Physical capacity and work-related musculoskeletal symptoms

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In the working population, muscle fatigue and musculoskeletal discomfort are common, which, in the case of insufficient recovery, may lead to musculoskeletal pain. Musculoskeletal pain at work may lead to medical consumption, sickness absenteeism, or disability claims with high costs for society. Several factors have been found that may increase the risk of future musculoskeletal pain among workers including gender, age, previous pain, and exposure to several work-related risk factors.

Furthermore, low physical capacity might be related to future musculoskeletal pain. Physical capacity includes measures of muscle strength, muscle endurance, mobility, and cardiovascular fitness.

In this thesis, the impact of physical capacity on future work-related musculoskeletal pain was investigated. More specifically, the different pathways in the generally accepted conceptual model of physical capacity and exposure to physical factors in relation to future low back, neck and shoulder pain were investigated. We focussed this thesis on muscle strength, and muscle endurance of the back and neck/shoulder muscles and mobility of the spine.

The generally accepted conceptual model of physical capacity and exposure to physical factors states that workers with high physical capacity can better deal with high exposure to work-related physical factors, than those with low physical capacity. This model is commonly used in every day practice as an explanation for future musculoskeletal pain. However, evidence to support the plausibility of this model is lacking. We assumed that both low physical capacity and high exposure to work-related physical factors might be independent risk factors for musculoskeletal discomfort at short-term and pain at long-term. Furthermore, we assumed that an imbalance between these two risk factors (i.e. low capacity in combination with high exposure) might be a stronger risk factor than each of these variables on its own. The different chapters of this thesis focus on the different pathways of the model.

Chapters 2 to 4 of this thesis focused on physical capacity. Chapter 2 reported on the age-related and gender-specific differences in physical capacity. We used data of the longitudinal Study on Musculoskeletal disorders, Absenteeism, Stress and Health (SMASH) to analyze this. This is a prospective cohort study of almost 1800 male and female workers from 34 companies throughout the

Netherlands with a follow-up of 3 years. It consisted of a mixed working population from white-collar, blue-collar and caring professions. At baseline, physical capacity, including isokinetic muscle strength of the back and neck/shoulder muscles, static endurance of the back, neck and shoulder muscles, and mobility of the spine were assessed. Measurements of static muscle endurance were repeated at follow-up. For isokinetic muscle strength, we analyzed the relationship with age only cross-sectionally at baseline using quadratic regression analyses. For static muscle endurance, we analyzed for 5-year age-groups the age-related differences both cross-sectionally and longitudinally using the mean differences at baseline and after three years of follow-up. We stratified the results for gender and sports participation.

The results of this chapter showed that performance in tests of isokinetic muscle strength was lower at older ages than at younger ages, with optima between 19 and 33 years. Men had higher isokinetic muscle strength than women. Cross-sectionally, the mean performance for static back endurance had its optima at 29 years and 42 years among men and women, respectively. However, for the neck and shoulder muscles, performance was higher among older workers. In contrast, muscle endurance decreased longitudinally among all age-groups. Taking sports participation into account, the results suggested that younger workers who participated in sports for 3 hours per week or more had the best performance. Surprisingly, however, the results suggested that older workers who participated in sports between 0 and 3 hours per week had higher isokinetic muscle strength than those who participated in sports for 3 hours per week or more.

We concluded that there were age-related differences in isokinetic muscle strength, and static muscle endurance of the back and neck/shoulder muscles. Isokinetic muscle strength was highest among young male workers who participated in sports. Static muscle endurance was highest among older workers, but was comparable among men and women. (Moderate) sports participation seems to be effective in keeping aging workers suitable for their relatively growing work demands.

Chapters 3 and 4 reported on the independent association between physical capacity and incidence of low back, and neck/shoulder pain both with regard to the evidence in the literature, and the evidence obtained from SMASH. Chapter 3 was a systematic literature review, in which the results of 26 previous prospective cohort studies were summarized on the evidence that low muscle strength, low muscle endurance, or reduced spinal mobility were predictors of future low back or neck/shoulder pain. Abstracts found by electronic databases were checked on several inclusion criteria. Two reviewers separately evaluated the quality of the studies. Based on the quality and the consistency of the results of the included studies, three levels of evidence were constructed.

