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COMPARISON OF TWO PHYSICAL EXERCISE PROGRAMS FOR THE EARLY INTERVENTION OF PAIN IN THE NECK, SHOULDERS AND LOWER BACK IN FEMALE HOSPITAL STAFF

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The aim of the present study was to compare the effect of increased aerobic capacity versus muscle strength rehabilitation of female hospital staff with long-lasting musculoskeletal back pain. Seventy-nine women agreed to participate in the intervention study. After a medical examination, 65 individuals were assigned to one of three balanced groups: Endurance training (aerobic capacity promoting training: ET: *n* = 22), strength promotion exercise (SP: *n* = 24) or a control group (CON: *n* = 19). The active groups met twice a week for 60 minutes of exercise over 15 weeks. Aerobic capacity (VO_{2max}) and musculoskeletal pain were measured immediately before (T1) and after the intervention period (T2). Aerobic capacity significantly increased in the ET group, whereas no change was observed in the SP group, and a significant reduction was found in the CON group from T1 to T2. Musculoskeletal pain was significantly reduced in both intervention groups, whereas minor changes were observed in the control group. Results from a 7-month follow-up (T3) survey confirmed the beneficial effects of interventions on musculoskeletal pain. In conclusion, improved aerobic capacity appeared not to be a necessary mechanism in musculoskeletal back pain reduction.

Key words: aerobic capacity, back pain, impairment, physical exercise, strength promotion.

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INTRODUCTION

Musculoskeletal pain is one of the most common causes of absenteeism from work. Around 25% of all sick leaves are directly related to musculoskeletal pain (1). The etiology is most often multifactorial due to external psychosocial and physical load factors as well as psychological and biological characteristics of the individual. However, the causal mechanisms in musculoskeletal pain may be even more complex: the experience of pain itself may accentuate the negative effects of external stressors, or provoke psychological and biological reactions that maintain or exacerbate pain in a vicious circle (2).

Good physical capacity and muscle strength are held to be important in the prevention of job-related fatigue and muscle pain. Physical exercise keeps the musculoskeletal system in shape and promotes psychological well-being (3).

Intervention programs with physical exercise have incorporated a variety of therapeutic elements, and the etiology of results is therefore not clear in studies involving multidisciplinary programs (4). Nonetheless, early intervention probably prevents chronification of muscle pain (5), and physical activity is an effective approach (6). However, there is hardly any evidence reported to shed light upon the relative importance of different types of physical exercise.

Increased body awareness is one consequence of programs designed to promote physical fitness. This effect in itself may be of therapeutic importance in the treatment of muscle pain (7–9). However, others have failed to see any effect on musculoskeletal pain following physical exercise (10, 11). These contradicting results may reflect methodological differences such as small samples, seasonal variations, duration and intensity of the exercise programs and different methods for assessment of muscle pain.

Aerobic capacity is one aspect of physical fitness. From a clinical perspective, fitness scores often reflect both aerobic capacity and muscle strength. It is difficult to determine which specific component is the most important for pain reduction.

Interestingly, Grønningsæter et al. (7), did not find any significant correlation between reduction in pain and increased aerobic capacity. This finding suggests that aerobic capacity may be of little importance in itself for musculoskeletal pain management. Most intervention studies using physical exercise have applied a combination of aerobic capacity promoting and strength developing activities, and they appear to have been biased toward aerobic activities. The relative importance of aerobic capacity versus strength development therefore remains unclear.

Effects of aerobic exercise should be superior to strength-promoting fitness training if poor aerobic capacity is an important mechanism in musculoskeletal pain. Alternatively, if the beneficial effects of physical exercise are due to the non-specific improvement of bodily well-being, strength promoting activities may also have beneficial effects upon musculoskeletal pain. Furthermore, improved muscle strength may moderate pain due to a relative reduction of physical load at work.

