ORIGINAL ARTICLE

Feasibility of power-type strength training for middle aged men and women: self perception, musculoskeletal symptoms, and injury rates

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Objectives: To examine the feasibility of a power-type strength training programme for middle aged men and women, the impact of the training programme on perceived health and fitness and on knee and low back symptoms, and the rate of exercise induced injuries.

Methods: A total of 154 voluntary, healthy, sedentary men and women participated in a training programme lasting about four months. The explosive force of leg extensor muscles was measured by means of standing long jumps and vertical squat jumps. Perceived health, perceived fitness, and low back and knee symptoms were assessed before and after the intervention by using a questionnaire. Musculoskeletal disorders and exercise induced injuries were reported during the training programme.

Results: Perceived fitness improved in both men ($p < 0.01$) and women ($p < 0.0001$), but perceived health only in women ($p < 0.01$). Men with increased explosive force in squat jumping also showed better perceived health ($p < 0.05$), and women with increased explosive force in standing long jump showed better perceived fitness ($p < 0.05$). Exercising men who had increased knee symptoms had significantly higher body mass index than the other exercising men ($p < 0.05$). The exercise induced injury rate was 19% in men and 6% in women.

Conclusions: Successful completion of the exercise programme, together with the increased physical activity and relatively low injury rate, may have contributed to the participants finding the exercise programme positive and stimulating and believing that their health and fitness had improved. The low rate of musculoskeletal injury suggests that this type of supervised exercise programme is feasible for untrained middle aged people.

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The beneficial effects of aerobic exercise on physical and mental health are well known.^{1–3} The impact of anaerobic and power-type strength training on health, however, has been less well investigated. Studies on muscle training programmes^{4–5} and anaerobic training programmes⁶ indicate that these training modes can also be beneficial to both physical and psychological health. Aerobic training and strength training programmes have been reported to enhance physical self perception and fitness, independently of activity.⁷

To avoid musculoskeletal injuries and symptoms during exercising, the training programmes should be carefully designed. This is particularly true for programmes designed for middle aged and sedentary people. Knowing that it is safe to exercise also has an impact on motivation. The risk of injuries induced by training increases with poor physical condition,⁸ and highly intensive fitness programmes may even have adverse effects on physical health in unfit subjects, in the form of increased muscle pain, muscle soreness, and injuries.⁹

With increasing age, the capacity to produce explosive muscle force declines more dramatically than maximal muscle strength.^{10–11} To maintain functional capacity, strength training and power-type strength training are recommended for middle aged and elderly people.^{10–11} A minimum of twice a week is recommended for strength training.^{12–13} A population survey¹⁴ showed that exercise related injuries constitute a high proportion of all injuries, particularly in men. The number of previous injuries and the total exposure time may also increase the risk of injury.^{15–16} According to a nationally representative survey in Finland,¹⁷ women had poorer health than men with respect to five out of eight health indicators, and men aged 50 or older rated their perceived health significantly lower (average, poor, or very poor) than women of matching age.

The purpose of this study was to examine the feasibility of a power-type strength training programme for middle aged men and women, and to investigate the rates of exercise induced injury as well as knee and low back symptoms. We also examined the subjective perception of health and fitness among the participants.

MATERIALS AND METHODS

The 226 participants were recruited from the staff of the Hotel and Restaurant Institute in Turku, the Turku School of Economics and Business Administration, local secondary schools and private companies, and from among participants on retraining courses and members of a local association of the unemployed. They were sedentary, healthy, middle aged men ($n = 83$) and women ($n = 143$) (table 1). Of the initial group, 55 dropped out during the exercise programme. Altogether 171 participants (61 men and 110 women) completed the exercise programme, and finally, 154 (53 men and 101 women) who returned all questionnaires were included in the analysis. Forty seven (21%) participants in the initial group, 21 (12%) of the participants who completed the exercise programme, and 26 (47%) of the drop outs were unemployed. The control group consisted of 18 non-exercising volunteers (10 men and eight women), of whom 12 at first intended to participate in the exercising programme, but changed their minds and volunteered as non-exercising controls instead. Forty percent ($n = 22$) of the drop outs stopped because of lack of motivation, 33% ($n = 18$) because of lack of time, 14% ($n = 8$) because of an exercise induced musculoskeletal symptom, and 13% ($n = 7$) for other reasons. All participants were examined by a doctor and qualified to

