The effect of outpatient mud and spa-therapies on the tissue perfusion measured with laser Doppler in work related upper extremities overuse syndromes

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Abstract

Introduction and objectives. The work related musculo-skeletal disorders (MSD) affecting the upper body and limbs are now recognized as one of the leading causes of pain and disability in the occupational health. The impairment of circulation could be one of the explanations for the work related musculoskeletal overuse syndromes. There is a long tradition of using of spa treatment in case of musculosceletal problems. The goal of this study is to detect the effect of outpatient mud and spa therapies on the perfusion in the upper limbs in case of the professional overuse.

Methods. Two factories where the previous work place risk analyses showed the upper extremities overuse for the workers were chosen into the study by the occupational medicine unit. The Standardised Nordic questionnaires for the musculoskeletal symptoms were used by the occupational medicine doctor to measure the individual level of MS pain of the upper extremities. The perfusion measurements on the forearms with laser Doppler before and in the end of spa treatments were done by the Physical Medicine and Rehabilitation doctor.

Results We found the significant changes in the perfusion, rest flow and peak flow measured by the laser Doppler after the 9 spa therapy sessions in the medium pain group.

Conclusions. in the case of upper extremities overuse syndrom with medium pain spa treatment restored microcirculation in the upper extremities exposed to the regular professional overuse. Spa treatment could be the method for the healh promotion in this subgroup.

Key words: upper extremity overuse, musculoskeletal disorders, circulation, laser-doppler, balneotherapy

Efecto en paciente ambulatorio de barro y balneoterapia sobre la perfusion tisular medida con lasser Doppler en trabajos relacionados con las extremidades superiores y síndromes por sobreesfuerzo

Resumen

Introducción y objetivos. Los trastornos relacionados con el trabajo musculoesquelético (MSD) que afectan a la parte superior del cuerpo y las extremidades son ahora reconocidos como una de las principales causas de dolor y discapacidad laboral. El deterioro de la circulación podría ser una de las explicaciones de trabajos relacionados con síndromes por sobrecarga muscular. Hay una larga tradición en el uso de tratamientos balneoterápicos en casos de trastornos musculares. El objetivo de este estudio es detectar en pacientes ambulatorios el efecto de la peloterapia y balneoterapia en la perfusión tisular en las extremidades superiores en casos de sobrecarga muscular.

Métodos. Los trabajadores fueron seleccionados por la unidad de Medicina del Trabajo de dos fábricas que con anterioridad mostraron riesgos por el uso excesivo de las extremidades superiores por los trabajadores. El médico de Medicina del Trabajo utilizó los cuestionarios estandarizados nórdicos para síntomas musculoesqueléticos, para medir el nivel individual de MS dolor de las extremidades superiores. Las mediciones de perfusión en los antebrazos con láser Doppler antes y al final de los tratamientos balneoterápicos se realizaron por un Médico Rehabilitador.

Resultados. Se encontró cambios significativos en el flujo de perfusión, el flujo de descanso y pico medidos por el láser Doppler después de las 9 sesiones de balneoterapia en el grupo de dolor medio.

Conclusiones en el caso de síndrome de sobreesfuerzo por uso de las extremidades superiores con dolor medio, el tratamiento balneoterápico, restaura la microcirculación en las extremidades superiores expuestas al uso excesivo profesional regular. La Balneoterapia podría ser el método para la promoción de la salud en este subgrupo

Palabras clave: sobrecarga de las extremidades superiores, trastorno musculoesquelético, circulación, láser-doppler, balneoterapia

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INTRODUCTION

Work-related musculoskeletal disorders describe a wide range of inflammatory and degenerative diseases and disorders. These conditions result in pain and functional impairment and may affect the neck, shoulders, elbows, forearms, wrists and

hands. For example in the Netherlands and Belgium approximately 30% and 40% of workers reported neck or upper limbmusculoskeletal disorders, respectively[1].

The work related MSDs affecting the upper body and limbs are now recognized as one of the leading causes of pain and disability in occupational health[2].

