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Changes of skin characteristics during and after local Parafango therapy as used in physiotherapy

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Background/aims: In physiotherapy, fango (mud) application is a frequently used heat therapy. The main therapeutic effects are due to the elevated temperature of the different tissues with a significant redistribution of blood towards the heated area. This may influence several cardiovascular parameters. There is only limited information on the effect of fango application on skin characteristics. It was the aim of the present study to evaluate the effects of fango application on skin temperature, perfusion of the microcirculation and skin colour. At the same time, cardiovascular parameters such as heart rate, systolic blood pressure (SBP) and diastolic blood pressure (DBP) were recorded.
Method: Eighteen healthy subjects (age 23.7 ± 3.8 years) entered the study. The skin characteristics and cardiovascular parameters were measured before, during and after a 21-min fango application at 44.5 °C.
Results: Skin temperature and perfusion of the microcirculation increased significantly during fango application: from 35.5 ± 0.4 °C to 44.3 ± 1.2 °C for skin temperature and from 23.2 ± 8.8 to 197 ± 41 p.u. for the skin microcirculation.These two parameters remained elevated during the fango application and decreased slowly to baseline values within 21 min after fango removal.Skin colour (CIELAB, a^* parameter) increased from 11.0 ± 2.5 to 17.9 ± 1.9 when comparing pre- with post-treatment values. At the end of the measuring period, the a^* parameter did not return to baseline values (15.8 ± 2.1). Heart rate increased with 8 bpm during the fango therapy and returned to baseline within 3 min after removal of the fango. SBP and DBP varied slightly during the fango application. They returned to baseline values within 21 min after fango removal.
Conclusion: The skin parameters indicate a transient temperature effect with an increased perfusion of the microcirculation and a flooding of the superficial capacitance system. The cardiovascular parameters were only slightly influenced and remained in the physiological range. Fango application seems not to be too demanding for the cardiovascular system in healthy subjects.

Key words: fango treatment – physiotherapy – local heat – skin temperature – skin colour – perfusion of the microcirculation

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Several therapeutic effects are attributed to local fango treatment as used in physical therapy. Most of the effects are assumptions based on longstanding empirical experience, mainly ascribed to local temperature elevation, with fango ion exchanges through the skin only playing a secondary role (1, 2). However, there are only a few publications describing the influence of local heat on the human body. Application of local heat to the skin leads to an increase in the perfusion of the microcirculation and heat is carried away by the blood flow. Heat is equally conducted towards deeper underlying tissues. Therefore, heat applied externally increases the skin and deep tissue temperature, which will stimulate the thermoreceptors (3, 4). This afferent thermal signal inhibits the transmission of nociceptive signals through the spinal cord to higher centres, leading to pain reduction (5). There is some evidence for antiphlogistic effects (6, 7), muscle tone reduction as a result of the decreased α-motor activity from the dorsal horn of the spinal cord (8), increased flexibility of connective tissue (9), decreased viscosity of the synovia (10), vasodilatation and nitric oxide generation (11), phagocytosis stimulation and white blood cell activation (12) and for synergetic effects with oral ibuprofen therapy (13). Cardiovascular diseases are often considered as a contraindication for local heat application in physical therapy because the vascular effects may be too demanding for heart patients.

Fango (mud) and humolites (humus) are peloids, consisting of humus and minerals with traces of organic substances (blue-green algae). Peloids are formed in a natural way in water and soil by the activity of microorganisms (microbial colonies and algae). Peloids have an oxido-reduction potential corresponding to that of ascorbic acid. They may contain sulphur, in its elementary form. Minerals from the soil and the environment enter the peloid. Trace elements found in peloids include boron, cobalt, copper, iodine and manganese. In some naturally formed peloids, hormones have been found while little is known about the vitamin, alkaloid and protein content of mud (14). Up to now, there are no studies indicating penetration of active compounds from the mud packs into the human skin (2). In balneotherapy, heat retentivity is an indication for the temperature dissipation of the fango, expressed in $^{\circ}C/cm^3$. It is the reciprocal of the coefficient of heat conduction (14).