To our knowledge, no published study has so far compared the potential for back pain reduction due to aerobic capacity

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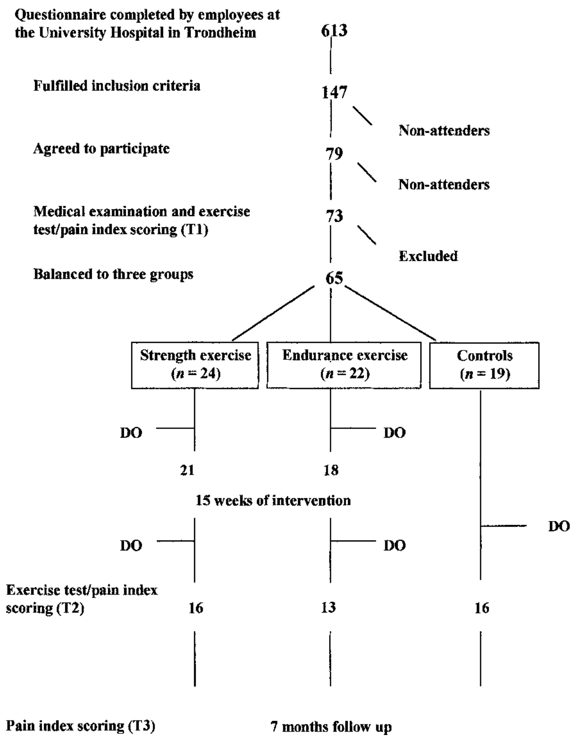

Fig. 1. Flowchart of survey sample (female hospital staff) and the process of recruitment of participants to the intervention study. DO = dropouts.

promoting training with effects following training to improve muscle strength. The purpose of the present study was to compare the effects of two training programs on the reduction of neck, shoulder and low back pain among female hospital staff. One exercise program aimed at improving cardiovascular fitness (aerobic capacity), whereas the other aimed at improving muscle strength and fitness without increase of aerobic capacity.

MATERIAL AND METHODS

Subjects

Six hundred and thirteen female employees at the University Hospital in Trondheim, Norway, completed a questionnaire and provided the recruitment base for selection of participants in the intervention study. They were all working full-time or at least 75% of full time. The survey group consisted of registered and auxiliary nurses as well as laboratory, administration and cleaning department staff.

Responses to items in the self-report Nordic Questionnaire (12) were used for subject selection. Criteria included pain in the neck, shoulders and/or lower back for at least 3 months during the past year and also recurring pain during the past 30 days. Additional criteria involved reporting reduced work capacity, sick leave or reduced leisure activity due to pain in these areas. A total of 147 women met these criteria and were invited to participate pending a medical examination.

Fig. 1 shows the flow chart of recruitment for the intervention study. Seventy-nine female employees agreed to participate in the intervention study. Seventy-three showed up for a physical exercise test and medical examination (six women did not attend this examination for practical or medical reasons). Individuals with radiating pain in arm or leg or pain from neck, shoulders and/or low back due to diagnosed diseases, were excluded. Other exclusion criteria were heart disease, blood pressure above 160/110 mmHg, lung diseases, diabetes mellitus and cancer. A total of eight people were excluded after the medical examination.

The remaining 65 individuals were balanced to one of three treatment groups: Endurance (aerobic capacity promoting training: ET) ($n = 22$), strength promotion (SP) ($n = 24$) and a waiting list group (control group: CON) ($n = 19$). They were balanced for age, marital status, occupation, type of work, pain and aerobic work capacity. (VO_{2max} was assessed as part of the medical examination.) In the SP-group, three individuals chose not to participate due to working hours and unfavourable travelling time, which conflicted with scheduled training hours. In the ET-group, four individuals dropped out for the same reasons. Following the exercise period of 15 weeks, a total of 51 individuals completed the post-tests (ET-group: $n = 15$, SP-group: $n = 19$, CON-group: $n = 17$). There were a total of seven dropouts during the intervention period. Dropouts counted two participants from the CON-group (moved away from the area), two from the SP-group (one with increasing back problems; one without given reason), and three from the ET-group (one with increasing back problem; two due to lack of time).

