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# Work-related musculoskeletal symptoms in industrial workers and the effect of balneotherapy

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**Abstract.** The aim of the paper is to present balneotherapy (mud treatment) effect in the rehabilitation and prevention of work-related musculoskeletal disorders (MSDs) of industrial workers. Balneotherapy significantly reduces the muscle pain complaints of the employees. The m.abductor pollicis brevis muscle tension measured decreased after the balneotherapy. The study included overall 114 industrial workers (91 female and 23 male persons from garment and woodworking industries) with professional overuse of the upper extremities. The average age of the workers was 49.1 (from 22 to 75) years, their average length of the service was 16.2 years. The main result of the questioning of the workers about the pain regions: there was quite a high incidence of musculoskeletal pain in the investigated workers with a work-related upper extremity syndrome: neck 68.4%, shoulders 63.2%, elbows 42.1% and wrists 78.9%. In the course of the study, balneotherapy was applied to 19 (13 female and 6 male) industrial workers who had pain at least in two regions of the body. The average age of these workers was 50.6 years and the average length of the service 21.3. After the balneotherapy, the 19 industrial workers' complaints of pain in the neck and in the wrists decreased from 2.37 to 1.13 points ($p = 0.05$) and from 3.25 to 1.03 points ($p = 0.007$) respectively on the VAS pain scale. Objective measurement of muscle fatigue with a myotonometer showed the decrease in the stiffness of hand muscles (Abd poll brev, right: from 278 $nM^{-1}$ until 342 $nM^{-1}$, $p = 0.006$). The results indicated that more attention should be paid to the early diagnostics and preventive measures.

**Key words:** physical overload, musculoskeletal disorders, myotonometry, industrial workers, balneotherapy.

## INTRODUCTION AND THEORETICAL BASIS

A work-related musculoskeletal disorder (MSD) develops slowly, stealthily; however, there is also a possibility that chronic musculoskeletal pathology may develop, which is often the cause of permanent incapacity for work. This is why it is essential that attention should be paid to early diagnostics of work-related MSDs as well as to preventive interference both for changing the working order and for commencing early treatment with a view to helping to prevent the development of chronic MSDs and to preserve the workers' ability to work (Reinhold et al., 2008; Oha et al., 2010; Öztürk & Esin, 2011; Pille et al., 2014).

The project studying the incidence of MSDs in working age population, *Fit for Work Europe*, covered 27 European countries, and within the framework of the study a report regarding each participating country was prepared. The *Fit for Work Estonia*

report was completed in 2011. The report indicated that MSDs reduce the working ability of at least half of the workers in Estonia. In 2009, the ability to work was limited in 59% of workers aged between 15 and 64 due to long-term hand, foot, back or neck problems. The problems are especially frequent in 40- to 65-year old women. Estonia is among the topmost EU member states where workers worry most about work damaging their health (in the opinion of 59% of the workers as compared to the average of the European Union, which is 33% (Zheltoukhova & Bevan, 2011).

In many European countries, incl. Finland, MSDs come second to psychic disorders as causes of permanent loss of ability for work (Martimo, 2010). Most of the MSDs cause local discomfort, muscle tension or pain; joint mobility may be impaired, which, in its turn, prevents people from coping with their everyday tasks. Almost all MSDs are physical load sensitive, even if the disorder is not work-related, physical load may aggravate the symptoms. In the most cases, there are combined causes for MSDs. However, the physical load of work, work intensity, and working and rest time regime have a significant role in the development of various MSDs. Excessive physical load, repetitive motion, and forced positions have a burdensome effect (Tammaru et al., 2004; da Costa & Vieira, 2010). Overwork brings about an accumulation of potassium and free radicals in muscle cells, which may cause damage to muscle cell membranes and to mitochondrial energy production (Hägg, 2000; Toomingas et al., 2011).

In the case of static muscle work, when a muscle contracts, the intramuscular pressure increases and the blood flow decreases. Insufficient blood flow may lead to oxygen deficiency in the muscle and, consequently, to a number of biochemical processes, which may produce pain (Toomingas et al., 2011). In case of non-specific muscle pains, their relation to repeated work motions has been proved (Macfarlane et al., 2000).