The thermophysical and hygienic conditions of fango were improved using a mixture of paraffin and peloids from the volcanic crater lake of Battaglia (Italy). This so-called parafango, with improved physical properties, ensured a slow heat conduction, allowing application of the parafango heated up to 50 °C without causing any damage to the underlying tissues. The 'Parafango di Battaglia' is the fango most commonly used in physical therapy (15).

Aim of the Study

As for the assumed therapeutic effects, few studies describe the temperature effects of parafango application. It was our aim to evaluate and quantify the temperature changes on the skin during parafango therapy. We equally tried to evaluate the local effects on the skin microcirculation on the arterial level (Laser–Doppler) and the venous level (Chromametry). In order to evaluate the impact of blood redistribution towards the covered skin area, we evaluated the effects of parafango therapy on several cardiovascular parameters. The latter may give more information concerning eventual contraindications for parafango application.

Methods

Eighteen healthy subjects (11 women, 7 men) without diabetes, vasoactive pharmaco-therapy, inflammatory joint diseases or skin diseases volunteered to participate in this study (age 23.7 ± 3.8 years). All volunteers respected a 20-min acclimatization period (room conditions 20 ± 2 °C; relative humidity $45 \pm 5\%$) before any experimental procedure was started. The first part of the experiment consisted of a relaxation period during which the subjects remained in a supine position for 21 min. During the entire period of this experimental procedure, subjects were covered by a cotton and a woollen blanket as during standard parafango treatment. In order to ensure a relaxing atmosphere, lights were dimmed and noise was avoided in the laboratory. After this relaxation period, fango was applied. A 1-cm-thick parafango mudpack ('Parafango di Battaglia', Padua, Italy) with a surface of 2500 cm^2 at 44.5 °C was applied for 21 min. Subjects were lying on the fango with direct physical contact between the parafango and the skin of their back. After removal of the parafango, the subjects stayed in a supine position for another 21 min.

At a 3-min interval before (relaxation period), during and after the parafango therapy, skin surface temperature (ST) (thermo-couple thermometry Testoterm 9010; Testoterm GmbH & Co., Lenzkirch, Germany) and microcirculation of the skin (PeriFlux PF3 Laser–Doppler; Perimed®, Sweden) were measured. The thermometer and Laser–Doppler probes remained in contact with the skin during fango application. The thermal probe was sealed on the skin under the parafango. The Laser–Doppler probe holder was inserted into the parafango, allowing direct contact between the probe and the skin. Owing to the size of the parafango and the treated area (2500 cm^2), covering the entire back, measurements on an untreated control side were impossible during the parafango application. Moreover, for the evaluation of the skin redness (as indicated by the a^* parameter from the L^* a^* b^* colour system, Chromameter; Minolta, Japan), the dimension of the measuring probe did not allow data collection during parafango application. As a consequence, information on skin redness was collected only pre- and post-parafango treatment. Before, during and after the parafango treatment, the heart rate, systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured every 3 min using an oscillometric method. An automatic monitor at the left wrist was used (Omron®; RX Classic, Kyoto, Japan). Statistical analysis was performed using the SPSS 13.0. Data were tested on normality by the Kolmogorov Goodness of fit test. Variations in skin parameters (temperature, perfusion and redness) and in cardiovascular parameters (heart rate, SBP and DBP) were compared using the ANOVA procedure taking into account the entire measurement period (pre, during and post treatment). If significant changes over the entire period were observed, analysis of the separate intervals (pre, during and post-treatment) was carried out. In case of stable (non-significant) pre-treatment values, these values can be used as a reference for the treatment and post-treatment measures (MANOVA procedure). Significance was set at $P < 0.05$.

