Muscle strength and resistance exercise in women with fibromyalgia - a person-centred approach

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The miracle isn´t that I finished, the miracle is that I had the courage to start.

(John Bingham)

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ABSTRACT

Fibromyalgia (FM) is characterized by generalized pain and associated with impaired physical capacity and activity limitations. Low-intensity exercise has been shown to be a safe way to exercise without risking an increase in disease-specific symptoms. There are few studies evaluating the effects of resistance exercise designed to improve muscle strength in FM. However they have documented promising effects of resistance exercise on muscle strength, health status and pain, but the paucity of studies implies a low quality of evidence and further studies to investigate the effects of resistance exercise in women with FM are needed.

The overall aim of this thesis was to seek deeper knowledge about muscle strength, to examine the effects of person-centred progressive resistance exercise on muscle strength and health, and to explore which factors promote physical activity, in women with FM.

Methods: A cross-sectional study investigated the degree of reduced physical capacity and associated factors in women with FM. The control-group consisted of healthy women matched by age and education (study I). A randomized controlled multi-center study examined the effect of person-centred progressive resistance exercise on muscle strength and health in women with FM (study II). A secondary analysis to study II aimed to examine explanatory factors for change in muscle strength or predictors for muscle strength in leg, arm and hand following resistance exercise (study III). A qualitative interview-study explored promoting factors for physical activity in women with FM (study IV).

Results: Women with FM displayed significantly lower physical capacity than healthy women and factors associated to reduced physical capacity were age, disease duration, Body Mass Index (BMI) and activity limitations (study I). Women with FM engaging in person-centred progressive resistance exercise for 15 weeks showed significant improvements regarding muscle strength, health status, pain intensity, walking ability, pain disability, and pain acceptance (study

II). Improvement in muscle strength following resistance exercise was explained to 32-40 % by baseline fear avoidance, baseline muscle strength, baseline pain, and change in pain, age, and BMI. The final value for muscle strength was predicted to 72-75% by baseline muscle strength, baseline fear avoidance, age, and BMI (study III). Factors experienced to promote physical activity in women with FM were, will to be physically active, adjustment, managing pain, and contextual factors (study IV).

In conclusion women with FM displayed significantly lower muscle strength and walking ability than healthy women, and this was associated to activity limitations. Engaging in person-centred progressive resistance exercise was shown to improve muscle strength and health, and reduce pain and activity limitations. Important factors for change in muscle strength were pain and fear avoidance during and following the exercise intervention. Women with FM had the will to be physically active but were challenged by pain and fatigue and experienced difficulties in finding the right level of exercise. The findings of this thesis highlight the importance of a person-centred approach when planning exercise programs for women with fibromyalgia.

Keywords: physiotherapy, fibromyalgia, muscle strength, physical capacity, exercise, physical activity, pain, person-centred

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SAMMANFATTNING PÅ SVENSKA

Muskelstyrka och styrketräning för kvinnor med fibromyalgi - ett personcentrerat perspektiv

Fibromyalgi (FM) är en muskuloskeletal sjukdom vars mest framträdande symptom är utbredd smärta. Andra vanliga symptom är trötthet, nedsatt fysisk kapacitet och aktivitetsbegränsningar i dagliga livet. Studier har visat att kvinnor med FM klarar att träna på lågintensiv nivå utan att få en ökning av sjukdomsspecifika symptom. Få studier har undersökt effekten av styrketräning för kvinnor med FM men de resultat som presenterats tyder på att styrketräning kan minska smärta och förbättra allmän hälsa. De studier som utförts har dock varit små och av låg kvalitet och det behövs fler studier för att undersöka effekten av styrketräning för kvinnor med FM. Det övergripande syftet med denna avhandling var att nå ökad kunskap om muskelstyrka, effekter av styrketräning samt faktorer som kan underlätta fysisk aktivitet på en mer ansträngande nivå för kvinnor med FM.

Avhandlingen består av fyra delarbeten. Den första studien var en tvärsnitts-studie som avsåg att undersöka skillnader i muskelstyrka och gångförmåga, mellan kvinnor med FM och friska kvinnor som matchats för ålder och utbildningsnivå, samt faktorer associerade med sänkt muskelstyrka hos kvinnor med FM. Den andra studien var en randomiserad, kontrollerad multi-center studie som avsåg att utvärdera effekter av personcentrerad progressiv styrketräning för kvinnor med FM. Den tredje studien avsåg att undersöka vilka faktorer som kunde förklara förbättring av muskelstyrka genom styrketräning och den fjärde studien avsåg att undersöka vilka faktorer kvinnor med FM upplever kan hjälpa dem att vara fysiskt aktiva på en mer ansträngande nivå.