Musculoskeletal discomfort (especially pain symptoms) that is at risk of worsening with work activities, and that affects work ability or quality of life, needs to be identified. Unpleasant sensations from the musculoskeletal system are experienced by everyone and can be adaptive in circumstances when muscle soreness is experienced after physical training, for example. In prevention of work-related MSDs, we need to assess musculoskeletal symptoms that have a potential of affecting workers' health in a negative way. Symptoms at risk of worsening (e.g. paraesthesia as a first phase before pain may be present in entrapment syndromes) which reduce work ability or impair quality of life should be targeted[3].

Usually MSD-s develop slowly, usually over a number of years, their symptoms in the initial stage of the disorder are nonspecific by nature. The main causes of repetitive strain injuries physical overload diseases are long-term work in a forced position, static tension of a single muscle groups, frequent repetitive stereotypic movements, manual displacement of weights.

Prolonged work will cause hypoxia in muscles, most of the energy will be produced anaerobically, lactic acid will start accumulating in the muscles, causing muscle fatigue. Increased oxygen consumption in case of physical labour is not the only cause of muscle hypoxia, it may also be caused by contraction of blood vessels due to increased muscle tone and in this way to a number of biochemical processes, could produce a pain[4].

Insufficient blood supply to muscles, as well as unfavourable metabolic processes plays a primary role in the development of overload disease. Fatigue is a subjective manifestation of onerous physical work. Overloaded motor units, Cinderella units, develop in encumbered muscles and are replaced by other motor units; however, inflammatory changes will develop in muscles later on[5].

Work which does not allow compensating changes in an organism by rest will result in chronic damage and overload-based diseases not only in muscles, but also in tendons and joints as well as in the form of pinched nerves (carpal tunnel syndrome) and functional disorders. That is why it is essential to pay special attention to the development of muscle fatigue, availability of sufficient rest breaks, to primary complaints and individual assessment of physical workload[6].

The goal of this study is to detect the effect of outpatient mud and spa therapies on the perfusion in the upper limbs in case of the professional overuse. We are looking for the new health promotion and treatment methods that could help prevent MSDs development and loss of permanent work ability in the working age population. The information about the circulatory system is very valuable because perfusion abnormalities are often an early stage in different malfunctions (e.g. overuse syndromes).

The perfusion measurements by Laser Doppler flowmetry (LDF)

LDF is well known techniques used to measure the total local microcirculatory blood perfusion.

As a consequence of the large normal variations observed in the microcirculatory blood flow, provocations are often used to facilitate data interpretation. The provocation test with the occlusion the upper extremity vessels with cuff for the post-occlusive reactive hyperemia (PORH), are used in this study. The PORH test has been proposed to assess the microvascular function. The local blood perfusion, e.g., distal extremity, is measured before, during and after performing arterial occlusion, to record the response upon releasing the occlusion.

Combining LDF with post-occlusive reactive hyperaemia (PORH) provides simple, non-invasive method for examining microvascular and endothelial function [7].

The physiological responses to termostress and spa therapy

The general response of organism to environmental factors, called stressors, is to sustain the internal homeostasis. Rise of the temperature either locally or generally activates protective tissue responses to diminish the energy load. The heated location is flushed with blood as a coolant and this process is controlled by local biochemical and neural mechanisms. If chronic pathology is present, harming normal function of local nervous system or functionality of the blood vessel, these mechanisms may fail.

If heat is induced to the sufficient surface of extremities, the core temperature starts to rise. The objective is that the blood carries the heat off from exposed areas dissipating it to the relatively colder areas.

The effects of mud-packs and thermal baths are partially related to temperature.

The warm application of mud, increases the surface temperature of the specific area of the body where applied and stimulates its warmth receptors, causing vasodilatation. Due the effects of vasodilatation improves the blood flow, blood viscosity reduces, the delivery of leukocytes and lymphatic circulation rise due to increase in permeability of capillary, which helps in removal of waste product. A mean temperature of 41.7+/-0.9 degrees C in heated tissue capillary fronts is a threshold temperature for heat-induced angiogenesis.