Results

The skin ST baseline value was 35.5 ± 0.4 °C. After parafango application with physical contact to the skin surface, the skin temperature increased up to 44.3 ± 1.2 °C. At the end of the parafango therapy, skin temperature was still elevated (40.3 ± 0.6 °C). After removal of the parafango, skin temperature decreased steadily and reached baseline values within 21 min (36.1 ± 0.4 °C) (Fig. 1). The ANOVA procedure indicated a significant effect over time for the skin temperature values ($P < 0.05$). Analysis of the different intervals revealed that the pre-treatment values remained constant ($P > 0.05$). Comparison with the latter values indicated significant differences for the treatment and post-treatment values ($P < 0.05$).

Baseline perfusion of the microcirculation of the skin (MC) as measured by the Laser–Doppler method was 23.2 ± 8.8 p.u. During parafango application, the perfusion increased immediately and peaked after 6 min (197 ± 49 p.u.). At the end of the parafango therapy, perfusion of the microcirculation was still elevated (159 ± 52 p.u.). After removal of the fango, perfusion of the microcirculation decreased, reaching a value of 48 ± 39 AU at the end of the recording period (Fig. 2). The ANOVA procedure indicated a significant effect over time for the perfusion of the skin microcirculation ($P < 0.05$). Again, the pre-treatment values remained constant ($P > 0.05$). Comparison with these values indicated significant differences in the treatment and post-treatment values ($P < 0.05$).

Skin redness (SR), as quantified by the a^* colour parameter, increased significantly during parafango application (from 11.0 ± 2.5 before up to 17.9 ± 1.9 immediately after removal of the parafango). The a^* parameter was still elevated 21 min after removal of the parafango (15.8 ± 2.2), (Fig. 3). Analysis of the a^* parameter for the pre- and post-treatment period over time indicated significant variations ($P < 0.05$). The pre-treatment skin colour values over time remained stable ($P > 0.05$). Comparison of pre- with post-treatment values indicated significant differences,

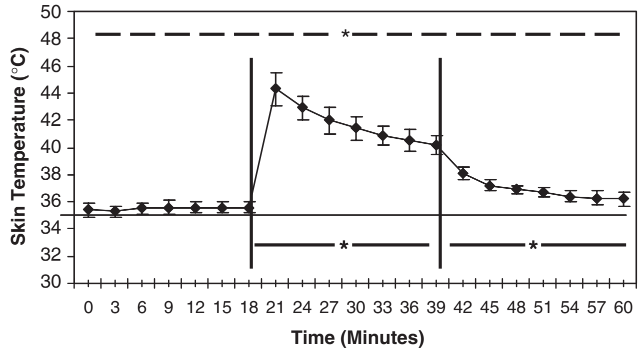

*Fig. 1. Skin surface temperature as a function of time before, during and after fango application. (- - * - -), Significant variation over the entire measurement period; (—— * ——), significant (during and post-treatment) compared with the pre-treatment period.*

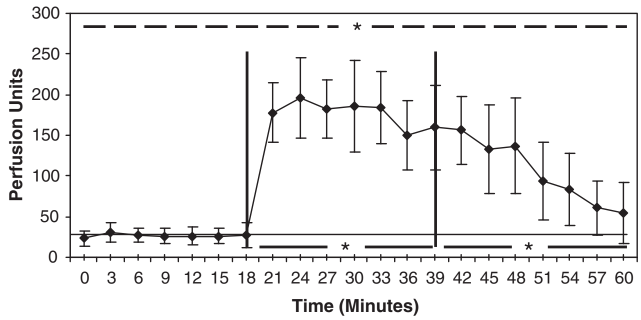

*Fig. 2. Perfusion of the microcirculation as a function of time pre, during and post fango application. (- - * - -), Significant variation over the entire measurement period; (—— * ——), significant variation (during and post treatment) compared with the pre-treatment period.*

