 1978). Newborns drinking colostrum are naturally protected against infection. Breast milk not only is a significant nutritional source for neonatal development, but also has a very important function in developing the power to resist infection (Goldman and Smith, 1973).

Newborns of mammalian species that have no way of communicating starve to death without exception if no breast milk is available. However, very few newborn of mammalian species other than human being die because of poor secretion of breast milk.

In contrast, mankind has a long history of feeding infants on breast milk, its substitutes or animal milk (Kobayashi, 1989), and today so many milk substitutes are available that bottle feeding is the first choice in nursing. This indicates that the human lactating capacity has decreased in comparison with other mammalian species.

Lactation depends on the development of mammary glands, blood circulation and hormonal control (Taketani and Oka, 1983); blood circulation is the most essential factor. However, several percent of the new mothers show poor lactation despite complete instruction and inducements, including breast massage.

Although massage is effective for maintaining a favorable blood circulation in the breast, single massage is not enough to dilate the blood vessels at
the base of the breast for long hours (Netsu, 1989). Continuous massage is necessary to maintain a better blood circulation throughout 24 hours. A mother can massage her breasts frequently while she is awake, but not during sleep. Consequently, no favorable lactation can be expected by breast massage alone.

The vasodilating and warming effects of ceramic far-infrared radiation have recently been reported in various studies (Honda and Inoue, 1988; Ise et al., 1987). However, there are few objective data on the physiological effect of this radiation on human bodies, and few studies have been done on the specificity and physiological action of the warming effect.

We first evaluated the warming effect of ceramics and then the influence of circulation on lactation.

MATERIALS AND METHODS

Of the women who gave birth at the Osaka City Perinatal Center and Osaka City Juso Citizens Hospital, 35 who had used bottle feeding for their previous babies because of poor lactation and 43 who gave up breast feeding for bottle feeding when their present babies were 4 puerperal weeks old were enrolled in the study.

Ceramic discs (a synthetic petalite disc of 0.2 cm thick and 3.8 cm in diameter; Hitachi Material Engineering Co. Ltd. and a glazing disc; Nishikawa Products Co. Ltd.) were inserted between the breast and the brassiere to adhere closely to the skin of the lower outer quadrant (LOQ). The temperature of the breast skin was recorded on a thermograph (Nihon Kohden Co. Ltd.) at the room temperature of 20°C before and 10, 20 and 30 min. after insertion of the ceramic disc to determine the regional, highest and mean temperatures by the built-in computer.

The radiospecificity of the ceramic material was measured with an emissivity measuring device (IR 435; Shimazu) in the wavelength range of 4000 cm⁻¹ (2.5 μm) ~ 500 cm⁻¹ (20 μm). The surface temperature of the ceramics at the time of measurement was 400°C.

In addition, two pocket heaters, one containing ceramics, were attached together to the lumbo-dorsal region for 5 min to compare changes in the skin temperature.

Twenty seven out of the 35 puerperal women who had had poor lactation previously were asked to attach a ceramic disc to a breast immediately after delivery, and 36 out of 43 puerperal women who had poor lactation this time to attach it one month after delivery until weaning. A total of 14 women, 7 from the former group and 7 from the latter group, was followed without using ceramic discs as a control group. Subsequently, the rate of breast feeding was calculated at intervals of one month. Complete breast feeding was rated (+ +); breast feeding plus two or more bottle feedings per day, (+); three or more bottle feedings per day, (±); and bottle feeding with little breast feeding, (−).

RESULTS

1. Far-infrared Specificity of the Ceramic Disc

At 400°C the calcinated product obtained by glazing ceramic material emitted far-infrared rays practically uniformly (72-84%) at wavelengths between 2.5 μm and 20 μm (Fig.1). In contrast, the synthetic ceramics showed lower emissivity rates up to the wavelength of 6 μm and higher rates in the higher zone. This led us to use glazing ceramics for the following breast feeding study and synthetic ceramics for the pocket heater study.