Table 1 Characteristics of the study groups

	Participants who volunteered for the intervention (n=226)		Participants who dropped out of the intervention (n=55)		Exercisers who returned both baseline and final questionnaires (n=154)		Non-exercising controls (n=18)	
	Men (n=83)	Women (n=143)	Men (n=22)	Women (n=33)	Men (n=53)	Women (n=101)	Men (n=10)	Women (n=8)
Age (years)	44 (8)	43 (8)	41 (6)	40 (8)	45 (8)	44 (8)	45 (9)	40 (5)
BMI (kg/m ²)	27 (3)	25 (4)	29 (4)	24 (4)	27 (3)	25 (4)	29 (3)	25 (5)

Values are expressed as mean (SD).
BMI, Body mass index.

participate. Medical screening included cardiovascular, neurological, and musculoskeletal examinations. All subjects were informed of the purpose of the study before they gave their written consent to participate. The study protocol was approved by the ethics committee of the Research and Development Centre of the Social Insurance Institution.

Procedure and measurements

Before and after the exercise intervention, the participants were asked about their subjective perception of health and fitness and about the presence of low back and knee symptoms during the preceding six months. Perceived health and fitness were assessed by using a five point Likert scale (poor, fairly poor, average, fairly good, good) used by, among others, Moum,¹⁸ Wolinsky and Johnson,¹⁹ and Rakowski *et al.*²⁰ This method has been shown to be reliable and consistent for assessing medical health and its functional consequences.^{21, 22}

The standardised Nordic musculoskeletal questionnaire²³ was used to assess low back and knee symptoms. The participants were also instructed in advance to report any injuries occurring during the training programme to the instructor, and to describe the injuries in detail. To minimise the number of missing reports, the participants were given a questionnaire form for reporting injuries. They were also asked to evaluate whether the injury was acute or a result of overuse.

Standing long jumps and vertical squat jumps were used to measure the explosive force of leg extensor muscles before and after the intervention. In long jumps, swinging of arms and leg countermovements were permitted. Vertical squat jumps

were measured by using a contact mat (Newtest powertimer, Oulu, Finland). The jumps were performed barefoot, with knees flexed at 100°. The subjects held a wooden stick behind their neck to standardise the position of arms and upper body. The recorded flight time (seconds) was transformed to vertical height in cm. Participants had three attempts at both types of jump, with one to three minutes of rest between attempts. The best results (cm) were used in the statistical analysis.

The training programme consisted of leg and trunk muscle exercises carried out in groups with little or no equipment. Exercise sessions were supervised and controlled by a professional gym instructor. The exercise programme lasted from 14 weeks to 21 weeks (average 18 weeks), as recommended in an earlier study.²⁴ Because of summer vacations, the first two groups (n = 15) exercised for 14 weeks (35 sessions) and 16 weeks (40 sessions), whereas the other groups exercised for 21 weeks (52 sessions on average). The training programme was progressive, emphasising power-type strength exercises and including three different exercise periods. The orientation phase consisted of exercises enhancing muscle endurance and muscle strength, cardiovascular capacity and coordination skills, and it constituted about 25% of the whole programme. The purpose of this period was to familiarise the participants with the exercises and to enhance muscle strength and motor skills. The second period (about 50% of the programme) consisted of muscle strength and power-type strength exercises. The last exercise period (about 25% of the programme) included solely power-type strength training. Exercises in the second and third periods were performed with maximal effort.

Table 2 Distribution of self rated health and fitness, expressed as percentages, and results in standing long jump and vertical squat jump, expressed as mean (SD), at baseline

	Participants who volunteered for the intervention (n=226)		Participants who dropped out of the intervention (n=55)	
	Men (n=83)	Women (n=143)	Men (n=22)	Women (n=33)
Perceived health (%)				
Poor	1	1	0	0
Fairly poor	1	1	0	3
Average	23	19	32	18
Fairly good	47	47	36	55
Good	28	32	32	24
Perceived fitness (%)				
Poor	1	3	0	6
Fairly poor	17	15	36	24
Average	48	48	54	43
Fairly good	25	31	5	21
Good	9	3	5	6
Long jump (cm)	226 (26) (n=68)	166 (23) (n=135)	215 (35) (n=12)	163 (23) (n=27)
Squat jump (cm)	27 (5) (n=79)	19 (4) (n=134)	27 (6) (n=21)	18 (3) (n=33)