Subjects who attended fewer than 15 exercise sessions ($n = 5$) were excluded from the statistical analysis because exercise frequencies below once a week have no clinical effect on physical variables (13).

Table I. *Demographic characteristics of hospital staff balanced across three different groups to test effects of two exercise-based intervention programs upon back pain*

		Controls $n = 16$		Endurance $n = 13$		Strength $n = 16$	
		Mean	SD	Mean	SD	Mean	SD
Age (years)		43.9	8.8	42.6	6.0	42.2	6.0
Weight (kg)		67.6	9.2	69.4	10.2	69.3	9.8
Height (cm)		166.7	6.6	167.8	4.0	168.7	4.9
BMI[a]		24.4	3.0	24.7	3.0	24.5	3.0
Employment (years)		18.5	9.0	18.9	9.0	17.6	9.7
Smoker		3 (18.8%)		6 (46.2%)		6 (37.5%)	
Marital status	Married/cohabitant	9 (56.3%)		7 (53.9%)		13 (81.3%)	
	Divorced/separated	2 (12.5%)		3 (23.0%)		2 (12.5%)	
	Single	5 (31.3%)		3 (23.1%)		1 (6.3%)	
	Children[b]	4 (25.0%)		5 (38.5%)		8 (50.0%)	
Physical exercise habits	Never	0 (0%)		2 (15.4%)		1 (6.3%)	
	1–2 times per week	7 (43.8%)		6 (46.2%)		9 (56.3%)	
	3–4 times per week	6 (37.5%)		4 (30.8%)		4 (25.0%)	
	5–7 times per week	2 (12.5%)		1 (7.7%)		2 (12.5%)	

Controls: no active intervention for 15 weeks; Endurance: aerobic fitness training; Strength: strength-promoting activities.
[a] Body mass index.
[b] Children below 18 years living at home.

Table II. *Description of the content structure of the strength promoting (Strength) and aerobic capacity promoting (Endurance) training programs*

Type of activity	Strength	Endurance
Body awareness	3–5 minutes	3–5 minutes
Warm-up	10 minutes	10 minutes
Endurance training		30 minutes
Strength promoting training	30 minutes	
Cool-down	5 minutes	5 minutes
Stretching	5–10 minutes	5–10 minutes
Relaxation	5–10 minutes	5–10 minutes
Total	60 minutes	60 minutes

Reasons for not attending exercise sessions were illness and working hours ($n = 3$), broken relation with spouse ($n = 1$) and work stress ($n = 1$). One person was excluded from the control group because she commenced her own structured physical exercise in her leisure time. The resulting data are based on 45 women (ET: $n = 13$) (SP: $n = 16$) (CON: $n = 16$).

The demographic data are presented in Table I. Demographic information included height, weight, marital status, education, children below 18 years living at home, work experience, caring for elderly relatives, prevalence of diseases, history of absenteeism due to illness, smoking habits and physical activity habits. The distribution of demographic characteristics across the three groups confirmed that groups were well balanced, except for a majority of married/cohabitant participants and children living at home among the members of the SP participants and few smokers in the CON group (see Table I).

Assessment measures for pain and aerobic fitness

Jonsson first presented the Nordic Questionnaire (NQ) in 1982 as a self-report instrument for assessment of musculoskeletal pain (12). This survey includes questions on pain in the neck, shoulders, elbows, hands, arms, upper and lower back, hip, knees, ankles and feet. Responses reflect the occurrence of pain during the past year and during the past month. They also indicate whether this pain forced the individual to stay at home, prevented him or her from doing activities in their leisure time or during work hours. Based on this information, two different pain indexes were calculated (see below for details on scoring). The Nordic Questionnaire for back pain assessment is regarded as a standardized and sensitive survey procedure in assessment of musculoskeletal pain (14).