In Tartu University, a methodology and equipment for diagnosing the functional state of skeletal muscles has been developed (myotonometry). The method comprises recording, by means of an acceleration transducer, the response of a superficial skeletal muscle or a part thereof to mechanical impact, and an analysis of the signal by means of a dedicated computer program. The criteria developed make it possible to perfect the diagnostics of the functional state of skeletal muscles (Vain, 2002).

The myotonometric method of muscle study may be used for early detection of work-related MSDs as well as for assessment of the difficulty of physical work for individual workers (Roja et al., 2006). The basic indicators of the skeletal muscle condition are frequency and stiffness. Frequency characterizes the muscle tension. In a normal muscle, the muscle tension at rest is slight, but frequency increases when the muscle is energized. Stiffness characterizes the muscle's capacity to resist its shape-shifting power. The values of stiffness are in the range 150 to 300 $Nm^{-1}$, depending on the type of the muscle (Vain, 2002).

One of the possibilities of relaxing a muscle and decreasing pain is heat application (Dehghan & Farahbod, 2014). The physiological effects of heat therapy include pain relief and increases in blood flow, metabolism, and elasticity of connective tissues. There is a limited overall evidence to support the use of topical heat in general; however, randomized controlled trials (RCTs) have shown that heat-wrap therapy provides short-term reduction in pain and disability in patients with an acute lower back pain and provides significantly greater pain relief of delayed-onset muscle soreness than does cold therapy (Decoster et al., 2005; Folpp et al., 2006; Verhagen et al., 2013;

Malanga et al., 2015).

According to the systematic review by Nakano (2012), the static stretch alone can improve the range of motion and this can be potentiated by the application of heat. Heat is an effective adjunct to developmental and therapeutic stretching techniques and should be the treatment of choice for enhancing ROM in a clinical or sporting setting. The effects of heat or ice on other important mechanical properties (e.g. passive stiffness) remain equivocal and should be the focus of future study (Bleakley & Castello, 2013).

The aim of the paper is to present balneotherapy's (mud treatment) effect in the rehabilitation and prevention of work-related musculo-skeletal disorders (MSDs) of the industrial (garment and woodworking) workers.

The hypothesis of the study is: the balneotherapy decreases the muscle tension and pain that employees feel?

## MATERIAL AND METHODS

### Subjects

The study included 114 industrial workers with professional overuse of the upper extremities. There were 91 women and 23 men in the group with an average age of 49.1 (22–75 years); their average length of service was 16.2 years. The workers were investigated by the questionnaire on the pain regions and pain strength. The 19 workers of the group who reported pain in the two or more regions of the upper extremities due to the work overload, received balneotherapy which took place at the outpatient clinic in 10 sessions. The data of the investigated subjects are presented in Table 1.

**Table 1.** The data on the subjects of the study

| | Total number of investigated workers N = 114; 23M; 91F | | | The workers who underwent the balneotherapy N = 19; 6M; 13F | | |
|---|---|---|---|---|---|---|
| | Mean | SD | Range | Mean | SD | Range |
| Age (years) | 49.1 | 11 | 22–68 | 50.6 | 9.37 | 22–65 |
| BMI (kg $m^{-2}$) | 27 | 5.4 | 18–37 | 26.3 | 2.42 | 21–29 |
| Length of service (years) | 16.2 | 10.2 | 0.5–48 | 21.3 | 13.9 | 3–47 |

M – male persons; F – female persons

### Assessment of musculoskeletal pain

The workers' musculoskeletal complaints were assessed on the basis of the Nordic Questionnaire. The intensity of pain was assessed from 1 to 10 on the Visual Analogue Scale (VAS). The questionaries' forms were filled out by the workers (N = 114).

### Hand-grip strength

The hand-grip pain was measured with hand dynamometry. Three trials for both the extremities were carried out (the best of three was taken as the result), in standing positions, hands next.

### Balneotherapy

The number of patients in the balneotherapy group was 19 (13 women and 6 men, the average age of 50.6 years and with the average length of the service of 21.3 years. The workers stated that their average working time was 7.65 hours on each workday.