Table 3 Proportion of participants with self reported low back and knee symptoms during the preceding six months before the intervention

	Participants who volunteered for the intervention (n=226)		Participants who dropped out of the intervention (n=55)		Participants who filled in both baseline and final questionnaires (n=154)		Non-exercising controls (n=18)	
	Men (n=83)	Women (n=143)	Men (n=22)	Women (n=33)	Men (n=53)	Women (n=101)	Men (n=10)	Women (n=8)
Low back symptoms (%)	43	43	27	39	51	45	30	63
Knee symptoms (%)	27	21	14	21	30	23	30	0

Participants were asked to exercise three times a week (on Monday, Wednesday, and Friday) for 60 minutes at a time. All sessions started with a warm up, including flexibility exercises, muscle stretching, brisk walking, and light jogging (15 minutes). The main part of the session (30 minutes) focused on training the strength and power of leg and trunk muscles. Leg muscles were trained with jumping exercises, such as countermovement jumps, squat jumps, single leg hops, and step aerobic exercises on a 15 cm high step board. Sprint exercises included explosive 3–5 m sprint runs at various velocities and in different ways, for example, running with raised knees or raised heels and combined with exercises demanding motor skills. The following trunk muscle exercises were used: sit ups and knee ups in a supine position; back lying cycling; side lying leg lifts and push ups; back extension and leg lifts in a prone position. All sessions ended with 15 minutes of stretching and relaxation.

According to the rate of attendance at training sessions, the participants were divided into a high training activity group, with attendance $\geq 50\%$, and a low training activity group, with attendance $< 50\%$. The limit was set at 50% because the participants with $< 50\%$ of attendance trained less than 1.5 sessions a week, which is just below the exercise intensity assumed to result in physiological enhancements.^{25, 26}

Statistical analysis

The data were analysed by sex and age group, and also by training activity. To investigate whether there were any changes in perceived health, perceived fitness, or the incidence of knee and low back symptoms during the exercise programme, the marginal probabilities of two dimensional contingency tables were used and analysed by sex using PROC CATMOD SAS/STAT. Further, the changes in jumping performance indices during the intervention in men and women were examined by using paired *t* tests. Analysis of variance

was used to examine the differences between participants with improved, deteriorated, or unchanged perceived health, perceived fitness, and low back and knee symptoms. $p < 0.05$ was considered to indicate significance.

RESULTS

Tables 1–3 show the baseline characteristics of the subjects: age; body mass index (BMI); perceived health and fitness; jump performance; knee and low back symptoms. At the baseline, the exercisers ($n = 171$) did not differ from non-exercising controls ($n = 18$) or drop outs ($n = 55$). The only difference was that the male drop outs showed a significantly poorer perceived health than the exercising men ($p < 0.01$). Men attended 62 (23)% (mean (SD)) and women 66 (18)% of the scheduled training sessions. Twelve men and 25 women attended 80% or more of the scheduled training sessions.

Subjective and objective effects of the training

Both men and women perceived that their physical fitness improved ($p < 0.01$ for men and $p < 0.0001$ for women) during the intervention period (fig 1). Perceived physical health (fig 2) improved in women only ($p < 0.001$). Non-exercising control subjects ($n = 18$) did not show any changes in either of these variables.

The high training activity group (attendance $\geq 50\%$) showed improved perceived fitness; in women the change was significant ($p < 0.05$). No significant differences were observed between male training activity groups. The data were analysed by both sex and age group. With the median age at 45 years in men and 44 years in women, no differences were observed between younger (< 45 years in men, < 44 years in women) and older (≥ 45 years in men, ≥ 44 years in women) participants in perceived health, perceived fitness, training

Figure 1 Perceived fitness in men ($n = 53$) and women ($n = 101$) before and after the intervention. The change was significant for both men ($p < 0.01$) and women ($p < 0.0001$).

Figure 2 Perceived health in men ($n = 53$) and women ($n = 101$) before and after the intervention. The change was significant ($p < 0.01$) for women.

attendance, knee and low back symptoms, standing long jump or vertical squat jump.

Changes in standing long jump and vertical squat jump were significant ($p < 0.001$) in both men and women after the training programme (table 4). Also, men with improved squat jump performance showed improved perceived health ($p < 0.05$), and women with improved standing long jump performance showed increased perceived fitness ($p < 0.05$). No such trends were observed in the non-exercising controls.