Twenty-four prospective cohort studies were included in the longitudinal relationship between physical capacity measures and the risk of future low back pain and three studies reported on future neck/shoulder pain. We found strong evidence for an absence of a relationship between trunk muscle endurance and the risk of future low back pain. Furthermore, due to inconsistent results in multiple studies, we found inconclusive evidence for a relationship between trunk muscle strength, and also inconclusive evidence for a relationship between mobility of the lumbar spine and the risk of low back pain. Finally, due to a limited number of studies, we found inconclusive evidence for a relationship between physical capacity measures and the risk of neck/shoulder pain. In conclusion, except for strong evidence for an absence of relationship between static muscle endurance and future low back pain, we found inconclusive evidence for a relationship between physical capacity and future musculoskeletal pain. Due to heterogeneity, the results of this systematic review have to be interpreted with caution.

Chapter 4 reported on the independent relationship between isokinetic muscle strength, static muscle endurance, or mobility of the lumbar spine, and future low back, neck or shoulder pain using SMASH-data. Pain was self-reported at baseline and three times annually during follow-up using an adapted Dutch version of the Nordic Questionnaire. We defined an incident case of low back, neck, or shoulder pain if a pain-free episode (i.e. no, or sometimes pain in the past 12 months) was followed by an episode with pain (i.e. regular, or prolonged pain in the past 12 months). Poisson Generalized Estimations Equations (GEE) was used to analyse the association between baseline physical capacity and low back, neck, or shoulder pain at every follow-up moment. In order to adjust for differences in performance in tests of physical capacity between men and women, we calculated sex-specific tertiles. Both univariate and multivariate risk ratios (RRs), with adjustment for confounders, were calculated with the highest tertile as reference category.

The results of this chapter showed an increased risk of future low back pain among workers with low static trunk muscle endurance, but no association with isokinetic trunk lifting strength, or mobility of the spine. Furthermore, we found an increased risk of future neck pain among workers with low isokinetic lifting strength, or low static muscle endurance. We did not find any association between physical capacity and future shoulder pain.

We concluded that poor low back and neck muscle endurance were independent predictors of future low back and neck pain, respectively, and that low lifting neck/shoulder strength was an independent predictor of neck pain. Low physical capacity was not a predictor of future shoulder pain.

Chapter 5 dealt with an imbalance between physical capacity and exposure to work-related physical factors, in relation to incidence of low back, neck, or shoulder pain. Again, we used data of SMASH. Exposure to work-related physical factors was assessed at baseline by means of video-observations. Imbalance was defined as lower than median capacity combined with higher than median exposure, "high balance" as high capacity with high exposure and "low balance" as low capacity with low exposure. Workers with high capacity and low exposure (i.e. "in balance") were the reference group. Again, data were analyzed by means of Poisson GEE.

We found that for both the low back and neck, imbalance between static muscle endurance and working in flexed postures was a risk factor for future pain. Low balance between these two variables was also a risk factor for future low back pain. Furthermore, low balance between isokinetic lifting strength and lifting exposure was a risk factor for future low back and neck pain, but this was not found for imbalance. No associations were found with future shoulder pain.

In conclusion, for low back and neck pain, this study partly supported our hypothesis that an imbalance between physical capacity and exposure to work-related physical factors would lead to an increased risk of future musculoskeletal pain. In general, however, an imbalance between physical capacity and exposure to physical factors was not found to be a more important predictor of future musculoskeletal pain than each of these variables on its own.

Chapter 6 reported on peak or cumulative musculoskeletal discomfort at work as predictors of future musculoskeletal pain among symptom-free workers.

Again, data of SMASH were used. Localized musculoskeletal discomfort (LMD) was assed at baseline. The LMD-method was based on the Borg category ratio scale ranging from 0 (no discomfort at all) to 10 (extreme discomfort, almost maximum). Workers were asked to indicate their LMD-ratings six times during a working day in 13 parts of the body using an adapted map of the back site of the body. Peak discomfort was defined as a discomfort level of 2 at least one time during a day, which was derived from the ISO-guideline for static working postures. Cumulative discomfort was defined as the sum of discomfort during the day. Reference workers reported a rating of zero at each measurement. We selected a symptom-free subpopulation of workers. Again, data were analyzed by means of Poisson GEE.