The average body mass index of male and female subjects was accordingly 26.41 and 26.23. The average handgrip strength of the male subjects was 46.66 kg for the right and 46.91 kg for the left hand; the respective indices of the female subjects were 27.87 kg and 24.96 kg.

In our study, we used warm (42 °C) mud application as thermal stimulation of the painful regions. 42 °C (Seese et al., 1998) has been proved to be the most effective temperature for improving the blood flow. During the balneotherapy period, no changes were made to their usual work and domestic activities.

**Myotonometry**

The Myoton 3 myotonometer was used in the current study. The following indicators of the thumb muscles (*abductor pollicis brevis* and *adductor pollicis)* were measured: frequency characterizing muscular tension and stiffness characterizing the property of a muscle to resist the deforming force. Those muscles were selected because of the intensive work with repetitive hand movements caused by the muscle tension in the thumbs (Radford et al., 2006).

*M. abductor pollicis brevis* abducts the carpometacarpal and metacarpophalangeal joints of the thumb in a ventral direction perpendicular to the plane of the palm. The muscle assists in opposition and may assist in flexion and medial rotation of metacarpophalangeal joint.

*M. adductor pollicis* adducts the carpometacarpal joint, and both adducts and assists in the flexion of the metacarpophalangeal joint, so that the thumb moves toward the plane of the palm (Kendall et al., 2005).

The hand muscles were measured using the Myoton-3 in the sitting position at rest. The patient had to sit in a comfortable position and relax the muscles completely during the measurement.

**Statistics**

The mean and standard deviation (SD) were calculated in the course of the measurements. The student t test was used. The statistical significance of the t test was $p = 0.05$.

## RESULTS AND DISCUSSION

**Assessment of musculoskeletal pain**

The results of the Nordic Questionnaire on the pain regions and of the VAS scale on the pain strength were as follows. There were 36 (32%) people who had no pain in the neck (Table 2), 32 (28%) people who had pain below 5.0 on the VAS scale, and 46 (40%) people whose pain in the neck was ≥ 5.0 (severe pain) on the VAS scale. The average pain in the shoulder region was the same as in the neck (VAS = 3.5). The number of people who had pain in the shoulders was 38 (33%), among them 23 (20%) people felt pain below 5.0, and 53 (46%) people's pain was ≥ 5.0 on the VAS scale. Less pain was reported in the elbow joints: there were 50 (44%) people, who had no pain; 25 (22%) people had pain below 5.0 and 39 (34%) people's pain was ≥ 5.0 on the VAS scale. The number of people reporting pain in the wrists was the highest. There were 27 (24%) people, who had no pain, 26 (23%) people who had pain below 5.0, and 61 (54%) people whose pain was ≥ 5.0. The spine was also remarkably painful in our study group: there

were 31 (27%) people who had no pain, 27 (24%) people who had pain below 5.0 and 56 (49%) people whose pain was ≥ 5.0 on the VAS scale.

**Table 2.** The regions of pain and the number/percentage of workers reported by the Nordic Questionnaire and VAS scale

| The body region | No pain | Pain < 5.0 by VAS | Pain by VAS ≥ 5.0 |
|---|---|---|---|
| Neck | 36 (32%) | 32 (28%) | 46 (40%) |
| Shoulders | 38 (33%) | 23 (20%) | 53 (47%) |
| Elbow joints | 50 (44%) | 25 (22%) | 39 (34%) |
| Wrists | 27 (24%) | 26 (23%) | 61 (53%) |

Increased stiffness, tenderness and muscle pain, particularly in the neck and shoulder regions, were common work-related complaints in our study group. An average level of pain in the group of 114 industrial workers' (measured on the scale of 0–10) was 3.5 in the neck and shoulder, 2.7 in the elbow joints, 4.2 in the wrists and 4.3 in the spine on the VAS pain scale. Due to the need of different treatment strategies for the mild, moderate and severe pain, we analyzed also a group of persons who had mild or moderate pain (pain less than 50% of maximum intensity), which could be treated with warm application.