Knee and low back symptoms

Table 3 gives the baseline distributions of self reported low back and knee symptoms in the initial study group ($n = 226$), drop outs ($n = 55$), exercisers with complete data ($n = 154$), and non-exercising controls ($n = 18$). The number of men reporting no low back or knee symptoms increased from 20 at the baseline to 25 after the intervention, and in women the corresponding values were 49 and 55. The frequency of low back symptoms alone decreased by 13% ($n = 7$) (NS) in men and by 10% ($n = 10$) (NS) in women. Knee symptoms increased by 2% (NS) in men and by 5% (NS) in women. Among the non-exercising controls, low back symptoms decreased by 11% and knee symptoms increased by 6%. Exercising men who reported more knee symptoms after the intervention had higher BMI (28 (3), $p < 0.05$) than men on average (BMI 26 (3)). The same was not observed in women. Some 11% ($n = 5$) of participants with knee symptoms at the baseline interrupted training for more than three weeks, all because of knee troubles. Exercising men had, more often than women ($p < 0.01$), participated in physical activities that may impose excessive strain on knees—for example, volleyball, ice hockey, and football—before the intervention. Of those participants who were free from knee symptoms before

the intervention, 17% reported symptoms in their knees during the programme, and 14% of the participants with knee symptoms before the intervention reported that their symptoms had been relieved after the programme.

Exercise induced injuries

The injury rate during exercise sessions was on average 10% ($n = 16$): 19% for men ($n = 10$) and 6% ($n = 6$) for women. The injuries included non-specific knee pain (19%), sprain or strain in the thigh (37%) and calf muscles (13%), twisted ankle (19%), muscle cramp in the lower back (6%), and strained shoulder muscles (6%). Four participants had breaks of up to four weeks in the exercise programme because of a muscle injury. Four of the participants who were injured while exercising had had symptoms in the injured area before the intervention. Five participants sustained overuse injuries during the intervention, including non-specific knee pain ($n = 2$), low back pain ($n = 2$), and pain in the calf muscle ($n = 1$).

DISCUSSION

After the intervention, women rated both their perceived health and perceived fitness better, and men believed that their fitness had improved. Mere participation in an intensive exercise programme may have influenced the exercisers' subjective perception of health and fitness; after the intervention many of them probably felt healthier and more fit simply because of a change in lifestyle, even if the change was temporary. Similar effects of participation in training programmes have been reported previously.^{3, 27} The positive experience with respect to health and fitness—for example, completed exercise programme and improvements in muscle performance tests—is in line with previous reports indicating that health behaviours are associated with self rated health:

Table 4 Baseline results and the changes in jump performance indices during the intervention in men and women in training groups and in non-exercising control groups

	Exercisers who returned both baseline and final questionnaires ($n = 154$)				Non-exercising controls ($n = 18$)			
	Men ($n = 53$)		Women ($n = 101$)		Men ($n = 10$)		Women ($n = 8$)	
	Before	Change	Before	Change	Before	Change	Before	Change
Long jump (cm)	230 (21)	5 (8)*	165 (21)	8 (9)*	216 (30)	1 (5)	175 (37)	-2 (8)
Squat jump (cm)	28 (5)	4 (2)*	18 (4)	3 (2)*	25 (5)	0 (1)	22 (8)	1 (1)

Values are expressed as mean (SD).

* $p < 0.001$.

subjects with low physical activity at leisure and with unhealthy dietary habits, as well as smokers, have shown poorer self rated health.^{28, 29} In our study, women rated their health and fitness better than men after the intervention, which is in line with the epidemiological study of Lahelma and coworkers.¹⁷ Our result may partly be explained by the lower injury rate among women and the fact that they are more familiar with the type of exercises used—for example, step aerobics.

During the intervention, 55 subjects from the initial sample of 226 participants dropped out. The unemployment rate was higher (47%) among the drop outs than the exercisers (12%), and the male drop outs had significantly lower perceived health. The drop outs did not differ in any other respect from those who completed the exercise programme. The unemployment rate among the drop outs was even higher than in the general population in Finland. The exercisers, however, can be supposed to represent the average population as far as their employment status is concerned. The participants were not randomised in this study; in fact, randomisation would be very difficult in this type of intervention where volunteers have to adhere to exercising three times a week. Participants who succeeded in completing the exercise programme were a selected population with regard to their interest and positive attitude to physical activity, although they were sedentary.