We found that LMD increased during the morning, decreased after the lunch break, and increased again during the afternoon, until the end of the working day. The mean LMD-ratings were low, due to a large percentage of workers that reported a rating of zero at all measurements. Peak discomfort was found to be a predictor of future low back, and neck pain, as well as future right- and left-sided shoulder pain. Cumulative discomfort predicted future neck pain, and right- and left-sided shoulder pain.

In conclusion, the results of this chapter suggest that both peak and cumulative discomfort could predict future musculoskeletal pain among symptom-free workers, even with relatively low ratings.

Chapter 7 reported on the effect of a resistance-training program on muscle strength, muscle fatigue, and musculoskeletal discomfort during simulated work tasks. The study design was a Randomised Controlled Field Experiment among 22 healthy workers.

The workers were matched on gender and age, and were randomized over an intervention group participating in a resistance-training program 2 times per week during 8 weeks, and a control group. Both at baseline and after the intervention period, isokinetic strength of the shoulder and back muscles, as well as muscle fatigue and musculoskeletal discomfort during a simulated assembly and lifting task were measured. Maximum isokinetic muscle strength was measured using a dynamometer (Cybex). During these muscle strength measurements, electromyography (EMG) of the shoulder and back muscles was performed in order to have an indication of the Maximal Voluntary Contraction (MVC). Furthermore, during the simulated work tasks, muscle fatigue was measured using EMG, and perceived discomfort was asked using the LMD-method. The resistance-training contained of exercises with loads to lift to increase muscle strength of the shoulder and trunk muscles. The results were analyzed according to the principle of intention-to-treat, i.e. we included all workers with non-missing follow-up data in the statistical analyses, independent of the compliance in the training group.

We analyzed the differences between the training and control group regarding the follow-up results corrected for the baseline results by means of Analysis of Covariance (ANCOVA). We focused on the following outcome measures: muscle strength, the time that the workers were able to perform the tasks, and muscle fatigue and musculoskeletal discomfort during the simulated work tasks.

We found no effects of the resistance-training program on isokinetic muscle strength of the back and shoulder muscles. Furthermore, we did not find any effect on EMG data as an indicator for muscle fatigue, or on LMD-ratings during the simulated work tasks. However, at the follow-up measurement, trained workers performed the lifting tasks for a longer time than those in the control group.

Chapter 8 contained the general discussion. In this chapter, we summarized the results by answering the research questions.

We found only few indications for each of the assumed pathways in the conceptual model of physical capacity and exposure to physical factors, and the relations were not as strong as expected. We concluded, when adding our SMASH-results to the results of our review, that there is inconclusive evidence for a relationship between low physical capacity and future musculoskeletal pain. Furthermore, the results of this thesis did not verify the hypothesis that an imbalance between physical capacity and exposure to physical factors might be a more important predictor of low back or neck pain than the effects of each of these variables on its own. Furthermore, we did not find any effect of a resistance-training program on physical capacity nor on musculoskeletal discomfort during simulated work tasks. However, we did find musculoskeletal discomfort as a predictor of future musculoskeletal pain. We concluded that the conceptual model of physical capacity and exposure to physical factors is less clear as generally accepted.

Finally, we gave some practical implications from the study results, and did recommendations for further research. The practical implications that could be derived from the findings of this thesis included that it is not appropriate to advice for physical capacity testing at work, that physical training or sports participation should be promoted for (aging) workers, and that discomfort rating scales could be used as a predictor of future pain among healthy workers. We recommended future studies on the different pathways of the conceptual model of physical capacity and exposure to work-related physical factors for specific groups of workers, in which fundamental research on the pathogenesis should be incorporated to epidemiological longitudinal studies. Furthermore, we recommended intervention studies on the efficacy of physical training programs in the prevention of musculoskeletal pain for different groups of workers (i.e. newly employed workers, male or female workers, or older workers).