Height, weight, resting blood pressure and maximal oxygen uptake (VO_{2max}) were measured before and after intervention. The participants were instructed not to perform fitness training nor to smoke or eat later than 2 hours before the test. VO_{2max} was measured by use of a Vmax 29, which is a cardiopulmonary exercise-testing instrument (Sensomedics, Netherlands): error variance 3%, where the subject walks or runs on a treadmill (Jaeger LE-3000, Germany). Following a 10-minute warm-up period, the inclination (0–10%) and speed were increased according to the subject's functional capacity, to bring the subject close to exhaustion after 2–3 minutes. The VO_{2max} assessment was performed at 10% inclination for all subjects. Heart rate was measured continuously during the test using a Sport tester PE 3000.

Intervention procedures

The exercise training groups. Training sessions lasted 60 minutes and took place twice a week for 15 weeks. Four alternative hours per week assured flexible alternatives for participation. Table II shows the structure of the aerobic capacity promotion and strength promotion training programs. The participants were encouraged to perform the exercise at a speed and intensity level that was not extremely strenuous, or caused more pain during or after sessions. The exercise intensity was progressively increased over the course of a training session. The participants were encouraged to find an intensity level that reflected their actual physical fitness level. The exercise hours in both intervention programs were offered in a building at walking distance from the hospital.

The aerobic capacity promoting training group. The program aimed at improving cardiorespiratory fitness, motor coordination, as well as stretching and relaxation of neck, shoulders and lower back. The exercises were dynamic and involved the large muscle groups of the trunk and extremities at moderate intensity. The work intensity was measured on two or three occasions during the intervention period using a pulse rate watch (Sport tester PE 3000). The work intensity was kept between 70% and 85% of the maximum heart rate, as defined for every participant at pre-test. The exercise was rhythmic, dynamic and focused upon simple coordination of arm and leg, avoiding arm exercises above shoulders. All activities were intended to provoke aerobic muscle metabolism, and they involved the use of music and Reebok steps. Occasionally, different international folk-dances were performed to incorporate diversity and facilitate fun.

The strength promoting group. The program aimed at improving muscular fitness and strength, body coordination, stretching and relaxation of neck, shoulders and lower back. The strength exercises were performed as dynamic movements, with 12–15 repetitions and 2–3 series on each muscle group. Typically, as a form of circuit training, after approximately 12–15 repetitions for one muscle group, they changed to another muscle group. Activities focused upon dynamic strength training, especially of the trunk region, arm/shoulder region, gluteal and hip muscles, quadriceps and hamstrings. Static work was avoided where possible. Resistance was progressively increased over the 15 weeks according to increasing tolerance of ergonomic load.

The control group. The control group participants were instructed to continue their daily activities as usual. They were promised participation in a short version of the exercise programs at the end of the intervention period. After completion of the intervention period, they were offered instructions twice a week for 2 weeks with a mixture of aerobic and strength promoting exercises, and they were encouraged to continue these exercises on their own.

Pain index scoring and statistical analyses

T1: A pain index was calculated at pre-test (pain $index_{pre}$) as the product of scores due to localization of pain (neck, shoulders and low back: minimum = 1, maximum = 3) multiplied with scores on the endurance of this pain (continuous for a period of at least 3 months over the past year: no = 1, yes = 2), reduced capacity at work (no = 1, yes = 2) and reduced leisure time activities (no = 1, yes = 2). Minimum score for this index is two and maximum score is 24.

T2: A pain index was also calculated at post-test (pain $index_{post}$). This index reflected the product of scores for localization of pain over the past 30 days from the neck, shoulder and lower back (0–3: no pain = 0, pain in all three areas = 3, respectively), intensity of such pain (1 = no, 2 = yes), reduced capacity at work (no = 1, yes = 2) and reduced activity in leisure time (no = 1, yes = 2). Minimum score on this pain index is 0 and maximum score is 24.

T3: This index was also computed to estimate the incidence of pain after 7 months (follow-up).

An alternative approach to the pain indexes excluded functional effects of pain upon work and leisure activities. This meant that prevalence of pain was the only pain indicator in this approach (range at pre: 1–3; and at post and follow-up: 0–3, respectively).