Resultaten visade att kvinnor med FM har sämre muskelstyrka och sämre gångförmåga än friska kvinnor matchade för ålder och utbildningsnivå. Faktorer som var associerade med lägre muskelstyrka var ålder, sjukdomsduration, BMI och aktivitetsbegränsningar (studie I). Kvinnor med FM som tränade personcentrerad progressiv styrketräning under 15 veckor förbättrade sin muskelstyrka, hälsostatus, smärtintensitet, smärthantering samt deltagande i vardagsaktiviteter (studie II). Faktorer som påverkade förbättring av muskelstyrka under styrketräningen var; muskelstyrka vid studiens start, rörelserädsla, smärta vid studiens start samt förändring av smärta under träningsperioden, ålder och BMI (studie III). Faktorer som upplevdes främja förmågan att vara fysiskt aktiv på en mer ansträngande nivå var viljan att vara

fysiskt aktiv, anpassning av belastning och träningsprogram, att hantera smärtan, och omgivningsfaktorer som tillgänglighet, arbete och ekonomi (studie IV).

Sammanfattningsvis så visade sig kvinnor med FM ha reducerad muskelstyrka och gångförmåga jämfört med friska kvinnor och detta hade samband med högre grad av aktivitetsbegränsningar. Styrketräning utformad enligt personcentrerade principer visade sig förbättra muskelstyrka och hälsa, samt minska smärta och aktivitetsbegränsningar. Viktiga faktorer för förbättring av muskelstyrka var smärta och rörelserädsla före- och under träningsperioden. Kvinnor med FM hade viljan att vara fysiskt aktiva men utmanades av smärta och trötthet och upplevde svårigheter med att hitta rätt nivå på sin fysiska aktivitet. Resultaten av avhandlingen understryker vikten av att genom ett personcentrerat förhållningssätt utforma träningsprogram som är anpassade till varje persons resurser och begränsningar och därmed förbättra förutsättningarna att hantera smärta och andra sjukdomsrelaterade symptom.

LIST OF PAPERS

This thesis is based on the following studies, referred to in the text by their Roman numerals.

I. Larsson A, Palstam A, Bjersing J, Löfgren M, Ernberg M, Kosek E, Gerdle B, Mannerkorpi K. **Controlled, cross-sectional, multi-center study of physical capacity and associated factors in women with fibromyalgia.** *Accepted*

II. Larsson A*, Palstam A*, Löfgren M, Ernberg M, Bjersing J, Bileviciute-Ljungar I, Gerdle B, Kosek E, Mannerkorpi K. **Resistance exercise improves muscle strength, health status and pain intensity in fibromyalgia – a randomized controlled trial.** Arthritis Research & Therapy. 2015;17:1-15

* These authors contributed equally

III. Larsson A, Palstam A, Löfgren M, Ernberg M, Bjersing J, Bileviciute-Ljungar I, Gerdle B, Kosek E,Mannerkorpi K. **Pain and fear avoidance partially mediate change in muscle strength during resistance exercise in women with fibromyalgia**. Journal of Rehabilitation Medicine. 2017; 49:744–750.

IV. Larsson A, Feldthusen C, Mannerkorpi K. **Factors promoting physical activity in women with fibromyalgia-a qualitative interview study**. *Manuscript*

CONTENT

ABBREVIATIONS

ACR	American College of Rheumatology
EULAR	European League Against Rheumatism
FM	Fibromyalgia
VAS	Visual Analogue Scale

DEFINITIONS IN SHORT

Activity limitations	Difficulties in executing activities of daily life *(WHO, 2001).*
Current pain	VAS for measuring current pain intensity is used in this thesis.
Chronic pain	Commonly defined as pain persisting for more than three months *(IASP, 1994).*
Exercise	A type of physical activity consisting of repetitive, planned and structured bodily movement to maintain or improve components of physical fitness *(Caspersen et al., 1985).*
Health	A state of complete mental, physical and social well-being and not merely the absence of disease or infirmity *(WHO, 1948).*
Health status	In this thesis measured by Fibromyalgia Impact Questionnaire (FIQ total) *(Bennett 2005).*
Muscle strength	The amount of external force that a muscle can exert *(Caspersen et al., 1985).*
Pain	An unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage *(IASP 1994).*
Person-centred	A person-centred approach means seeing the patient as a person. Treatment is based on partnership, shared decision making and who the person is: their context, their individual strengths, and weaknesses *(Ekman et al., 2011).*
Physical activity	Any bodily movement produced by skeletal muscles resulting in energy expenditure

