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# Acute effects of a work-related rehabilitation program on cardiovascular fitness, pain, and sleep

BEV 3901 Master's thesis in Human Movement Science

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## Acknowledgments

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## Abstract

*Aim:* The aim of this study was to assess the short-term effects of a work-related rehabilitation program on cardiovascular fitness, musculoskeletal symptoms, and cardiac autonomic regulation during sleep, by comparing a group receiving long-stay rehabilitation (3.5 weeks) vs., a group receiving short-stay rehabilitation (4+4 days).

*Method:* Three tests were performed on the patients enrolled for the work-related rehabilitation program: 1) Åstrand/Ryhming cycle test, 2) pressure pain threshold (PPT), and 3) heart rate variability during sleep. Subjective pain was scored on visual analogue scale (VAS). The pre-test measurements were performed on the first day of the intervention and post-test were performed during the last week of the intervention.

*Results:* No significant within or between group differences were found for maximal oxygen uptake or HRV during sleep from pre- to post-test. No significant change was found in subjective pain scores, although PPT in trapezius and erector spinae were significantly decreased from pre- to post-test. There was no significant difference in change in pain between the short- and long-stay groups.

*Conclusion:* The acute effect of the work-related rehabilitation program in cardiovascular fitness, autonomic regulation (indicated by HRV) and pain was small and mainly insignificant and there was no difference between the long-stay and short-stay groups. This study evaluated some of the factors that commonly are targeted in work-related rehabilitation programs, and the results highlight the importance of evaluating these programs. Future studies should investigate the long-term effect for the patients enrolled at the rehabilitation program.

**Keywords:** Work-related rehabilitation, musculoskeletal disorders, cardiovascular fitness, pressure pain threshold, sleep quality.

## Contents

## Introduction

Statistics from the Norwegian labour and welfare administration (NAV) shows that musculoskeletal disorders was the most common reason for long-term sick leave (> 16 days) in 2012, accounting for 32.5 % of the cases.[1] Long-term sick leave due to musculoskeletal disorders has decreased slightly the last years, while disability pension due to such disorders tended to increase, particularly among young adults. The number of persons who receive a disability pension in the age group 30-39 years have increased fourfold from 1977 to 2006, while the increase in the age group 25-29 years is threefold.[2] The most common musculoskeletal disorder associated with disability pension are back pain and widespread musculoskeletal pain, especially among women.[3]

The large individual and societal costs associated with musculoskeletal disorders underscore the importance of improving or maintaining musculoskeletal health and physical function.[4] Prevalence of musculoskeletal disorders increases with age, but is also very common among young people in the age group 20-29 years.[5] It is therefore important to develop measures that are effective in the secondary prevention of musculoskeletal disorders to reduce the adverse long-term consequences such as reduced work ability and disability.[6] It has been shown that the difficulty in returning to work increase with the length of the sick-leave period.[7] Thus, it is important that secondary preventive measures are implemented at an early stage in the sick-leave period.[8] Moreover, being on sick leave has been associated with a negative effect on psychological factors such as low self-esteem, loss of social contact, and less participation in social activities.[7]

The cause of musculoskeletal symptoms is likely to be multi-factorial and several risk factors have been identified including physical and psychosocial workplace factors[9] as well as life-style factors such as physical inactivity and obesity.[10, 11] Several different approaches and rehabilitation programs have been explored and applied to facilitate return to work after onset of musculoskeletal disorder.[6] Since musculoskeletal disorders are likely to have a multi-factorial origin, and that the mechanisms are unclear, compound rehabilitation programs are often used. The interventions often include a combination of physical activity, cognitive behavioral therapy, and workplace adaptations like ergonomic improvements and gradual exposure to the workplace and work tasks.[6, 12] Interventions which include work-related factors are scarce; a cohort study by Wåhlin and colleagues[8] in Sweden evaluated 699 patients who received either clinical or combined clinical and work-related interventions in order to return to work. They found that of those included in the cohort, approximately one-fourth of

the included sick-listed patients with musculoskeletal disorders received work-related intervention, and less than half of the included sick-listed patients with mental disorders received work-related interventions. Furthermore, a recent review found that clinical interventions (e.g., pain relieving medication, exercise therapy, back schools) is more commonly used in a rehabilitation setting than a work-setting (e.g. workplace adaption, job training, job redesign). Additionally, they found that only 9-20% of the Swedish patients that were sick-listed 3-4 months due to low back pain received work-related interventions while 62.6% received pain relieving medication.[13] These findings may appear paradoxical since several studies have shown that inclusion of work-place involvement in rehabilitation is effective[8, 14, 15] and more successful than treatment-as-usual.[16, 17] However, there are several open questions regarding the effectiveness of vocational rehabilitation programs, and some conflicting results have also been reported. Wåhlin and colleagues[8] found increased return to work in patients with mental disorders, but research on this patient group is scarce, and no firm conclusion can be made. In patients with musculoskeletal disorders, they found no difference in return to work between work-related interventions and treatment-as-usual.[8]

Physical activity is regarded as an essential part in most intervention programs, and there is convincing evidence that physical activity prevents chronic pain,[11] improves function and reduce pain in affected individuals.[9, 10] It is also well documented that physical activity reduces sick leave.[18, 19] However, there is still some uncertainty whether certain types of activity are more beneficial on musculoskeletal health than others.