2. Temperature Elevation of the Lumbo-dorsal Skin by Far-infrared Radiation

A commercially available disposable pocket heater was put in a pouch (1), and another in a similar pouch (2) with a ceramic disc attached to the inner surface to come in contact with the skin. These two pouches were attached symmetrically to both sides of lumbar spine between L3 and L4 for 5 min. The regional skin temperature was measured with the thermograph at intervals of 5 min for 10 times for the examination of regional temperature
Fig. 1  Emissivity Rates of a Glazing Ceramic Disc (dotted line) and a Synthetic Ceramic Disc (solid line) at 400°C.

As shown in Fig.2A and B, the skin temperature on the plain pocket heater pouch side (1) rose rapidly immediately after 5 min to reach a peak of 37.9°C and fell rapidly after removal to 32.9°C 45 min later. In contrast, while the temperature on the ceramic disc pouch side (2) remained definitely low, 35.6°C, immediately after removal, it was 34.6°C 45 min after removal, significantly higher (P < 0.05) than the contra-lateral temperature (Fig.2C).

Comparison of mean temperatures revealed no significant difference between the plain (1) and ceramic (2) sides immediately after removal, but a rapid temperature fall on side (1) starting 10 min after removal to 32.8°C 35 min later. However, the temperature on side (2) remained significantly (P < 0.01) higher (33.6°C) 45 min after removal. Similar results were obtained when pouch (1) and (2) were exchanged.

3. Temperature Elevation of the Mammary Skin by the Ceramic Disc (Table 1)

Within 8 days after delivery (an average of 3.3 ± 1.9 days), mammary temperatures were measured 4 times at intervals of 10 min in the 24 women who had ceramic discs attached closely to the LOQ of both breasts. (Fig.3A) The temperature of the mammary skin rose with time to a mean increase of 0.59 ± 0.26°C 30 min after attachment.

On the other hand, when a ceramic disc was applied unilaterally to a breast, the contra-lateral breast also showed a mean temperature increase of 0.58°C which was not a significant difference from that of bilateral attachment. Fig.3B shows an instance for whom a ceramic disc was applied at the left outer quadrant of the breast.

4. Evaluation of the Effect on Lactation (Table 2)

Since the temperature of the contra-lateral breast rose when a ceramic disc was attached unilaterally,
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A. Histogram of Peak Temperature Distribution just after Removal of the Pouches.

The Ceramic Pouch Side  Thermography (range: 30~40°C)  The Plain Pouch Side

B. Histogram of Peak Temperature Distribution after Removal 30 min.

The Ceramic Pouch Side  Thermography (range: 30~40°C)  The Plain Pouch Side

C. Regional Skin Temperature Changes after Removal of the Pouches for 45 min.
the red line: plain pocket heater
the blue line: ceramic pocket heater
Numbers at the basal line represents times of temperature measurement at 5 min. interval.

Fig. 2  The Regional Skin Temperature Changes after Attaching Pocket Heater with Ceramic and without Ceramic Discs at the Lowback (L₁~L₄) for 5min.
A. Effect of ceramic discs on the mammary skin temperature 30 min. after attachment.

Before attachment

30 min. after

B. Temperature elevation of the contralateral breast by unilateral attachment (left) of a ceramic disc.

Before attachment

30 min. after

Fig. 3 Temperature Elevation of the Mammary Skin by the Ceramic Discs
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Table 1. Temperature Elevation of the Mammary Skin by Attaching Ceramic Discs for 30 min

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (y)</th>
<th>Post Partum (d)</th>
<th>Before (°C)</th>
<th>Temperature 30 min After (°C)</th>
<th>Difference (°C)</th>
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<tbody>
<tr>
<td>1</td>
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</tr>
<tr>
<td>2</td>
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<tr>
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<td>19</td>
<td>2</td>
<td>35.1</td>
<td>35.4</td>
<td>+0.3</td>
</tr>
<tr>
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<td>36.0</td>
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</tr>
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<td>5</td>
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<td>17</td>
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<tr>
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<td>23</td>
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<td>24</td>
<td>3</td>
<td>34.3</td>
<td>35.2</td>
<td>+0.9</td>
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</tbody>
</table>

Mean±SD 28.9±6.0 3.3±1.9 34.1±0.8 35.2±0.7 +0.59±0.26

The effect of the ceramic disc on lactation was evaluated in the 27 women who had had poor lactation previously (first group) and in the 36 with current poor lactation (second group) at 4, 8, 12 and 20 puerperal weeks.