Hot stimuli may influence muscle tone and pain intensity, helping to reduce muscle spasm and to increase the pain threshold in nerve endings. According to the ‘‘gate theory’’, pain relief may be due to the temperature and hydrostatic pressure of water on the skin[8].

The increase in beta-endorphin demonstrated to occur with various spa therapy techniques has an analgesic and antispastic effect that is particularly important in patients for whom pain is the prevalent symptom. It has been revealed that the application of mature thermal mud in healthy individuals brings about a rapid increase in plasma beta-endorphin, which returns to pre-treatment levels within the

period of so-called thermal reaction. This increase in beta-endorphin is probably the key factor in the mechanism of individual tolerance to thermal mud baths[9].

Mud-pack is defined as a natural product that consists of a mixture of mineral or mineral-medicine water with organic or inorganic material produced from biological and/or geological processes and used as a therapeutic treatment in the form of a mud wrap applied locally or to the whole body.

76 269 mud treatment procedures were done in Estonia in 2013 based on the database of The National Institute for Health Development in Estonia.

Due to its specific geological and geomorphological characteristics there are several important deposits of lake and marine curative mud, with public health and commercial benefits in Estonia. At present, five deposit areas, containing about 174 320 tons of healing mud, are in active use. However, the mud resources are underutilized if compared to their earlier use during the 20th century.

A complex geochemical characterization of Estonian curative mud deposits has been done in the mud laboratory by Tallinn Univesity Haapsalu College. The Haapsalu Bay mud has been used in this study. Spatial distribution of organic matter and heavy metals of Haapsalu Bay surface sediments were mapped using inorganic methods: thermogravimetric analysis and energy-dispersive X-ray fluorescence spectrometry. The average concentrations of selected heavy metals in all Estonian curative mud deposits were compared against the Estonian and international reference values for soils and sediments, to prove the safety of the therapeutic mud[10].

There is a long practice of using the spa therapy for the chronic pain syndromes[11-12], rheumatological rehabilitation[13-14], fibromyalgia[15-16] and also for the specific hand problems[17-18].

Spa therapy may have beneficial effects on muscle tone, joint mobility and pain intensity. The rehabilitation methods for the work related MSDs should be developed and spa therapy could be one of the possibilities.

METHODS

Two factories where the previous workplace risk analyses showed the upper extremities overuse for the workers were chosen to the study by the occupational medicine unit. The Standardised Nordic questionnaires on the musculoskeletal (MS) symptoms were used by the occupational medicine doctor to measure the individual level of MS pain of the upper extremities on the Visual Analogue Scale (VAS) 0 to 10.

The perfusion measurements on the forearms with laser Doppler before and in the end of spa treatments were done by the PRM doctor.

For the investigation 85 garment workers were questioned. The self -assessment of workers about musculoskeletal and other health disturbances based on the Work Ability Index and the Standardised Nordic questionnaires had been done.

PRM doctor prescribed an one of the next spa-treatment: mud (hole body or local for the hands), bath or paraffin for the hands.

The questionnaire was filled and microcirculation measurements were done before the first and the ninth of the treatment.

Laser Doppler instruments with a probe with standard fiber separation (0.25 mm), and a 780 nm wavelength laser was used. A standard laser Doppler probe for the PORH test was placed distal to the cuff which is then inflated to a pressure well above the systolic blood pressure. After 3 to 5 minutes occlusion, pressure is released instantly and the laser Doppler signal is evaluated.

The microcirculation: perfusion (PU), rest flow (RF) and peak flow (PF) in the post-occlusive reactive hyperaemia (PORH) test were monitored before the first and after the 9th of spa therapies. The post-occlusive reactive hyperaemia test involves blood perfusion measurements before, during and after occlusion.

RESULTS

Group **A**: 10 persons (9 women, 1 man) in the pain free group. An average age 50,6 (35-63), the length of service 14,6 (3-32), BMI 26,3 (21-35) and an average arterial blood pressure 109 and diastolic 75.