All the 19 persons who were chosen for the balneotherapy group complained of two or more local pain regions (Table 3). 13 workers (68.4%, I group) complained of neck pain, and the average pain on the VAS scale was 2.37. After the treatment, the pain decreased to an average pain level of 1.13 points and the change was statistically significant ($p < 0.05$). We saw the same positive dynamics after the balneotreatment on wrists. Wrist pain was declared in 15 cases (78.9%) in this group; that was also the most often reported pain region with an average intensity of pain of 3.23 on the VAS.

**Table 3**. Health complaints assessed by the Nordic Questionnaire and pain by the VAS scale

| Area of pain | Complaints (number of workers and percentage of subjects) before treatment | Intensity of pain (0–10) before treatment | Complaints (number of workers and percentage of subjects) after treatment | Intensity of pain (0–10) after treatment |
|---|---|---|---|---|
| Neck | 13 (68.4%) | 2.37 | 7 (36.8%) | 1.13 ($p < 0.05$) |
| Shoulders | 12 (63.2%) | 2.43 | 7 (36.8%) | 1.07 ($p < 0.12$) |
| Elbow joints | 8 (42.1%) | 1.87 | 4 (21.1%) | 0.63 ($p < 0.12$) |
| Wrists | 15 (78.9%) | 3.25 | 6 (31.5%) | 1.03 ($p < 0.007$) |

After the treatment, 6 workers (26.3%, II group) still had pain, but the average intensity of the pain was 1.03 on the VAS. The change was statistically significant ($p < 0.007$).

There were two regions: the shoulder and elbow joints, where we saw positive changes in the pain on the VAS scale, but these changes were not statistically significant in this small group.

As a rule, pain was suffered over an extended period of time: 71% of the study subjects named 30 days and more as the duration of the pain.

**The results of the myotonometric measurements**

The results of the myotonometric measurements were analyzed by means of the Student t-test. Objective measurement of the 19 workers' hand muscles with a myotonometer for frequency and stiffness of *M. add pollicis brevis* did not show any statistically significant changes in this group due the balneotherapy (Table 4). There was a statistically significant decrease only in the frequency and stiffness of the *m. abd pollicis brevis.* It could be explained that the left hand gets probably less overloaded and will repair better and faster. *M. abd pollicis brevis* is an extensor and therefore its stiffness is more important than the flexors' stiffness regarding the range of motion in the joints.

The questions was raised: is there any comorbidity responsible for persisting muscle stiffness? In the II group (6 people) with wrist region tenosynovitis, operated for *syndr. Canalis carpalis*, *MCF joint arthrosis*, their muscles did not show positive changes in stiffness and frequency in myometrical measurements after the treatment (Table 4, 5).

**Table 4**. The II-group (n = 6) muscle frequency

| Muscle site | Side | Frequency (Hz) before treatment | | Frequency (Hz) after treatment | | |
|---|---|---|---|---|---|---|
| | | mean | SD | mean | SD | p-value |
| Abd poll brev | left | 18.63 | 4.72 | 19.35 | 4.15 | 0.71 |
| | right | 18.37 | 4.18 | 22.73 | 4.79 | 0.01* |
| Add poll | left | 16.1 | 1.98 | 16.7 | 4.47 | 0.79 |
| | right | 15.6 | 1.82 | 17.13 | 3.06 | 0.35 |

**Table 5.** The II group (n = 6) muscle stiffness

| Muscle site | Side | Stiffness ($Nm^{-1}$) before treatment | | Stiffness ($Nm^{-1}$) after treatment | | |
|---|---|---|---|---|---|---|
| | | mean | SD | mean | SD | p-value |
| Abd poll brev | left | 295.17 | 72.55 | 309.0 | 64.96 | 0.616 |
| | right | 278.0 | 65.30 | 342.0 | 56.31 | 0.006* |
| Add poll | left | 272.17 | 45.35 | 297.17 | 48.46 | 0.110 |
| | right | 280.5 | 40.94 | 280.67 | 38.62 | 0.990 |

*$p < 0.05$ = significant difference before and after treatment

The I group (13 persons) with no chronic diseases in the wrist region showed positive and significant changes in the myometrical measurements – a statistically significant decrease in stiffness and frequency of *m. abductor pollicis brevis* (Table 6, 7). The stiffness and frequency of M. *adductor pollicis* were quite low (left 16.31 and right

16.45) already before the treatment and did not show any significant changes after the treatment.