Physical exercise has several possible mechanisms in pain reduction. Specific strength exercises may contribute to improvement of neuromuscular function and to restore sensorimotor control of the muscles.[20] Further, it has been hypothesized that resistance training may stimulate muscle spindles and Golgi tendon organs in the exercised muscles, and mechanoreceptors around the joints. This stimulation increase afferent nerve activity, which may inhibit the activity in the pain nerves, due to the gate control theory.[20] Additionally, physical exercise has showed central effect on pain inhibition. Exercise promote a decrease in sympathetic activity,[21] as well as induce release of endogenous opiods, which may reduce both peripheral and central pain by central desensitization.[20-22]

Chronic pain patients often have sleep disturbances and/or insomnia as comorbid symptoms.[23] The study of sleep in chronic pain patients is of importance because of the negative influence of poor sleep on pain, cognitive performance, vigor and mood.[24, 25] Studies have showed that more than 50% of patients with chronic pain are complaining of sleep disturbances or suffering from non-restorative sleep.[26, 27] Both experimental and prospective

studies indicate a bi-directional association between musculoskeletal pain and sleep disturbances, meaning that pain can disturb sleep and that poor sleep can amplify or cause pain.[27, 28] A dysfunction in the mesolimbic dopamine function, is central in the association between chronic pain and poor sleep.[23]

In general, sleep is a condition with higher vagal activity and lower sympathetic activity than during the awake state.[29] Analysis of heart rate variability (HRV) is a commonly used non-invasive method to explore cardiac autonomic regulation[30, 31] and provide useful information regarding possible derangements in autonomic regulation.[29] Recordings of HRV in patients with fibromyalgia during sleep have shown elevated sympathetic activity,[32] as well as attenuated parasympathetic activity during stage 2 sleep and REM sleep when compared to healthy individuals.[10] Other studies have shown that deprivation of slow wave sleep may induce fibromyalgia-like symptoms.[33] Thus, the current evidence indicates a strong association between poor sleep and chronic pain. However, whether work-related rehabilitation programs induce improvements in sleep quality and/or pain is still an open question.

The aim of the current study was to assess the short-term effects of a work-related rehabilitation program on cardiovascular fitness, musculoskeletal symptoms, and cardiac autonomic regulation during sleep, by comparing a group receiving long-stay rehabilitation vs., a group receiving short-stay rehabilitation.

## Methods

*Participants*

Thirty patients enrolled for work-related rehabilitation at Hysnes helsefort in the period from august 2013 to February 2014 were recruited for this study.

Hysnes helsefort is a rehabilitation center located outside of Trondheim, with focus on work-related rehabilitation. Participation in the current study was voluntary for those enrolled for the work rehabilitation program at Hysnes helsefort. At the day of arrival an information meeting was arranged, and the patients were given the opportunity to sign up for the study. They were informed that the participation would not affect the rehabilitation program.

The patients enrolled to the current study were offered two different treatments programs; 1) a program that last for 3.5 weeks and that demanded a continuous stay at Hysnes helsefort during the whole program period (i.e. defined as the *long*-stay group) or 2) a program that consist of 4 + 4 days stay at Hysnes helsefort, separated by two weeks (i.e. defined as the *short*-stay group). All participants in the current study fulfilled the following

criteria: 1) age 18-59 years, 2) at least 8 weeks, but less than 12 months continuous sick-leave, 3) residence in the Nord-Trøndelag or Sør-Trøndelag county, and 4) musculoskeletal disorder, light psychiatric disorders or/and unspecific disorders. The study protocol was approved by the Regional Committee for Ethics in medical research (project no. 2013/1125-6 REK midt) and all participants signed an informed consent before enrollment. The study was carried out according to the Declaration of Helsinki.

Characteristics of the participants in the long- and short-stay groups are presented in table 1. There was no significant difference between the groups in age, BMI or habitual physical activity.

Table 1. Baseline characteristic of the participants. Values are mean ± SD (range)

| | Long-stay (n=14) | Short-stay (n=16) | *p*-value |
|---|---|---|---|
| Male/Female | 3/11 | 2/14 | |
| Age (years) | 44.9 ± 6.5 (30-56) | 45.5 ± 7.0 (33-57) | 0.80 |
| BMI (kg/m$^2$) | 27.9 ± 2.2 (23.7 – 31.2) | 27.8 ± 7.5 (19.6-45.1) | 0.95 |
| IPAQ Index* | 3839 ± 3475 (165 – 11154) | 2066 ± 2426 (99-7784) | 0.79 |

Abbreviations: BMI, body mass index; IPAQ, international physical activity questionnaire
* MET score (MET-minutes/week)

The overall aim of the rehabilitation program at Hysnes Helsefort is to improve coping with work situations and health problems in patients on long-term sick-leave, by focus on three main measures; cognitive behavioral therapy (CBT), physical exercise and work-related training. An example of a typical week at Hysnes helsefort is showed in table 2. Moreover, an explicit aim by the rehabilitation program is to increase the participant's motivation and self-efficacy, increase their knowledge about physical exercise and to increase their physical capacity during the rehabilitation stay. The physical exercise in the long-stay group consisted in total of 12 hours of indoor individual and group training sessions (including strength training and endurance training), with each session lasting 1 – 1.5 hours. Additionally, the physical exercise consists of 8 hours of outdoor activities (including walking and an excursion). The short-stay groups' physical exercise consisted in total of 10.5 hours of individual- and group sessions (including strength training and endurance training), with each session lasting 1 – 1.5 hours. The patients were also encouraged to exercise unsupervised during their leisure time. The indoor exercise programs were individualized by taking the patients' initial training status and ambitions in consideration.

Table 2. An example of a time-table for long-stay and short-stay group the second week of the stay.

| Long-stay | | | | | |
|---|---|---|---|---|---|
| | Monday | Tuesday | Wednesday | Thursday | Friday |
| 08.00-08.30 | *Breakfast* | *Breakfast* | *Breakfast* | *Breakfast* | *Breakfast* |
| 08.30-09.30 | Walking | | Mindfulness | Walking | Mindfulness |
| 09.30-11.30 | CBT | Excursion | Indoor exercise | Spinning | CBT |
| 11.30-12.30 | *Lunch* | | *Lunch* | *Lunch* | *Lunch* |
| 12.30-14.30 | Relaxion and movement | | Dialogue | CBT | |
| 15.30 | *Dinner* | *Dinner* | *Dinner* | *Dinner* | *Dinner* |
| Short-stay | | | | | |
| 08.00-08.30 | | *Breakfast* | *Breakfast* | *Breakfast* | *Breakfast* |
| 08.30-09.30 | | | | Mindfulness | |
| 09.30-11.30 | | CBT | CBT | Indoor exercise | CBT |
| 11.30-12.30 | | *Lunch* | *Lunch* | *Lunch* | *Lunch* |
| 12.30-14.30 | | Indoor exercise | Movement | Dialogue | |
| 15.30 | | *Dinner* | *Dinner* | *Dinner* | *Dinner* |