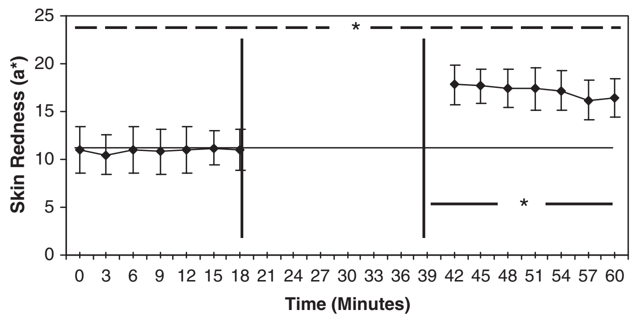

Fig. 3. a parameter as a function of time before and after fango application. (- - * - -), Significant variation over the entire measurement period; (—— * ——), significant variation over the post-treatment period compared with the pre-treatment period).*

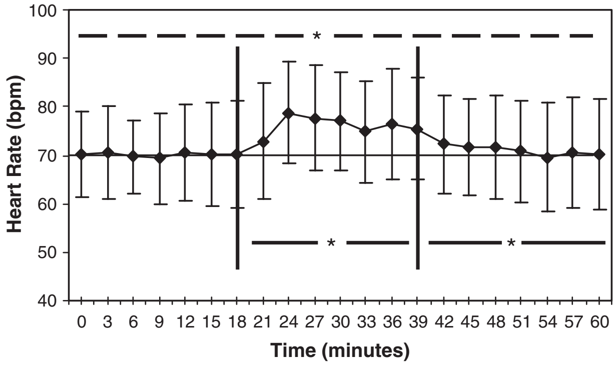

Fig. 4. Heart rate as a function of time before, during and after fango application. (- - * - -), Significant variation over the entire measurement period; (—— * ——), significant variation over a particular measurement period (during and post treatment) compared with the pre-treatment period.

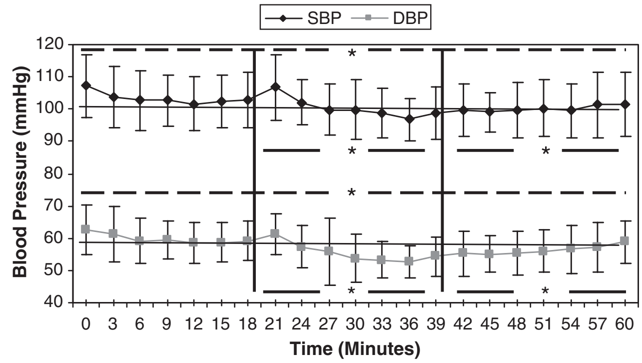

Fig. 5. Systolic and diastolic blood pressure as a function of time before, during and after fango application. (- - * - -), Significant variation over the entire measurement period; (—— * ——), significant variation over a particular measurement period (pre; during; or post treatment).

with higher values over the entire post-treatment period ($P<0.05$).

The resting heart rate was around 70.5 ± 9.9 bpm. During heat application, the heart rate increased, and reached the highest values within 6 min (78.8 ± 10.5 bpm). At the end of the parafango therapy, the heart rate was still 75.5 ± 10.5 bpm. Within 3 min after cessation of the parafango application, the heart rate decreased to 71.1 ± 10.0 bpm and remained constant for the rest of the recording period (Fig. 4).

The ANOVA procedure revealed significant variations ($P<0.05$) over time. The pre-treatment heart rate remained constant ($P>0.05$). Significant differences were detected when comparing, respectively, the treatment and post-treatment values with the pre-treatment reference values ($P<0.05$).

SBP varied around 102.9 ± 8.9 mmHg during the pre-treatment period and decreased to 98.7 ± 8.2 mmHg during the parafango application. At the end of the post-treatment period, SBP increased to the baseline level (101.5 ± 9.8 mmHg). DBP slightly increased within 3 min after parafango application (from 59.8 ± 6.8 mmHg to 61.2 ± 6.5 mmHg). Three minutes later, DBP decreased again up to (57.4 ± 6.5 mmHg) and at the end of the 21-min parafango therapy period DBP was 54.3 ± 6.0 mmHg (Fig. 5).