All statistical analyses were performed by use of the SPSS software (Windows) with the 0.05 alpha criteria to define statistically significant effects. Repeated measures F-tests (ANOVA: groups by time; groups = ET, SP, CON; time = T1, T2, T3) and post-hoc Student *t*-tests were used to assess pair wise group differences. The follow-up period was not included in the repeated measures ANOVA because this would increase a design-induced risk of supporting a conclusion with no interaction between the group and time factors: the balanced recruitment design assured that no pain difference was present at pre-intervention, whereas after intervention (T2) also the CON group was instructed to perform regular exercises over the follow-up period. At follow-up, therefore, the design would work in favour of the null-hypothesis on a repeated measure ANOVA for the group by time effect. Note that a significant group by time interaction occurs when there is a difference between groups at one or two of the three assessment times. Whereas a time effect reflects only time differences, and a group effect reflects only group differences.

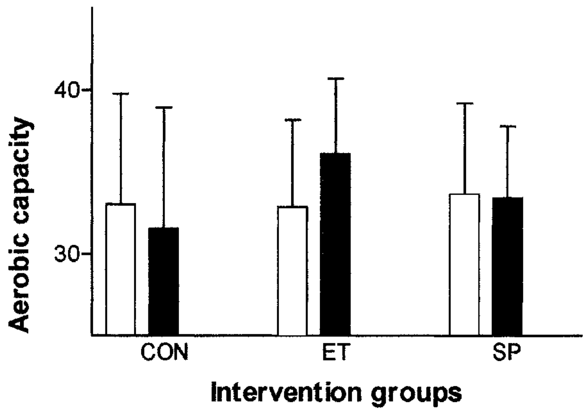

Fig. 2. Aerobic capacity (VO_{2max}: ml/kg/min) before (open bars) and after 15 weeks of intervention to reduce back pain among female hospital staff. CON: waiting list control sample with no active intervention; ET: training biased toward aerobic fitness promotion; SP: training biased toward strength promotion.

RESULTS

The mean adherence rate to exercise hours was 81% in the ET-group and 77% in the SP-group. The body mass index did not change significantly in any of the groups from pre- to post-test. In the pre-test, there were no significant differences between the three groups in aerobic capacity or prevalence of pain (Fig. 2).

There was no overall significant group difference in VO_{2max} ($F(2/39) = 0.43$), and there was no significant overall change of VO_{2max} from pre- to post-test ($F(1/39) = 0.77$). However, the analyses showed a significant effect upon VO_{2max} due to interaction of the time and group factors; i.e. change in VO_{2max} differed across the groups from pre- to post-test ($F(2/39) = 10.22$, $p = 0.0004$). This overall effect reflected the fact that the ET-group increased their VO_{2max} from 32.9 to 36.1 ml/kg/minute ($t = 3.40$, $p = 0.005$), whereas the SP-group did not change their VO_{2max} (33.4–33.6 ml/kg/min from pre- to post-test: $t = 0.30$), and the CON-group showed a significant decrease in VO_{2max} (33.4–31.6 ml/kg/min from pre- to post-test: $t = 3.11$, $p = 0.009$; Fig. 2).

There was no significant group difference in pain $index_{pre}$ scores ($F(2/42) = 1.31$), but the time factor yielded a significant overall change from pre- to post-test ($F(1/42) = 26.75$, $p = 0.0004$). Moreover, the pain scores showed a significant interaction of the group and time factors ($F(2/42) = 3.76$, $p = 0.031$). This was due to a reduction in reported pain from pre- to post-test from 13.5 to 4.1 in the ET-group ($t = 5.78$, $p = 0.0001$) and from 12.3 to 5.3 in the SP-group ($t = 3.26$, $p = 0.005$), whereas a non-significant decrease from 12.9 to 11.0 was found in the CON-group ($t = 0.88$) (Fig. 3).