Group **B**: 35 persons (25 women, 10 men) in the group where the pain in no of the neck, shoulder, elbow or hand region was not over 5 on the pain VAS The average pain VAS in the neck was 2,9, shoulder 2,6, in the elbow 2.3 and hand 3,4. An average age 51,2 (23-68), the length of service 20,6 (4-47), BMI 28,0 (19-43), age average arterial blood pressure 131 and diastolic 87.

Group **C**: 40 persons (33 woman, 7 men) in this group with the pain at least in one of the region more than 5: average pain in the neck 4,6; shoulder was 5,1; in the elbow 4,3 and arm 6,2. An average age 49,2 (22-64), the length of service 15,0 (0.5-48), BMI 28,3 (21-50), an average arterial blood pressure 121 and diastolic 80.

The perfusion change after the spa were statistically important only in the medium pain group (Table 1, Figure 1).

The rise in two other microcirculation measurements- rest flow and peak flow in the PORH test were also found in the medium pain subgroup.

The average rest flow before the treatment (RF 1) was 252,9 and in the end of treatment (RF2) was 13,9 in the medium pain group. The rise was 19.4 %. The average peak flow before the treatment (PF1) was 348,1 and in the end (PF2) was 390,2 in the medium pain group. The rise was 10,8 % (Table 2 y 3, Figure 2).

Table 1 – The perfusion in the three groups

	Perfusion before 9 spa therapies	**Perfusion after 9 spa therapies**	**%**	**t-test**
A - no pain	287.3	317.3	9.5	p< 0.4
B - medium pain	258.9	300.7	14.0	p< 0.05
C - strong pain	302.0	301.7	0	p< 0.3