Statistical analysis indicated variations over time for SBP and DBP over the entire measurement period ($P<0.05$). For both parameters, the pre-treatment values were unstable ($P<0.05$). As a consequence, these values could not be used as reference values. However, on analysing the during and post-treatment SBP and DBP values we equally detected unstable values ($P<0.05$).

Discussion

Our data showed that parafango therapy ('Parafango di Battaglia'), commonly used as a local heat treatment in physical therapy, resulted in significant changes of skin characteristics at the treatment site. As observed in other experiments (16), these changes are characterized by (i) an increase of the skin ST, (ii) an increase of the superficial microcirculation and (iii) an increase of skin redness indicating flooding of the deeper venous system.

Laser–Doppler flowmetry and skin surface thermo-couple thermometry are methods for evaluating the more superficial skin properties. Both the volume and mean velocity of the erythrocytes circulating in the superficial skin vessels will influence the Laser–Doppler signal. This method is very sensitive for evaluating changes in the microcirculation of the superficial skin layers and reflects cardiac, respiratory and arteriolar vasomotion fluctuations. The latter are the main sources of skin blood flow modification over time (17).

Using a similar experimental protocol but applying a 15-mm and a 30-mm thick 'La Léchère' mud pack (a mixture of clay and La Léchère mineral water) at 50 °C, Poensin et al. (17) found that skin temperature (+2 °C) and superficial skin flow (+600%) increased at the treated side and that these properties remained significantly above the baseline value for at least 5 min after pack removal ($P = 0.004$). In our study, the skin

ST increased by 8 °C while superficial skin blood flow increased 900%. Because methods of evaluating thermometry and flowmetry in both studies were comparable, it seems that the effects of parafango therapy (despite the thinner pack and the lower application temperature) were more pronounced compared with the application of the 'La Léchère' mud pack. However, the differences may be explained partially by the use of longer application times or differences in response between the experimental groups: Poensin et al. (17) used female volunteers between 28 and 67 years (median age 51 years) while we worked on younger male and female volunteers (11 women, 7 men; mean age 23.7 ± 3.8 years).

Skin colour as assessed by the Chromameter reflects changes in the superfical and deeper dermis. Our findings indicate that there is a vasomotion of the capacitance vessels of the deeper layers of the skin, increasing the blood circulation and the temperature. This may explain some of the therapeutic effects of fango therapy (e.g. better diffusion of catabolic waste products). However, vasomotion of the superficial and deeper blood vessels may also be a part of the thermoregulatory system. Poensin et al. (17) used the coefficient of variation (standard deviation/mean) of the Laser–Doppler flowmetry signal for superficial skin flow as an indirect evaluation method of vasomotion. They recorded very low-frequency vasomotion waves at the treated side. Together with their finding of the blood flow increasing disproportionally compared with the skin ST increase at the treated side, and the observation that no changes occurred at the non-treated side in combination with a constant core temperature, they concluded that central mechanisms related to thermoregulation were not involved.

Our results indicate that the overall systemic cardiovascular effects (heart rate and blood pressure) were rather weak. An increase of the heart rate (around 10 bpm) was measured immediately after fango application. In our opinion, this may be caused by a redistribution of the blood towards the more superficial veins as part of the thermoregulation response. SBP and DBP varied already during the pre-treatment period, but also during the treatment and post-treatment periods. The pre-treatment values decreased as a function of time. This may be an indication of the decreased stress and that the volunteers became used to the different measurement procedures. Again, the measured variations of SBP and DBP are very weak and of no clinical significance.