Abbreviations: CBT, cognitive behavioral therapy

*Physiological recordings*

Cardiovascular fitness was measured by the Åstrand/Ryhming cycle test, performed on an ergometer cycle (828 E Monark, Sweden). Measuring heart rate (HR) at submaximal load and extrapolate them into the expected age-adjusted maximal HR values is commonly used as an indirect measurement of cardiovascular fitness (Bahr, 1991). HR was measured by Polar F1+ wrist watch (Polar Electro, Finland).

Pressure pain threshold (PPT) was measured by an algometer (Somedic Algometer type 2, Sweden). Patients with painful conditions commonly report soft tissue tenderness. Measurement of PPT has been shown to be a reliable method to indicate level of soft tissue tenderness.[34, 35]

Autonomic regulation during sleep was evaluated by HRV recordings obtained by Actiheart (CamNtech Ltd., UK). Several studies have shown that the Actiheart is a reliable tool for measuring HR, HRV and activity.[36-39] It combines a HR monitor that record beat-to-beat intervals and a uni-axial accelerometer in a small and compact device. The Actiheart is worn on the chest, attached to two standard ECG electrodes. It is a waterproof, non-invasive

device, weighing less than 10 grams, which makes it comfortable and easy to wear over multiple days.

*Procedure*

The data collection took place at Hysnes helsefort. The pre-test was carried out on the day of arrival, while the post-tests were completed 3 weeks later. Figure 1 show the timeline of the testing process during the rehabilitation stay. The procedure for data recording was identical at the pre- and post-test.

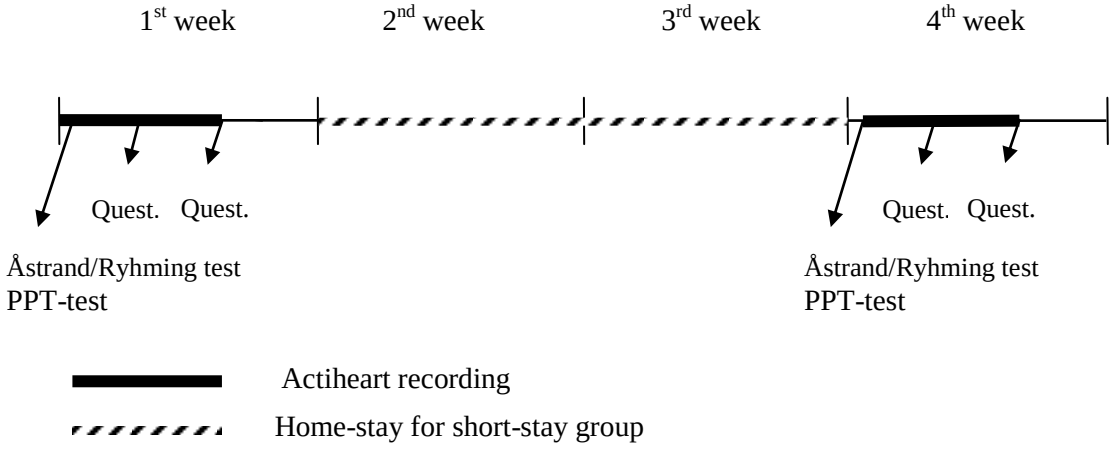



Figure 1. Timeline of the rehabilitation stay at Hysnes helsefort including pre- and post-test. The long-stay group stayed at Hysnes helsefort throughout the 3.5-week period while the short-stay group stayed home the 2nd and 3rd week.

First, measurements of weight and height were performed, followed by placement of the Actiheart. The placement of the electrodes differed between sexes; on females the first electrode was placed at sternum at the level between costa 2 and 3, and the second 10 cm to the left. On males, the first electrode was placed at sternum at the level between costa 4 and 5, and the second just below the left pectoralis major. The registration started immediately.

The PPT was measured seated, and the pressure was performed bilaterally on trapezius, infraspinatus, erector spinae and tibialis anterior. The probe area was 1 $cm^2$ and pressure increase speed was 40 kPa/s. The patients were instructed to press the signal button when the pressure changed to being painful. The test was repeated 3 times, separated with 2 minutes break. The PPT was expressed as mean values of the 3 measurements for each individual muscle.

Finally, the Åstrand/Ryhming cycle test was performed. HR was recorded by a HR monitor (Polar T31) placed around the chest. The participant was instructed to maintain a cadence of 60 rpm throughout the test and the starting load was estimated by taking age, gender and training status in consideration. If the initial load was set too high or too low, it could be adjusted during the test, although, the last load should be continued for 6 minutes. The test was approved if the participants achieved a heart rate between 120 - 160 bpm after 6 minutes. Maximal oxygen uptake (ml/kg/min) was estimated by taking the average of the two last measurements of the HR, and applied this value to the Åstrand/Ryhming nomogram,[40] corrected by the Åstrand age factor.[41]

The subjective measures were collected by questionnaires. One questionnaire was handed out to the participants at the pre- and post-test with instruction to complete the questionnaire upon awakening the two following mornings. The questionnaire included evaluation of sleep quality the preceding night by the questions: 1) 'How deep was your sleep?', with 5 answers ranging from 'very light' to 'very deep', 2) 'Have you been awake during the night and, if so, for how long', with the answers 'not at all', 'a few minutes (1-10 min)', '10-30 minutes', '30-60 minutes' and 'more than one hour', and 3) 'How many times were you out of bed during the night?' with answers ranging from 0 – 5 times or more.