Pain status 7 months after intervention (follow-up)

The participants completed the pain questionnaire 7 months after the end of the intervention period. The follow-up results for the pain index showed that the ET-group increase their pain score from 4.1 at post-test to 5.7, but they were still significantly better than before intervention ($t = 2.08$, $p = 0.05$). The SP-group increased their score from 5.3 to 6.8 at follow-up, and they also continued to report significantly less pain than before intervention ($t = 5.32$, $p = 0.0001$). The CON-group continued to reduce their mean pain score from 11.0 at post to 6.8 at follow-up, and at this time their pain levels were on average significantly better than before intervention ($t = 2.44$, $p = 0.03$).

The alternative pain index where functional consequences of the pain upon work and leisure activities were excluded, yielded only one marginally significant effect due to the interaction of the time and group factors; i.e. a pattern of change from pre- to post-test that differed across the three groups ($F(2/42) = 2.79$, $p = 0.073$). This was due to a reduction of pain from pre- to post-test in the ET-group (from 2.3 to 1.7: $t = 3.41$, $p = 0.005$) as well as in the SP-group (from 2.1 to 1.6: $t = 1.93$, $p = 0.07$), whereas the CON-group remained almost unchanged (from 2.1 to 2.0). No other significant effect was found for this approach to the consequences of the exercise programs upon pain change.

DISCUSSION

The results of the present study support the view that aerobic as well as strength-promoting fitness training on non-specific muscle pain reduction in the neck, shoulders and lower back. In addition increased aerobic capacity seems not to be a crucial mechanism in such back pain reduction. At follow-up (T3), results indicated that participants in all three groups were significantly improved. This improvement included the control group and should, therefore, be related to the fact that controls were offered a composite version of the two exercise programs after the end of the intervention period.

For ethical reasons, participants were assured the right to drop out at any time without given reason. Total proportion of dropouts in our study was 31%. Among these, 15% started in the program, but did not complete for various reasons. These proportions are close to those observed by Kellet et al. (15). They reported having a total dropout of 36%, of whom 10.3% were individuals who did not complete the intervention due to progressive pain or other bodily complaints.

The average attendance rate in the present study was 77% in the SP-group and 81% in the ET-group. Grønningsæter et al. (7), reported an attendance rate of 80% among women and 76% among men. Their participants were offered training during paid work hours. In our study, the training took place just before or after the work hours. This pattern of attendance ratios indicates that high attendance can be less dependent upon training sessions within or outside work hours and more dependent upon intrinsic motivation. According to Robinson & Rogers (16), the completion of training depends on physical factors such as motivation, education, and knowledge of and belief in the beneficial effects of physical activity on health, weight and mental health. We experienced the importance of other attendance factors such as work and family situation, ease of travel to training, expenses, social feedback, training intensity and organization, feeling of mastery, pain response to interven-

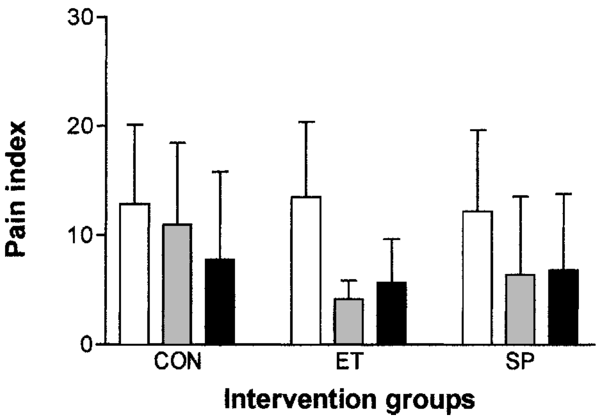

Fig. 3. Mean pain index scores (pain index$_2$) before a 15-week intervention period (open bars), after intervention (shaded bars) and at follow-up 7 months later.

tion and the ability of the instructor to relate to group members at an individual level.

Grønningsæter et al. (7), included only individuals who were physically inactive. Our study did not exclude physically active individuals. This meant that our groups were somewhat heterogeneous with regard to aerobic capacity. From this perspective, change of aerobic capacity in the aerobic group appears to support findings reported by Skargren & Öberg (17), where a significant reduction in muscle pain after eight weeks of training was explained primarily by a reduction among those who were physically inactive before inclusion. However, our findings from the strength promoting program suggest that pain reduction may be less dependent upon aerobic improvement than are indicated in the studies by Grønningsæter et al. (7) and Skargren & Öberg (17).