In the first group of 27 subjects, at week 4, breast feeding alone was used by 9 (33.3%), and 12 (44.4%) were able to raise their babies primarily with breast milk. At week 8, there were 13 women (48.2%) who were able to do complete breast feeding, and 14 (51.8%) continued to do so until weaning.

In the second group, 30 of 36 (83.3%) were able to breast-feed at 4 weeks after ceramic attachment, and 77.7% and 72.2%, respectively, were still breast feeding at 8 and 12 weeks after attachment. Furthermore, 19 (52.8%) of the 36 were able to continue breast feeding until weaning.

Both the first and the second group enhanced lactation significantly (P<0.001~0.01) when compared to the control group where 3 (21.4%) and 2 (14.3%) women were able to breast-feed at 16 and 20 puerperal weeks.

However, the number of mothers switching to bottle feeding increased in all these three groups after the 16th puerperal week.

**DISCUSSION**

The recent recognition of the importance of
breast milk has triggered various types of movements for promoting nursing with breast milk by different organizations (Kries et al., 1977; American Academy of Pediatrics Committee on Nutrition, 1977). This is due to revelation of the harmful influence of bottle feeding, in addition to the discovery of many indispensable substances in breast milk for newborns (WHO, 1981). Importance is attached to the establishment of breast feeding not only from the aspect of its nutritional significance for newborns, but also from that of establishment of the mother–child bond (De Chateau and Wiberg, 1977). In fact, infants can go to sleep when they touch their mother’s warm and tender breasts and by the feeling and a little of breast milk when they suck. It is naturally best to bring up human infants with human breast milk. However, very many human mothers, approximately 40% of mothers, have poor lactation, and various milk substitutes have been developed.

It has been pointed out from a social point of view that poor lactation occurs in many urban mothers rather than in those with a lower income whose nutritional condition tends to be poor (Gussler and Breisemeister, 1978). City life itself places a distance between the mother and child, disturbing the intrinsic biological behavior of breast feeding that requires a close contact (Jelliffe and Jelliffe, 1970).

Poor lactation is certainly attributable to the vicious cycle in which it is intensified for fear of such a state.

The currently available methods for enhancing lactation are enforcement of breast feeding, breast massage (Netsu, 1989), nutritional supplements and drug therapy, in which antilulcer drugs, such as sulpiride and metochlopramide, enhance prolactin secretion in antagonism to dopamine at the receptor level (Kugu et al., 1989).

However, the most basic and rational reason why only the human species among the mammals tends to suffer from poor lactation is their ecological specificity, i.e. the upright posture.

The fact that even now, many women develop accessory breasts along the line connecting the subaxillary region and the suprapubic margin indicates that the ancestors of humans, walking on four feet, had multiple breasts.

In quadrupeds, the nipples and breasts face the earth vertically, so that the blood vessels and mammary glands in the breast are protected from compression, as in Holsteins. While the positional relationships of the organs of contemporary humans are exactly the same as those in the quadrupedal era, the upright posture has caused changes in the positional relationship to gravity at 90° centered around the spine (Ogita, 1989). As a result, there is only one uterus and only one pair of breasts, which have changed positionally 90° against gravity. In

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Table 2. The Enhancement of Lactation by Attachment of a Ceramic Disc