	(Caspersen et al., 1985).
Physical capacity	Refers to the ability to execute a task or an action in a given domain at a given moment *(WHO, 2001).*
Repetition maximum	The heaviest resistance that can be used for one complete repetition of an exercise *(Fleck et al., 2014).*
Resistance exercise	A type of exercise that requires the musculature to move, or attempt to move, against an opposing force, usually some kind of equipment *(Fleck et al., 2014).*
Self-efficacy	A person´s belief in their capabilities to produce desired effects by their actions (*Bandura, 1994).*

INTRODUCTION

Chronic pain is a common disorder that affects approximately 20 % of the general population worldwide [1-4]. It is one of the most common reasons for sick-leave, entails large costs for the society, and for the individual due to long-term sickness absence [5, 6], and also has a major negative impact on quality of life [7].

Fibromyalgia (FM) is a musculoskeletal disorder with a prevalence of 2% in the general population [8, 9]. FM is a heterogeneous and complex condition that is six times more common in women than in men [9]. Although widespread pain is the most prominent symptom, FM is also associated with increased pain sensitivity and tenderness [10], activity limitations [11], fatigue, and distress [9, 10].

Women with FM suffer from impaired physical capacity [12, 13], and muscle strength is reduced by 20-35% [14-17]. Activity induced pain is common in FM [18] and could be a reason why patients suffering from FM avoid physical activity that might increase pain. Pain in FM commonly hinders all activities on a strenuous level [19], and can also raise fear avoidance beliefs about physical activity [20].

The studies in this thesis investigate aspects related to muscle strength and physical capacity and factors associated to impaired muscle strength in women of working age with FM. Women with FM have problems in managing activities of daily life, probably due to impaired muscle strength. Exercise is commonly recommended as treatment to manage symptoms, but few studies have investigated the effects of resistance exercise in FM [21], and more research is warranted to examine the effects of resistance exercise on physical capacity and disease related symptoms.

Gradual introduction to heavier loads might reduce the risk of exercise induced pain and also using a person-centred approach is supposed to reduce fear-avoidance for physical activity and enhance the ability to manage pain.

PERSON-CENTREDNESS

Person-centredness is an ethical ground that should guide our practical actions as professionals and as fellow human beings and this ethical ground encompasses the philosophy of personalism [22]. Person-centered care involves the person in care and treatment as an active partner and emphasizes the importance of knowing the patient as a person with reason, will, feelings, and needs [23]. It is important to remember that the role of being a patient is just one part of being a person and a person should not be reduced to a disease alone [24]. To be a person is about self-respect, to have a history, to interact with others, to be capable and to be a partner in healthcare [24]. Sometimes we emphasize a clear patient role in healthcare and focus on the disease, care, rehabilitation, and so on, and sometimes the patient role is more dimmed.

Centre for person-centred care in Gothenburg (GPCC) has developed three key concepts for person-centred care: partnership, patient narrative and documentation [25].

The most central aspect of person-centred care is the *partnership* and building the partnership includes sharing of information, shared decision-making and shared deliberation [25]. The partnership involves mutual respect regarding each other's knowledge and expertise. The starting point for partnership is the invitation to the patient to relate a narrative. This invitation sends a message to the patient that her feelings and experiences of the disease are important [25].

Through the *patient narrative* the patient emerges as a person. The patient contributes with knowledge about her body, her wishes and goals, resources, limitations and life situation [25]. The narrative communication between patient and health care provider involves learning from each other and creating a common understanding of the experience of the illness. The narrative together with biological markers, images, and physical examinations give the professional a good basis for planning care and treatment together with the patient [26].

Documentation of the patient narrative, the shared decision-making and the active involvement in care serves at giving legitimacy to patient perspectives and safeguarding the partnership [25]. The documentation facilitates continuity in the health care chain and should be a living document that is accessible to the patient, is revised continuously, and follows the patient through the healthcare chain.

Person-centred care in practice

Clinicians often claim that they already work in a person-centred manner, but to act according to this ethic in every situation and in every meeting is difficult and requires reflection and awareness about ones actions [25, 27]. It also requires routines, working procedures and that the organization is adapted to person-centred care [28]. Person-centred care offers a way to clarify, structure and maintain the person, and has established a theory concerning the ”silent” knowledge which exists, not least among physiotherapists [27].