More general information about musculoskeletal pain, fear avoidance beliefs, and quality of life were collected at the first or second day after arrival and again after completing the rehabilitation program. Norsk smerteforenings minimumsspørreskjema (Nosf-miss) is a questionnaire used to assess pain.[42] It consists of selected questions from other validated questionnaires (Brief Pain Inventory[43] and Coping Strategies Questionnaire[44] were used in this present study). Nosf-miss included questions to indicate the 'worst pain during the last week', 'least pain during the last week', and the 'average pain the last week' excluding pain localization. The questions were scored on a visual analog scale (VAS) from 0-10 (0=no pain, 10=worst possible pain).

The Fear Avoidance Belief Questionnaire (FABQ)[45] include questions on how pain is affected or associated with physical activity (response option '0 - completely disagree' to '6 - completely agree' on all items): 1) 'My problem was caused by physical activity', 2) 'Physical activity makes my problem worse', 3) 'Physical activity might harm my body', 4) 'I should not do physical activities which might make my pain worse', and 5) 'I cannot do physical activities which might make my pain worse'. The total FABQ score were calculated by adding the scores from question 2-5.

Additionally, one questionnaire was asked only at baseline: International Physical Activity Questionnaire (IPAQ)[46] was used to assess the participant's physical activity level. They were asked to recall how many days and hours a day of vigorous, moderate and low intensity activity performed the last 7 days. The answers gave a total MET-score of MET-min/week which can estimate the activity level.

*Data analysis*

The data from Actiheart was analyzed using the Actiheart software (version 4.0.103). Two separate sleep analyses were made, both using time and frequency domain analysis. The sleep period was determined by self-reported sleep time. The first analysis included a detailed analysis of inter-beat interval (IBI), including low frequency (LF) and high frequency (HF) components, as well as root mean square successive difference (RMSSD) and total HRV (standard deviation of RR-intervals) of the IBI data, HR and activity counts. The analysis of HRV was done by using the average of each HRV variable from the first and second night.

The second HRV analysis evaluated the cardiac autonomic regulation during different sleep stages; stage 1/2 sleep (i.e. light sleep), stage 3/4 sleep (i.e. deep sleep) and rapid-eye-movement (REM) sleep, including only continuing periods of 5 minutes of the same stage. HR, total HRV and RMSSD was included in this analysis.

The statistical analysis was performed in IBM SPSS statistics 20 and Microsoft Excel. A repeated measure ANOVA test was used to test the differences from pre- to post-test in Åstrand/Ryhming test, PPT, HRV and subjective pain scores (VAS), and to test the interaction between the two groups within these variables. A Shapiro-Wilk test was used to examine if the data were normally distributed. Logarithmic values for HRV and PPT were calculated because they were not normally distributed.

To evaluate sleep quality, a Wilcoxon signed rank test was performed to assess changes in pre- and post-test due to not normally distributed variables. Logarithmic values were not possible to obtain because of frequent zero-values. To compare the two different groups, a Mann-Whitney U-test was used.

## Results

Of the 30 participants enrolled to the study, one participant from the short-stay group was excluded from analysis of maximal oxygen uptake due to technical failure during data recording. Seven participants were excluded from the HRV analysis because of technical

failure during the recordings (2 in the short-stay group and 5 in the long-stay group). Finally, 3 participants in the long-stay group were excluded from questionnaire analysis, because of missing data.

*Maximal oxygen uptake*

Table 3 shows the estimated maximal oxygen uptake (ml/kg/min) for the long- and short-stay group at the pre- and post-test. There was no significant effect of time (pre- vs. post-test) on the estimated maximal oxygen uptake ($F$[1, 27]=2.87, $p$=0.10) and no group by time interaction ($F$[1, 27 ]=0.35, $p$=0.56).

Table 3. Estimated maximal oxygen uptake (ml/kg/min) at pre- and post-test. Values are mean ± SD.

| | Pre-test | Post-test | Δ (post-pre) |
|---|---|---|---|
| Long-stay (n = 14) | 25.3 ± 5.3 | 26.8 ± 6.2 | 1.5 ± 3.9 |
| Short-stay (n = 15) | 27.2 ± 10.5 | 27.9 ± 10.5 | 0.7 ± 3.2 |

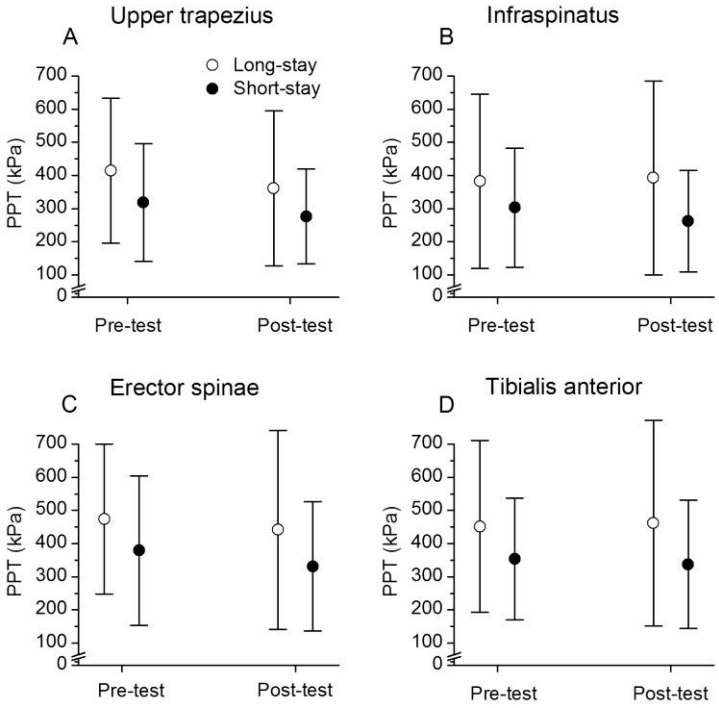
*Pressure pain threshold and subjective pain scores*

Figure 2 shows PPT for upper trapezius (A), infraspinatus (B), erector spinae (C), and tibialis anterior (D). There was a significant effect of time for trapezius ($F$[1-28]=11.209, $p$=0.002) and erector spinae ($F$[1-28]=6.005, $p$=0.02) indicating a reduction in PPT from pre- to post-test; however, there was no group by time interaction neither for trapezius ($F$[1, 28]=0.447, $p$=0.51) or erector spinae ($F$[1, 28]=0.094, $p$=0.76). There was no significant effect of time for infraspinatus ($F$[1, 28]=1.112, $p$=0.30) or tibialis anterior ($F$[1, 28]=0.390, $p$=0.54) and no group by time interaction: infraspinatus ($F$[1, 28]=1.006, $p$=0.32,) and tibialis anterior ($F$[1, 28]=0.006, $p$=0.94).