<table>
<thead>
<tr>
<th>Puerperal women</th>
<th>Lactation</th>
<th>0</th>
<th>4</th>
<th>8</th>
<th>12</th>
<th>16</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Previous/Present poor lactation control</td>
<td>-/+</td>
<td>14(100%)</td>
<td>9(64.3%)</td>
<td>7(57.1%)</td>
<td>8(57.1%)</td>
<td>11(78.6%)</td>
<td>12(85.7%)</td>
</tr>
<tr>
<td>+</td>
<td>-</td>
<td>4(28.6%)</td>
<td>6(42.8%)</td>
<td>5(35.7%)</td>
<td>3(21.4%)</td>
<td>2(14.3%)</td>
<td></td>
</tr>
<tr>
<td>+ + ≤</td>
<td>-</td>
<td>1(7.1%)</td>
<td>1(7.1%)</td>
<td>1(7.1%)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Previous: poor lactation ceramics within 1 puerperal week | -/+ | 27(100%) | 6(22.2%) | * 4(14.8%) | * 8(29.6%) | * 13(48.2%) | * 13(48.2%) |
| + | - | 12(44.4%) | 10(37.0%) | 11(40.7%) | 10(37.0%) | 11(40.7%) | * |
| + + ≤ | - | 9(33.3%) | * 13(48.2%) | * 8(29.6%) | * 4(14.8%) | * 3(11.1%) | * |

| Current: poor lactation ceramics from 4 puerperal week | -/+ | - | 36(100%) | 6(16.7%) | * 8(22.2%) | * 10(27.8%) | * 17(47.2%) |
| + | - | - | 19(52.8%) | 12(33.3%) | 13(36.1%) | 13(36.1%) | * |
| + + ≤ | - | - | 11(30.5%) | * 16(44.4%) | * 13(36.1%) | * 6(16.7%) | * |

Underline represents the week used a ceramic disc

*: P < 0.01, **: P < 0.001
other words, the base of the breast has shifted 90°, forcing the nipple and the parenchyma of the mammary gland to flex downward. The blood vessels have also flexed, resulting in a decreased blood flow in the mammary gland.

It is widely recognized that breast massage and a warm compress are the most basic procedures for enhancing lactation. These procedures stimulate blood flow to the breasts. Netsu et al. (1989) reported that adequate mammary management induced a satisfactory volume of lactation in 95% of puerperal women.

While physical stimulation by massage or warm compresses is effective, the resultant increase in blood flow does not persist. Theoretically, it is possible to elicit a better effect by making the physical stimulation to last longer.

Although there are now many types of far-infrared electric heaters and far-infrared ceramic goods on the market, the number of available physiological reports on the warming effect of far infrared radiation is small.

Ise et al. (1987) and Katsuura et al. (1989) studied the dermal vasodilating effect of far-infrared radiation. In the present study, the temperature of the lumbar skin raised by a pocket heater containing ceramics persisted, instead of a temporary rise. The difference in the rates of temperature fall seems to indicate that the pouch was highly likely to have dilated deeper blood vessels, in addition to the superficial ones.

Attachment of the ceramic-containing pouch caused a temperature rise in the breasts by a mean of 0.59°C from the level before attachment. Since this temperature change was in the range of normal (body) temperature, the difference was not as marked as that caused by warming with a pocket heater. Nevertheless, since the increase of 0.59°C, an imperceptible temperature rise, persists for 24 hours, the cumulative temperature added to the breasts amounts to 0.59°×24=14.2°×time, which is higher than that of max. temperature elevation of 1.8°×max. duration of 2 hours=3.6°×time and 2.0°×2 hours=4.0°×time attained by massage or a warm compress respectively.

The enhancement of lactation observed one month later in about 3/4 of the women who had poor lactation previously or currently indicates that the persistent increase in the breast temperature dilated the blood vessels supplying the breasts, activating lactogenesis in mammary gland tissue. Clinical experience of needs for cold compresses and/or binding breasts tightly to cease lactation inversely supports the above mentioned.

The increase in the rate of bottle feeding after the 16th puerperal week was attributable to the mothers' social rehabilitation after a maternal leave.

In the present study, ceramic far-infrared radiation was found to be an effective remedy for enhancing lactation without any trouble. Therefore, combined use of both breast massage and this remedy has clear advantage over single method. Further study may be necessary in order to confirm the effect of far-infrared radiation on lactation from aspect of morphological maintenance of the breasts in an effort to establish breast feeding.

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