The aim of physiotherapy is to promote health, and to prevent illness and suffering [29]. From a person-centred perspective, care and rehabilitation should be anchored in the experience of another's subjective experience as well as in documented knowledge, and it is a challenge for the healthcare providers to take the patient's situation seriously while having a distant critical view [30]. It is vital that caregivers can see the patient as a person with the ability to act and take responsibility for her actions, an integrated and autonomous person with a history and a future [22, 31]. A person who is involved in the treatment, has the ability, the will, specific wishes, and who is the expert of her experience of the disease and its consequences [24]. Our function in healthcare is to try to identify, support, and strengthen the health resources available to a person with a disease.

FIBROMYALGIA

Fibromyalgia (FM) is a musculoskeletal pain condition that affects approximately 1-3 % of the general population; it is more common among women and prevalence increases with higher age [32-34]. The most prominent symptom in FM is persistent widespread pain, and FM is also associated with increased pain sensitivity, tenderness [10], impaired physical capacity [12-14], activity limitations [11], fatigue, and distress [9, 10]. Although the precise etiology of FM is not known, physical deconditioning is expected to contribute to the development of FM [21]. One reason for deconditioning is that women with FM are less physically active than healthy age–matched controls. Women with FM engage less in physical activities of all intensities [35]. Overweight and obesity, common in FM [36], has also been associated to systemic low-grade chronic inflammation [37]. There seems to be an increased risk of developing or augmenting FM symptoms when being overweight or obese, especially for women who report low levels of physical activity [38]. Also socioeconomic factors, such as education level, have a strong positive association to health and physical capacity [39]. The odds of having FM are strongly associated with low levels of education [9, 40].

Criteria for classification

Fibromyalgia as it is known today has been described since the nineteenth century and in 1904 a condition called "fibrositis" was described by Gowers [41]. In 1950 the concept "pain syndrome" was introduced [42] and in the 70´s and 80´s areas of extreme tenderness were identified as tender points and the condition was named *fibromyalgia* [43, 44]. In 1990 the American College of Rheumatology (ACR) published a multicenter study defining criteria for the classification of fibromyalgia (FM) [10]. According to these criteria a person diagnosed with FM should have a history of widespread pain for at least three months. The pain should be present in the left and right side of the body, above and below the waist, and also axial located along the spine [10]. Also the patient should experience pain on manual palpation in at least 11 of 18 defined tender points [10], Figure1. In this thesis the ACR 1990 criteria have been used. In 2010 a new set of preliminary criteria were proposed that focused more on multiple symptoms [45], and these criteria were later modified to require only self-report of symptoms [46]. These criteria have yet to be formally adopted and are at present "approved by the ACR Board of Directors as provisional" [45].

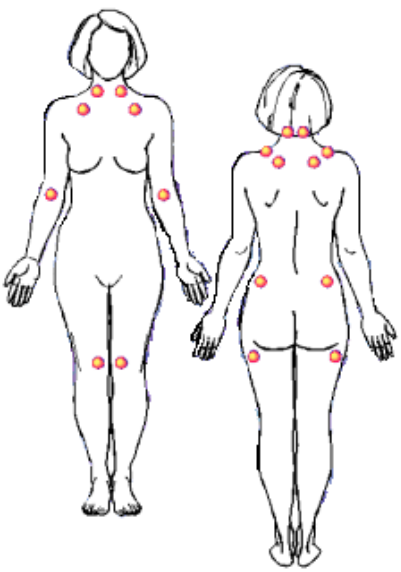

Figure1. Locations of tenderpoints included in the American College of Rheumatology 1990 criteria for fibromyalgia

Etiology

Pain is a subjective experience and The International Association for the study of Pain (IASP) defines pain as "an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage" [47] implying that pain can be present in the absence of tissue damage. The experience of pain is influenced by psychological, social and biological aspects [48]. It is difficult to distinguish pain caused by tissue damage from pain without pathophysiological cause but if the experience is regarded as pain and described in the same terms as tissue damage it should be accepted as pain [47]. Pain persisting more than the normal time it takes for an injury to heal, three months, is defined as chronic pain [49].

The etiology of FM is still poorly understood but researchers agree that disturbances both in central and peripheral pain modulating mechanisms contribute to the maintenance of widespread pain [50, 51]. The pain in FM is attributed to amplification of nociceptive input due to central sensitization and impaired central pain inhibition [50, 52]. Physical deconditioning is believed to contribute to the development of FM [21]. Hypothetically, physical deconditioning leads to enhanced muscle ischemia, increasing peripheral sensitization and thus contributing to the central sensitization [53, 54].