All the three sub-groups scored below age-defined average in aerobic capacity (32–40 ml/kg/min) after adjustment for age and sex (18). The CON-group achieved a significant reduction in aerobic capacity over the 15 weeks of being on the waiting list when they were encouraged to be as inactive as before. This reduction may reflect a seasonally induced confounding factor due to the fact that intervention was carried out during the winter when slippery roads and trails obstructed people from habitual outdoor jogging and walking. This is to say that the participants in the ET and SP groups may have experienced the same drop of aerobic capacity if not involved in the exercise programs.

Poor muscle strength in the thigh, dorsal and abdominal muscles can indirectly cause pain in the back. For example, weakness-related fatigue in the thigh muscle at the end of a day at work can cause one to lift with straight knees and a bent back rather than bending at the knee and hip joints. This former way of lifting causes increased load on the passive structures in the back musculature (19). Assessment of upper and lower limb strength, was not possible in the present study. The members of the SP-group achieved significant reduction in their back pain despite no change in VO_{2max}. This effect is most likely related to increased muscle strength because others have reported significant strength improvement following a similar dose (repetitions, resistance) and duration of strength promoting training (20, 21).

Although the relationship between muscle strength, aerobic fitness and musculoskeletal complaints remains uncertain, Gerdle et al. (22) claimed that positive effects of increased fitness levels can be recognized in reduced absenteeism from work, periods of sick leave, and medical expenses as well as in improved general well-being, sleep and other psychological factors. Gerdle et al. (22), did not find any correlation between physical capacity and musculoskeletal symptoms, whereas Gundewall et al. (4) concluded that reduced sick leave reflects increased muscular strength as well as endurance.

Grønningsæter et al. (7), did not find any correlation between reduction in muscular pain and increased aerobic capacity, which is in accordance with our results, since strength-promoting program also provided pain relief. Along the same line, Skargren & Öberg (17) found that 8 weeks of training among female hospital employees reduced their musculoskeletal symptom, but increased their cardiovascular capacity as well as muscle strength. However, their reported effect of muscular strength upon pain reduction was less consistent than the effect of cardiovascular (aerobic) capacity upon the reduction of musculoskeletal symptoms. This biased effect may reflect a relatively moderate proportion of strength-promoting activities in their program (a total of 7 minutes, twice a week, over a period of 8 weeks).

The number of individuals accepted for statistical analyses is low in the present study ($n = 45$). One might therefore argue that the power of the statistical analyses is limited. However, careful selection of eligible individuals to address the aim of the study meant that subjects were excluded to reduce the risk of confounding factors and increase the quality of data. A less strict recruitment procedure would have inflated the number of participants, but would also have incorporated a reduction in quality. Nonetheless, more studies are needed to provide a solid empirical basis for the recommendation of a greater diversity of elements in exercise-based back pain intervention. The present results indicate a scientific basis for the selection of effective elements in such intervention where the program can be biased toward those activities that the client finds to be the most enjoyable or least adverse. This flexibility is a logical consequence of the present results where increased aerobic capacity turned out not to be a crucial mechanism in beneficial effects of physical training upon non-specific back pain.

Finally, the generalizability of the present results may be questioned mainly for two reasons. One is the diverse etiology of the presenting pain in the neck, shoulders and lower back, even when employees with known medical causes of such pain are excluded (see method section above). For this obvious reason, it is encouraging to observe the significant effects of the present programs in the early intervention of non-specific back pain in hospital staff.

A second source of limitation is the highly selected samples recruited for intervention. Approximately one-third of the staff was included among those who met the presenting pain criteria. More staff might have been recruited with a shorter intervention period such as Skargren & Öberg (17). However, the present approach avoided the risk of poor effects from a short intervention period. From this perspective it is possible that the present findings suggest successful prevention from sick leave among staff who are highly motivated to actively cope with non-specific back pain problems.

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