**Table 6.** The I group (n = 13) patients muscle frequency

| Muscle site | Side | Frequency (Hz) before treatment | SD | Frequency (Hz) after treatment | SD | |
|---|---|---|---|---|---|---|
| | | mean | | mean | | p-value |
| Abd pollicis brev | left | 19.72 | 4.97 | 16.68 | 4.23 | 0.0259* |
| | right | 21.29 | 3.88 | 16.21 | 4.98 | 0.0065* |
| Add pollicis | left | 16.31 | 1.97 | 16.92 | 3.96 | 0.4374 |
| | right | 16.45 | 1.89 | 16.65 | 3.03 | 0.8128 |

**Table 7.** The I group (n = 13) patients muscle stiffness

| Muscle site | Side | Stiffness ($Nm^{-1}$) before treatment | SD | Stiffness ($Nm^{-1}$) after treatment | SD | |
|---|---|---|---|---|---|---|
| | | mean | | mean | | p-value |
| Abd pollicis brev | left | 313.85 | 63.50 | 254.46 | 54.45 | 0.0022* |
| | right | 313.31 | 65.98 | 248.87 | 48.32 | 0.0126* |
| Add pollicis | left | 288.46 | 42.10 | 287.31 | 38.42 | 0.9123 |
| | right | 285.15 | 40.56 | 290.92 | 39.54 | 0.5449 |

*$p < 0.05$ = a significant difference before and after treatment

**Discussion**

The myotonometrical measurements and the professional analysis of the results enable to determine the 'key' muscles under tension connected with the exact work movements of the person. With the use of the myotonometric muscle testing, it is possible to evaluate the level of occupational muscle overload and dynamically follow up the 'key' muscles after the physio-/balneotherapy.

After balneotherapy, the 19 industrial workers' complaints of pain in the neck and in the wrists decreased from 2.37 to 1.13 points ($p < 0.05$) and from 3.25 to 1.03 points ($p < 0{,}007$) respectively on the VAS pain scale. The change is statistically significant. There was no significant lessening of pain according to the pain scale in the study subjects whose pain syndrome persisted. The group who had persisting complaints after the treatment had chronic problems in the wrist area. It should also be taken into account that most of the workers studied (71%) had an established (exceeding 30 days) muscle pain syndrome.

As regards the myotonometrically measured parameters, a certain decrease in muscle stiffness could be observed. The changes were better in the extensors (*m. abductor pollicis*) and in the group of people without hard chronic comorbidities in the measured wrist region. The stiffness of extensors (*abductor pollicis)* was higher than in the flexors (M. *adductor pollicis)* already before the treatment. The reason could be that the extensors had a higher static overload due the work activity.

The assessment of the muscle tension by means of the myotonometric method makes it possible to select out the workers who need the treatment and preventive measures in order to prevent the development of chronic MSDs.

There was quite a high incidence of musculoskeletal pain in the 114 investigated workers with a work-related upper extremity syndrome: neck 68.4%, shoulders 63.2%, elbow 42.1% and wrists 78.9%. The results indicated that more attention should be paid to early diagnostics and preventive measures in order to reach the average of the European Union, which is 33% (Zheltoukhova et al., 2011).

## CONCLUSIONS

On the basis of the study it may be concluded that the work-related musculoskeletal complaints of pain could be changed by balneotherapy. Balneotherapy (in our study warm mud applications) is one of the old possibilities of treating joint and muscle diseases using heat, and therefore can be used for the rehabilitation of the work-related MSDs without hard comorbidities.

In the course of the study, balneotherapy was applied to 19 industrial workers (from garment and woodworking industries). By the means of balneotherapy, work-related musculoskeletal complaints of pain decreased significantly. Objective measurements with a myotonometer showed a decrease in the stiffness of hand muscles.

Further research will be necessary for working out of the methodology of using the myotonometric measurements of muscles in different work conditions.

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