Detailed statistics of the subjective pain questionnaires are shown in table 4. There was no significant effect of time for strongest pain ($F$[1,25]=2.224, $p$=0.15), weakest pain ($F$[1,24]=0.01, $p$=0.92) or average pain ($F$[1,25]=0.842, $p$=0.37). Furthermore, there was no group by time interaction in any of the variables: strongest pain ($F$[1,25]=0.076, $p$=0.79), weakest pain ($F$[1,24]=1.086, $p$=0.31) or average pain ($F$[1,25]=0.842, $p$=0.37) .

*Nocturnal heart rate variability and sleep quality*

Figure 3 shows HRV averaged over the total sleep period (A-C), during stage 1/2 sleep (D-F), during stage 3/4 sleep (G-I), and during REM-sleep (J-L).




Figur 2. PPT at pre- and post-test for upper trapezius (A), infraspinatus (B), erector spinae (C) and tibialis anterior (D). Open circles indicate values for the long-stay group and filled circles the short-stay group. Values are mean ± SD.

Considering the total sleep period there was no significant effect of time (pre- vs. post-test) for any of the HRV variables: BPM ($F$[1, 21]=1.805, $p$=0.19), total HRV ($F$[1, 21]=0.338, $p$=0.57), RMSSD ($F$[1, 21]=0.032, $p$=0.86), and LF/HF ($F$[1, 21]=0.481, $p$=0.50), (not shown in figure). Furthermore, there was no group by time interaction for any of the variables when considering HRV for the total sleep period: BPM $F$(1, 21)=0.001, $p$=0.98, total variability $F$(1, 21)=0.594, $p$=0.45, RMSSD $F$(1, 21)=0.535, $p$=0.47, LF/HF $F$(1, 21)=0.066, $p$=0.80. Further analyses of HRV within stage 1/2, stage 2/3, or REM sleep showed no significant effect of time ($p\geq0.15$ for all comparisons) or group by time interaction ($p\geq0.29$ for all comparisons).

Table 4. Subjective pain score (VAS) last week at pre- and post-test. Pain scores are irrespective of location. Mean values ± SD.

| | Pre-test | Post-test | Δ (post-pre) |
|---|---|---|---|
| Long-stay | | | |
| Strongest pain | 5.4 ± 2.2 | 4.7 ± 2.7 | -0.6 ± 2.0 |
| Weakest pain | 1.7 ± 1.6 | 2.0 ± 1.7 | 0.3 ± 1.1 |
| Average pain | 3.5 ± 1.8 | 3.5 ± 1.8 | 0.0 ± 2.1 |
| Short-stay | | | |
| Strongest pain | 5.4 ± 1.7 | 5.0 ± 2.6 | -0.4 ± 1.7 |
| Weakest pain | 2.8 ± 1.7 | 2.4 ± 1.8 | -0.4 ± 1.8 |
| Average pain | 4.7 ± 1.7 | 4.8 ± 2.1 | 0.1 ± 1.7 |