We assume that the therapeutic effects are mainly due to the temperature changes and the increased blood flow. Similar therapeutic effects are ascribed to rubeficiant massage products containing nicotinates as active ingredients. Earlier findings indicated a nicotinate concentration-dependent increase in skin temperature (up to 2 °C) and perfusion of the microcirculation (up to 880%) (16). These results are completely comparable with the results of the fango therapy by Poesin et al. (17).

We conclude that during and after parafango therapy, there are strong local effects on skin properties as measured with thermo-couple thermometry, Laser–Doppler flowmetry and the Chromameter for assessing skin erythema. However, the systemic effects are rather weak. Therefore, there is evidence that parafango therapy may be safe for patients with venous insufficiency.

References

1. Egger C, Taeymans J, Clarys P. Wärme und Kreislaufeinfluss einer 21-minütigen Wärmeapplikation auf den Blutdruck und die Herzfrequenz. Fisio active 2003; 5: 5–13.
2. Beer AM, Junginger HE, Lukanov J et al. Evaluation of the permeation of peat substances through human skin in vitro. Int J Pharm 2003; 253: 169–175.
3. Cameron MH. Heat-thermotherapy. In: Physical agents in rehabilitation. Philadelphia: Saunders, 1999: 149–175.
4. De Pace DM, Newton R. Anatomic and functional aspects of pain-evaluation and management with thermal agents. In: Michlovitz SL, ed. Thermal agents in rehabilitation, 3rd edn. Philadelphia: F.A. Davis Co, 1996: 30–57.
5. French SD, Cameron M, Walker BF et al. Superficial heat or cold for low back pain. Spine 2006; 31: 998–1006.
6. Erasala GN, Rubin JM, Tuthill TA et al. The effect of topical heat treatment on trapezius muscle blood flow using power Doppler ultrasound. Physical Therapy 2001; 81: A5.
7. Nadler SF, Steiner DJ, Erasala GN et al. Continuous low-level heat wrap therapy provides more efficacy than Ibuprofen and acetaminophen for acute low back pain. Spine 2002; 27: 1012–1017.
8. Lundeberg T, Ekholm J. Pain from periphery to brain. Disability Rehabil 2002; 24: 402–406.
9. Lehmann JF, de Lateur BJ. Therapeutic heat and cold, 4th edn. Baltimore, MD: Williams & Wilkins, 1990: 417–581.
10. Oosterveld F, Rasker JJ, Jacobs JW et al. The effect of local heat and cold therapy on the intra articular and skin temperature of the knee. Arthritis Rheum 1992; 35: 146–151.
11. Tucker AT, Pearson RM, Cooke ED et al. Effect of nitric-oxide-generating system on microcirculatory blood flow

in skin patients with severe Raynaud's syndrome: a randomised trial. Lancet 1999; 354: 1670–1675.
12. Lau CS, O'Dowd A, Belch JJ. White blood cell activation in Raynaud's phenomenon of systemic sclerosis and vibration induced white finger syndrome. Ann Rheum Dis 1992; 51: 249–252.
13. Akin MD, Weingand KW, Hengehold DA et al. Continuous low-level topical heat in treatment of dysmenorrhea. Obstet Gynecol 2001; 97: 343–349.
14. Jenoure P, Lehmann PW. Utilization of fangotherapy in sport medicine using Parafango Battaglia. Schweiz Z Sportmed 1975; 23: 195–200.
15. Vanderstraten G, Holvoet J, Segers M. La température tolérée par la peau pendant fangothérapie. Presse Thermale Climatique 1989; 126: 13–16.
16. Clarys P, Barel AO, Buchet E. Evaluation of different topical vasodilative products with non-invasive techniques. In: Scott RC, Guy RH, Hadgraft J, Boddé HE, eds. Prediction of percutaneous penetration, methods measurements modeling, Vol. 2. London: IBC Technical Services Ltd, 1991: 46–59.
17. Poensin D, Carpentier P, Féchoz C et al. Effects of mud pack treatment on skin microcirculation. Joint Bone Spine 2003; 70: 367–370.

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