Low back symptoms were less common after the intervention, which perhaps reinforced the experience of better perceived health and fitness among participants. The presence of a professional instructor, who supervised and controlled the group and adjusted the intensity of the exercises accordingly, contributed to the reduced exposure to injury. Sufficient warming up before strength exercises and careful stretching after them probably prevented muscle cramps.^{30, 31} As the instructor was present during the session, the participants were able to ask for advice in the case of minor musculoskeletal problems. Despite the high amount of jump and sprint exercises in the training programme, knee symptoms did not show any significant increase compared with the non-exercising control group, which certainly contributed to the increase in self rated health and fitness among participants. However, old knee troubles recurred in male participants who had previously practised various kinds of sports that stress the knees, such as ball games. High BMI may also have increased the risk of knee disorders.³² Knee symptoms, especially knee pain itself without any exercise involved, are associated with poor perceived health and increased mental distress.³³ In this study, the interruptions in training were short, indicating that the disorders and injuries were not serious. The training programme appeared to be safe; only eight (14%) of the drop outs interrupted their training because of exercise induced musculoskeletal symptoms. Other reasons, such as lack of motivation ($n = 22$) or time ($n = 18$), were more common causes for dropping out.

The injury rate in this study was low (19% in men and 6% in women). For comparison, injury rates ranging from 24% to 40% have been reported among middle aged male and female runners; knee injuries were the most common.^{34, 35} Correspondingly, the injury rate was 12% for middle aged sedentary male and female participants in a supervised one year worksite exercise programme.³⁵ In an epidemiological study by Hootman *et al*,³⁶ the knee was the most commonly injured site (one fifth of all injuries), both for activity related and all cause injuries in men and women. The higher injury rate among men in our study is in line with a previous survey of exercise related injuries by Uitenbroek.¹⁴

Exercise induced injuries were rare, although most of the participants were unfamiliar with power-type strength training before the intervention. Our results differ from the study of Almeida *et al*,³⁷ in which the overall injury rate was 39.6% during a vigorous physical training period of 12 weeks. The authors suggested that the sudden increase in training volume

Take home message

Power-type strength training appears to be suitable for middle aged sedentary men and women. The intervention resulted in an increase in perceived health and fitness. The low rate of exercise injuries and the unchanged status of low back and knee symptoms probably contributed to the beneficial effects.

may have contributed to the high injury rate. In our study, this was avoided by having a sufficiently long orientation phase.

Muscle strains occurred mainly during sprint or step aerobic exercising, and twisted ankles during jump or sprint exercising. Overuse symptoms in knees, leg muscles, and low back muscles were mostly caused by sprint or jumping exercises. The fact that sedentary middle aged participants are an at risk group for injuries¹⁴ was counterbalanced by such factors as a controlled and supervised training programme, sufficient warming up before training, muscle stretching after training, gradual increasing intensity, variation in exercises, and finally, subjectively set goals in training (no competitive elements were included in the training programme).

The exercise period was five to seven weeks shorter for 15 of the participants. It can be speculated that the rates of overuse injuries, exercise induced low back and knee symptoms, as well as acute exercise injuries are lower because of the shorter exercise periods. However, the effects of the shorter duration of training are probably compensated for by the small proportion of these participants (15 of the total of 171 exercisers) and their high training attendance (79 (6%). In our opinion, the shorter exercise periods had a relatively small impact on the total outcome of the study.

The training programme was shown to be suitable for middle aged people, for both sexes and for sedentary people, but for obese people or people with musculoskeletal symptoms, it should be applied in a more individual way. When high intensity exercise programmes are designed and implemented, the participant's previous exercise history, current fitness, and injury history provide valuable information for the prevention of exercise induced injuries and musculoskeletal symptoms. This background information is also essential for the training instructor to be able to optimise the intensity and progression of the programme.

In conclusion, participation in a supervised and controlled training programme resulted in increased perceived health and fitness. Well structured and carefully planned exercise sessions with sufficient warming up before and stretching after prevented injuries and muscular disorders. The low injury rate and low incidence of muscular disorders probably contributed to the increase in perceived health and fitness in both sexes. We suggest that this kind of power-type strength training programme is feasible for sedentary middle aged people.

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