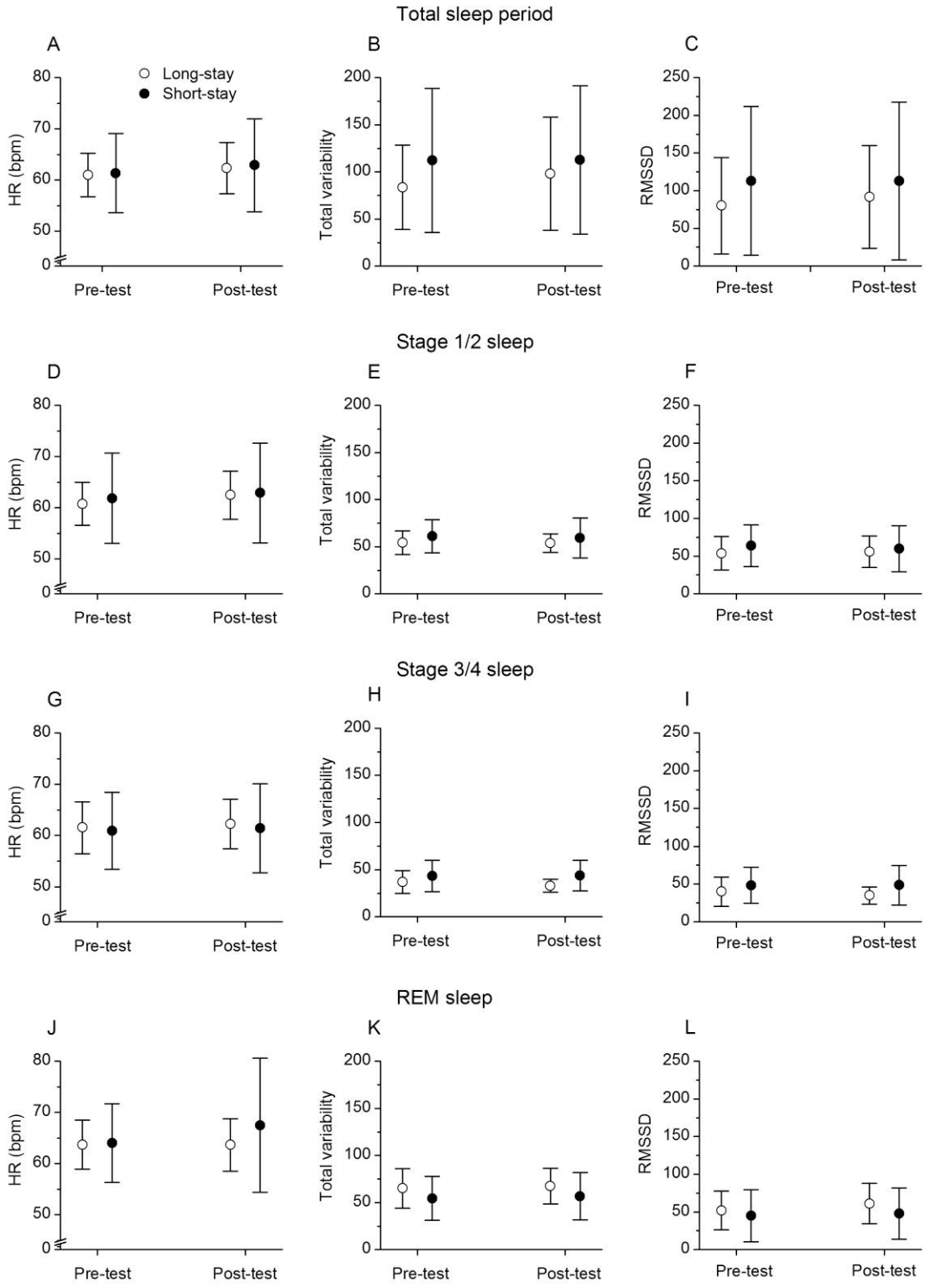



Figure 3. HRV during the total sleep period (A-C), stage 1/2 sleep (D-F), stage 3/4 sleep (G-I), and REM sleep (J-L) for the long- (open circles) and short-stay (filled circles) group at pre- and post-test. Values are mean±SD.

Table 5 shows the subjective scores of sleep quality at the pre- and post-test, and the change from pre- to post-test. There was no significant difference between pre- and post-test within the groups ($p \geq 0.67$ for both comparisons), and there was no group difference at pre-test, post-test or in Δ-change from pre- to post-test ($p \geq 0.29$).

Table 5. Subjective scores of sleep quality from 1 (very light sleep) to 5 (very deep sleep). Values are mean ± SD

| | Pre | Post | Δ (post-pre) | *p*-value* |
|---|---|---|---|---|
| Long (n = 9) | 3.3 ± 0.8 | 3.3 ± 1.1 | 0.0 ± 1.5 | 0.67 |
| Short (n = 15) | 2.8 ± 0.9 | 2.8 ± 1.1 | 0.0 ± 1.6 | 0.92 |
| *p*-value** | 0.29 | 0.44 | 0.93 | |

* Wilcoxon signed-rank test within group
** Mann-Whitney u-test between groups

*Fear Avoidance Beliefs*

Table 6 shows the total FABQ score at the pre- and post-test and the change from pre- to post-test. No significant change in FABQ score from pre- to post-test was found within groups ($p \geq 0.50$ for all comparisons), and there was no difference between groups ($p = 0.72$).

Table 6. FABQ score ranging from 0-24. Values are mean ± SD

| | Pre | Post | Δ (post-pre) | *p*-value* |
|---|---|---|---|---|
| Long-stay (n = 11) | 6.0 ± 5.2 | 6.9 ± 9.0 | 0.9 ± 6.9 | 0.89 |
| Short-stay (n = 16) | 10.8 ± 6.3 | 10.0 ± 6.2 | -0.8 ± 3.7 | 0.50 |
| *p*-value** | 0.04 | 0.15 | 0.72 | |

* Wilcoxon signed-rank test within group
** Mann-Whitney u-test between groups

As shown in table 7, there was a relatively strong association between pain and one of the statements in FABQ; 'physical activity increase the pain' at baseline (Spearmans $\rho = 0.44$ to 0.71, $p = 0.01$ to 0.18). This association remained essentially unchanged from pre- to post-test.

Table 7. Correlation (Spearman´s ρ) between baseline subjective pain (VAS) and FABQ 'physical activity increase the pain'.

| | Long-stay (n = 11) FABQ | Short-stay (n = 16) FABQ |
|---|---|---|
| Strongest pain | 0.46 | 0.49 |
| Weakest pain | 0.61* | 0.58 |
| Average pain | 0.71** | 0.44 |

* $p<0.05$
** $p<0.01$

## Discussion

The purpose of this study was to investigate the acute effects of a work-related rehabilitation program on maximal oxygen uptake, pain, and HRV during sleep. A second purpose was to compare effects between a long- vs. short-stay group. Overall, there was no change on maximal oxygen uptake, HRV during sleep, subjective sleep quality, or subjective pain scores from pre- to post-test. A decrease in PPT in trapezius and erector spinae was found from pre- to post-test, while PPT in infraspinatus and tibialis anterior remained unchanged. There were no differences between groups regarding changes from pre- to post-test. It remains unclear whether the rehabilitation program has any long-term effect.