Figure 1 – Perfusion before and after spa therapies

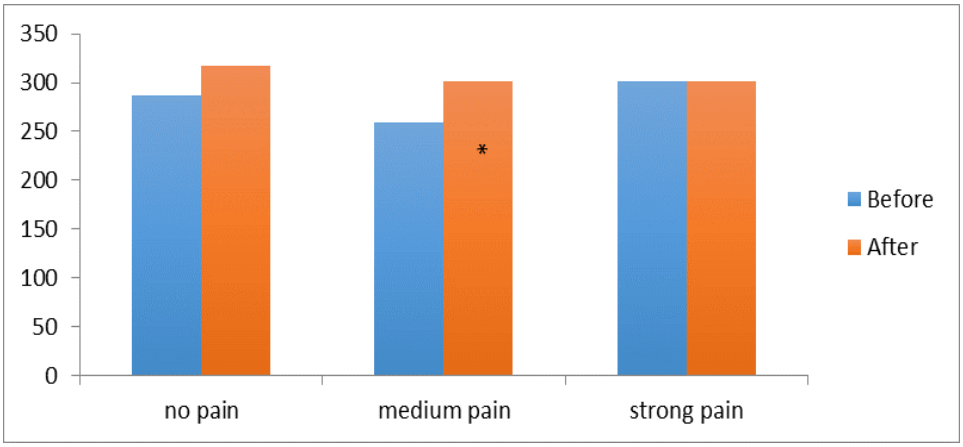


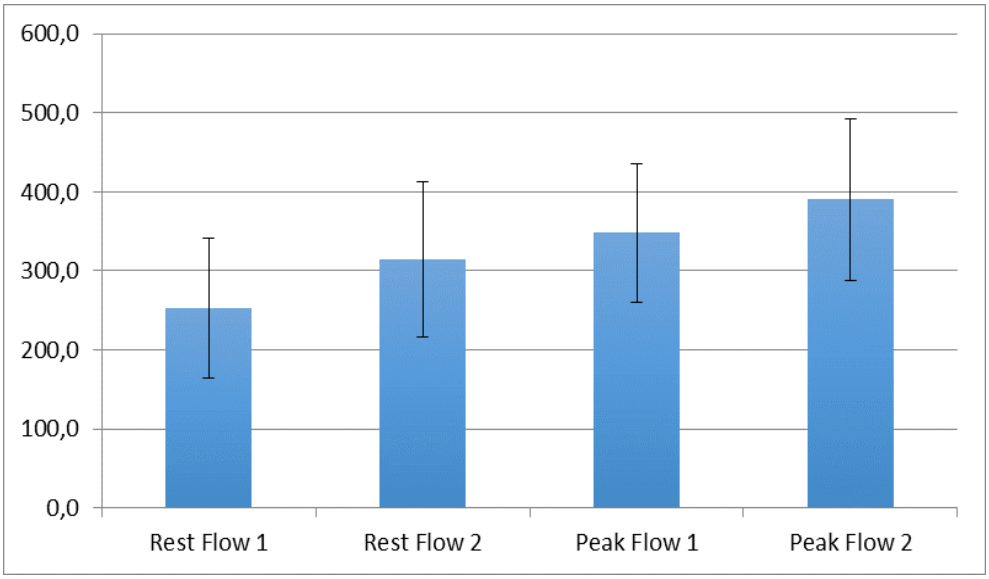
Table 2 – The average rest flow in the three groups

	Rest flow before 9 spa therapies	**Rest flow after 9 spa therapies**	**%**	**t-test**
A - no pain	268,0	304,7	12%	p< 0.3
B - medium pain	252,9	313.9	19,4%	p< 0.005
C - strong pain	300,7	294,1	-2,2%	p< 0,74

Table 3 – The average peak flow in the three groups

	Peak flow before 9 spa therapies	**Peak flow after 9 spa therapies**	**%**	**t-test**
A - no pain	388,9	404,6	3,9%	p< 0.6
B - medium pain	348.1	390,2	10,8%	p< 0.02
C - strong pain	384,2	410,7	6,4%	p< 0,37

Figure 2 – Rest and peak flow before and after the spa therapies in the medium pain group



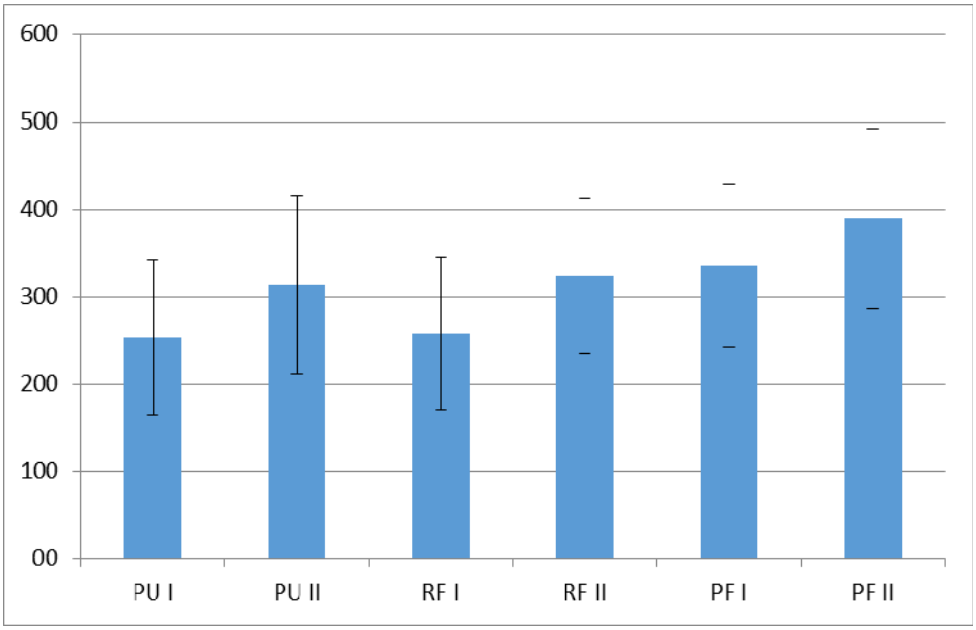
There were 10 women and 8 men in medium pain group, who passed body mud therapy 9 times. The average age was 51,6, the length of service 31,4. And average BMI 28,3. Laser-Doppler measurements in the subgroup showed statistically important changes in the perfusion, rest flow and peak flow.