*Maximal oxygen uptake*

The results for the maximal oxygen uptake in the present study are in contrast to other studies that have investigated the effect of endurance exercise in patients with musculoskeletal disorders. Valim and colleagues[21] found that low-intensity walking, 3 times a week for 20 weeks, was sufficient to increase physical capacity in women with fibromyalgia. Additionally, a review by Mannerkorpi and Henriksson[47] found that supervised aerobic exercise at 55-90% of maximum HR, performed 20 minutes twice a week, improved aerobic fitness in fibromyalgia patients. A likely explanation for the lack of improvement in maximal oxygen uptake in the present study, especially in the long-stay group, is inadequate duration and intensity of the physical exercise. Mier and colleagues[48] studied cardiovascular adaptations in healthy subjects and found an increase in $VO_{2max}$ after a 10 days training regime. The subjects exercised 1 hour each day with high intensity interval training. Furthermore, Hickson and colleagues[49] found a 14% increase in $VO_{2max}$ within the first 3 weeks of a cycle exercise intervention for healthy subjects, which included exercise for 40 minutes/day, 6 days/week. The exercise consisted of 3 days of high intensity interval training and 2 days of continuous training. The studies show that the body can adapt rapidly to training, and an increase in $VO_{2max}$ can occur within short time.[50]

The baseline maximal oxygen uptake was low in both groups in the current study (i.e., 25.3 ml/kg/min in the long-stay group and 27.2 ml/kg/min in the short-stay group). Because of this low baseline, one could expect that their maximal oxygen uptake would increase rapidly due to enhanced amount of exercise. One could also expect that there would be a difference between the long- and short-stay group due to the difference in the amount of physical activity during the stay. However, no difference was found between the two groups,

which indicate that the duration and intensity of the exercise in the long-stay group is insufficient to induce an increase in maximal oxygen uptake.

*Pressure pain threshold and subjective pain scores*

An unexpected decrease in PPT was found in trapezius and erector spinae from pre- to post-test; however, there was no significant difference in change between the groups. The subjective pain scores (VAS) did not show any significant difference from pre- to post-test, nor any difference were found between the groups. These results are in contrast to earlier studies evaluating multidisciplinary treatment in chronic pain patients.[14, 51] Becker and colleagues[51] found that an individual outpatient multidisciplinary treatment program, including primarily CBT and an introduction to exercise programs, had a reduction in pain intensity after 3 and 6 months follow-up. Similar results were found in a pilot study by Dunstan and Covic,[14] who evaluated a multidisciplinary work-related activity program in chronic pain patients. A reduction in pain severity was found from pre- to post-test after a 6 week intervention including CBT and low intensity endurance exercise.

Furthermore, the results are in contrast to earlier reports indicating that exercise have an analgesic effect in humans due to increase in β-endorphin levels, which are associated with change in pain perception.[21, 22] Moreover, studies have investigated effects of physical training on pain perception by PPT measures.[52, 53] Nielsen and colleagues[53] found that 20 minutes of specific strength training intervention in affected muscles, 3 times a week for 10 weeks, increased the PPT in the trained muscles in women with trapezius myalgia compared to a non-exercising reference group. Additionally, they found that both specific strength training and general fitness training increased PPT in non-painful reference muscles. Andersen and colleagues[52] found that interventions with both 2 minutes and 12 minutes of strength training 5 days a week over a 10 week period, increased PPT in both trained and non-trained reference muscle. Furthermore, Casso and colleagues[54] evaluated a physical reconditioning program including both strength training and endurance training. They found that a 3 week intervention, including 3 hours of training a day, 5 days a week, reduced the subjective pain score (measured by VAS) by 18% from admission to discharge in non-specific low back pain patients. The amount of training differs from the present study, and may explain the deviating results. Moreover, the mean VAS pain score were lower in the present study; 4.7 and 3.5 in short-stay and long-stay respectively, whereas 6.1 in the study by Casso on colleagues. The improvement potential may therefore be lower in the present study, and could explain the different results.

Moreover, the lack of change in PPT in the present study compared to the other studies may be due to lack of improvements in physical fitness. Aerobic exercise has shown effect on pain reduction.[47] A review by Mannerkorpi[47] evaluated the non-pharmalogical treatment in patients with chronic widespread musculoskeletal pain, and found that moderate – to high-intensity aerobic training improved pain and well-being. Two controlled trials[55, 56] evaluated the effect of aerobic exercise in patients with fibromyalgia. McCain and colleagues[55] found improved fitness and pain thresholds after a 20 week cycling regime including 1 hour exercise 3 times a week. Similar results were found by Wigers and colleagues,[56] evaluating a 14 week aerobic training regime including 45 minutes of exercise 3 times a week. They found improved aerob capacity, reduced number of pain sites and tender point score.

One could also suggest that the enhanced amount of exercise during the rehabilitation stay could have a negative effect on pain perception. A review by Kurtze[57] evaluated the effect of physical exercise on fibromyalgia patients, and found that in several cases pain and stiffness were enhanced during the initiation of an activity program, although this condition could gradually be reversed by continuing the exercise. Many of the studies in the review by Kurtze were limited by short intervention time, which lead to the suggestion that any training intervention less than 20 weeks would be too short to evaluate any decrease in pain intensity. Additionally, a review by Clark and colleagues[58] identifying the risks and benefits of physical exercise in fibromyalgia patients, indicates that exercise may trigger the stress hormones and induce post-training pain.

*Nocturnal heart rate variability and sleep quality*

Because of the high prevalence of sleep disturbances and non-restorative sleep in chronic pain patients,[26, 27] evaluation of interventions and the effect on sleep quality is of major importance. In this present study, the sleep HRV analysis and sleep stage analysis did not show any significant change from pre- to post-test. Neither any difference was found between the groups. Further, no significant change was found in subjective sleep quality from pre- to post-test, nor was there any difference between the groups. These results are in contrast to earlier findings that physical activity has positive effect on sleep quality and insomnia.[59] A study by Reid and colleagues[59] evaluated the effect of aerobic exercise and sleep education on self-reported sleep quality in older adults with insomnia. The intervention included moderate-intensity training with increasing duration up to 40 minutes 4 days a week for 16 weeks. The study showed improvements in subjective sleep quality from pre- to post-test. The effect size

for the improvements was similar or even greater than reports from other studies including CBT interventions or other physical activity interventions.[59]

A study by Becker[51] including CBT in a multidisciplinary rehabilitation program, did not find any short-term effects on sleep quality. However, at 6-months follow-up, a modest within-subject improvement was found. One could assume that changes could be measured after a longer period. Thus, a long-term follow-up on HRV and sleep quality would therefore be of interest also in the current study.

A review by Smith and Haythornthwaite[27] investigated the relationship between sleep disturbance and chronic pain, and found that there are inconsistent results on the effect on sleep disturbance after multidisciplinary rehabilitation programs including CBT. However, they found that CBT aimed specifically for insomnia are likely to be effective on sleep quality in chronic pain patients. There are limited case studies and clinical trials within this area and further research are needed. The CBT in the rehabilitation program in the current study was mainly aimed to increase the participant's motivation, self-efficacy and reduce sickness absence, and may therefore have limited effect on sleep.

*Fear avoidance beliefs*

The patients answered questions from the FABQ, which is a validated and reliable questionnaire to evaluate fear avoidance beliefs in pain patients.[45] The results from the FABQ did not show any significant difference from pre- to post-test, nor any difference between the groups. The lack of significant change in FABQ could be due to low ability to detect changes in the FABQ-scale, in particular, if the patients are in the lower end of the scale at baseline.[60] Maximum score from FABQ on physical activity is 24, and the participants in the present study had a mean score of 6.0 and 10.8 in the long- and short-stay group respectively, which place them in the lower end of the scale. Furthermore, it is suggested that FABQ may be a prognostic measure rather than a tool to evaluate an effect of intervention.[60]

The relative strong correlation between the question 'physical activity increase the pain' and pain scores on VAS may describe the study group. Because of the pain, the patients may no longer perform physical activity because the belief that the physical activity increase the pain. This result are similar to findings by Chung and colleagues[61] who showed significant correlation between FABQ for physical activity and subjective pain score evaluated by VAS in patients with low back pain.

*Limitations of the study*

There are several limitations to the present study that should be considered in the interpretation of the results. First, the number of participants was rather small, thereby limiting the possibility to detect small difference between the groups. Moreover, missing or inadequate data in some of the subjects further reduced the sample size in some of the statistical analyses. A larger group of participants would be necessary to further evaluate the acute effects of the rehabilitation stay at Hysnes helsefort.

Second, the persons participating in this study were a heterogeneous sample, including multiple diagnosis, diverse pain locations, pain intensity, and age. This heterogeneity introduces large variability in the data and reduces the possibility of detecting differences between the groups. Moreover, because of the heterogeneity in the study group, it makes it difficult to compare the present study to other similar studies that often operates with well defined and more homogeneous groups. Nevertheless, there were no within-subject differences indicating that the rehabilitation program at Hysnes helsefort has limited impact on cardiovascular fitness, pain and sleep problems, although these analyses could be hampered by low statistical power.

Third, there were limitations regarding the measurements. Measuring cardiovascular fitness by Åstrand/Ryhming cycle test is an indirect measure of maximum oxygen uptake, which may lead to uncertain outcome compared to direct measures, e.g., systematic underestimation of maximum oxygen uptake in unfit individuals.[41] However, the test is useful to evaluate within subject changes. The biases in Åstrand/Ryhming cycle test are related to HR measurements, variations in work efficiency and maximum HR. Within the same individual these biases are mostly constant, which makes it a reliable test to measure change in cardiovascular fitness (Bahr 1991). The reliability of the Åstrand/Ryhming cycle test is confirmed by several studies, and evaluated as good.[62, 63]

Further, measuring pain by PPT could include measurement error. However, using an algometer for objective PPT is by several studies considered as a reliable technique for measuring tenderness in muscles.[34, 35, 52, 64, 65] Inflammation, excessive strain and psychosocial stress are believed to sensitize nociceptors in affected areas.[66] Further, PPT is considered as an efficient technique to evaluate effects of rehabilitation or training on soft tissue tenderness.[66] The subjective pain scores (VAS) were obtained by the Nosf-miss questionnaire, which is a well established tool for pain evaluation in patients,[42] and the validity and reliability have been evaluated as good.[67]

Finally, the lack of effect on sleep quality in the present study may be due to inadequate measure of sleep quality. Using data from HRV measures is an indirect technique to assess sleep, which must be taken into consideration. However, knowing that sleep consists of fluctuation of autonomic activity and that this activity is reflected in variations of the heart rate, HRV measurements can be used to evaluate cardiac autonomic regulation during sleep.[29] This method was recently supported in a case-control study by Burton and colleagues[68] where HRV data were compared to subjective data. In the present study there were collected nocturnal HRV data. Because of limited sleep registration by the Actiheart monitor, the valid sleep period could not be determined objectively. Subjective reports were used to determine the sleep period, which could include some recall biases. To increase the validity of the measurement in the present study, the HRV recording was continuous for 48 hours, including two nights of sleep. This reduced the bias of adapting to new environment, which could be present in the first night.

There is in general lack of studies in return-to-work rehabilitation, and in vocational rehabilitation area in particular. Vocational rehabilitation is developing, and studies indicate positive results compared to traditional rehabilitation stay.[8, 12, 16] The present study was a small study, but indicates the importance of evaluating the existing work-related rehabilitation programs. In all industrial countries, the costs of sickness- and disability benefits have increased considerably the last decades,[69] which makes it important to attain more research within this area to prevent the increase in disability pension and to improve work ability in patients on long-term sick-leave.

## Conclusion

The current study evaluated acute effects of the two different work related rehabilitation groups at Hysnes helsefort, including patients with 2-12 months sick-leave. There was no significant change in cardiovascular fitness or sleep quality from pre- to post-test. A significant decrease in PPT in trapezius and erector spinae was found from pre- to post-test, however, no significant difference was found in subjective pain scores (VAS). Overall, there was no significant difference between the long- and short-stay group on any of the outcomes. The long-term effects and the return-to-work status after enrollment in the rehabilitation stay at Hysnes helsefort, still remains unclear. This study evaluated some of the important factors that are involved in regular work-related rehabilitation programs, and the results contribute to highlight the importance of evaluating these programs. Because of the increase in disability

pension and high societal costs, it is important to approach the most economic and effective intervention. Future studies should investigate the long-term effect for the patients enrolled at Hysnes helsefort.

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