The perfusion rose 19.1 %, rest flow 20.58% and peak flow 13.74% in the medium pain group where people get hole body mud treatment 9 times (Table 4, Figure 3).

Table 4 – Medium pain (group A) mud therapy subgroup

	Before 9 mud therapies	**After 9 mud therapies**	**%**	**t-test**
Perfusion	253.6	313.5	19.1	p< 0.04
Rest flow	257.3	324.0	20.6	p< 0.01
Peak flow	335.8	389.3	13.7	p< 0.02

Figure 3 – Microcirculation changes due the mud therapy in the medium pain group



DISCUSSION

In the group **A** including people who did not report pain in their upper extremities, perfusion was quite high (average PU 287.3) already before the treatment and the rise due therapy was not statistically important. The soft tissue response to repeated heating is mainly due the capillary vascularisation and heat dissipation due blood flow. Capillary densities in heated tissue capillary fronts could triple from 2 to 7 weeks [19].

The response is depended of the initial vascular density in the manner that better vascularised tissue show less effort to achieve the goal - to sustain the internal homeostasis. But if there is enough capacity to achieve to the goal, the internal homeostasis, with the existing capillary system, then there is probably no need to double or triple the vascular system and then we do not get long lasting effect from the repeated heating.

In the medium pain group **B** the most of persons had quite low perfusion (below 250). Due the spa therapy the statistically significant changes of the perfusion (PU). We saw also statistically important changes in the PORH test in the this medium pain group B: the peak flow before the therapy course was 348,1 and raised up to 390.2 after the 9^{th} treatment ($p< 0.02$). Post-Occlusive Reactive Hyperaemia (PORH) is an objective method to study the endothelium and assess the subject's endothelium dependent and endothelium independent vasodilation when subjected to local heating. Though, this change is a marker of positive changes in the endothelial function due the repeated heating.

There were no statistically significant changes also in the strong pain group **C**, where we saw also quite high PU prior the treatment. The explanation of the no statistical important results in the strong pain group could be that in this case we have to talk about so called acute pain model.

An acute pain at an intensity of 5 on a VAS of 0-10 caused autonomic changes such as sweating and blanching in these healthy subjects. Since pain-related autonomic changes such as sweating and blanching are rarely, if ever, observed in patients with work-related overuse syndromes, yet pain scores of 5 on a 10 point VAS scale are commonly reported by them, these patients may have an average level of pain that is an order of magnitude less than that fostered in the above acute pain model [20].

In our study laser Doppler data shows, that also in a case of pain at an intensity of 5 and more on a VAS in the case of the professional overuse syndromes without clear autonomic changes like sweating and blanching, we have reason to talk about the acute pain model in the local vascular system based on laser Doppler data.

CONCLUSIONS

Repetitive tasks with hands can cause often the loss of work capacity in long term practice. We need good tools to prevent and rehabilitate these conditions before the permanent loss of work capacity appears. The traditional spa therapy is quite expensive. We were looking for the effective methods to use the traditional spa treatments in the less expensive way in the out- patient practice.

The soft tissue response to repeated heating is mainly due the capillary vascularisation and heat dissipation due blood flow. In our study the rise of microcirculation due the repeated heating was statistically important in the medium pain group. The

medium pain subgroup, who got hole body mud therapy the perfusion rose 19.1 % (p 0.039), rest flow 20.58% (p 0.011) and peak flow 13,74% (p 0.017) after 9 times therapy.

The better understanding of physiological background of the work-related musculoskeletal pain syndrome (e.g. microcirculation status) could help to prevent the musculoskeletal health problems on the workplaces with the ergonomic risks or plan an appropriate treatment for the persons with overuse syndromes.

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