There are at present no laboratory tests which are specific for diagnosing the disease. The diagnosis remains clinical with physical examination and laboratory tests only ruling out alternative diagnoses [55].

Muscle strength and Activity limitations

Physical capacity refers to aerobic capacity, muscle strength, flexibility and balance and influences the ability to manage tasks of everyday living [56]. Muscle strength is essential for performing activities such as walking stairs, lifting, and carrying heavy objects as well as rising from a chair. Description of muscle strength has so far been based mainly on patients with FM examined in a specialist rheumatology setting, and the results show that muscle strength in women with FM is reduced by 20-35% [14-17], when compared to healthy women. Possible physiological explanations for the reduced strength include structural changes in muscle fibers [57], altered neuromuscular control mechanisms [58], impaired blood circulation [59], and disturbances in regulation of growth and energy metabolism [60]. Another contributing factor may be deconditioning due to pain and fatigue, leading to a decreased level of physical activity as women with FM engage less in physical activities of any intensity, than healthy women [35].

Muscle-strengthening activity, such as resistance exercise, is recommended in the general population in order to prevent age-related loss of muscle mass, impaired physical function [61], and the development of degenerative age-related chronic conditions [62]. The prevention of loss of muscle mass and physical function might be even more important in the population with FM, given their impaired muscle strength [12], and reduced levels of physical activity [35]. As lower muscle strength has been associated with higher levels of pain in FM [63] it is also reasonable to assume that a longer duration of FM symptoms is associated with lower levels of muscle strength [12].

TREATMENT

There is currently no cure for FM, despite the growing knowledge about the disease. Patients are prescribed a wide variety of pharmacological and non-pharmacological treatments. European League Against Rheumatism (EULAR) have recently suggested evidence-based guidelines for the treatment of FM based on expert consensus and systematic reviews [64]. The recommendations conclude that although pain is the dominant symptom, other symptoms such as cognitive impairment, fatigue and mood-disturbance are common, and emphasize the fact that fibromyalgia is a complex condition [64]. Optimal management includes assessment of pain, physical function and psychosocial context, and also patient education regarding the condition. EULAR recommendations emphasize prompt diagnosis, and that the patient should be provided with an explanation concerning the nature of the disease and a clear treatment strategy [64]. Treatment should primarily be focused on non-pharmacological therapies with the aim to improve health-related quality of life, maintain function, and reduce symptoms [64]. Choice of treatment should be based on patient preferences, and realistic goals should be developed together with the patient. The recently (2016) updated EULAR guidelines provide evidence for using aerobic or resistance exercise as first choice treatment improving pain, physical function, and well-being [64]. If there is a lack of effect individualized therapy including pharmacotherapy may be needed [64].

Pharmacological treatment

Pharmacotherapeutic treatment guidelines for FM recommend amitryptiline, a tricyclic anti-depressant (TCA), increasing the activity of inhibitory neurotransmitters; pregabalin an anti-epileptic drug (AED), reducing the activity of facilitating neurotransmitters; and serotonin-norepinephrine reuptake inhibitors (SNRI), duloxetine and milnacipran [64]. The use of strong opioids is discouraged but there is weak recommendation for mild opioids such as Tramadol [64]. Non-Steroid Inflammatory Drugs (NSAIDs) as first-line

treatment for FM are discouraged [65]. A recent review concludes that there are considerable variations in the pharmacotherapeutic treatment of FM, and that a large proportion of patients do not receive guide-line recommended treatment following diagnosis [65].

PHYSIOTHERAPY

Physiotherapy is integrated with science and comprises knowledge about the human being as a physical, psychological, social, and existential whole from a health perspective. In the center of knowledge is the understanding of the body, its movements and function, interacting with others and with the environment. Movement is the foundation of human functioning, and through movement humans can achieve health and quality of life [29].

In their policy statement The World Confederation for Physical Therapy (WCPT) describes physiotherapy as follows: Physical therapy provides services to individuals and populations to develop, maintain, and restore maximum movement and functional ability, throughout the lifespan. Functional movement is central to what it means to be healthy [66].

The aim of physiotherapy is to promote health, and to prevent illness and suffering. Further physiotherapy aims at maintaining or regaining optimal movement- and functional ability, and participation in social life for persons suffering from illness or injury [29].

Physical exercise is both internationally and in Sweden suggested as first choice treatment in FM improving pain, physical capacity and quality of life [64, 67]. Aerobic exercise has been shown to improve global well-being and physical function [68]. Resistance exercise has been shown to improve activity limitations, pain, and muscle strength in women with FM [21], but the paucity of studies implies that evidence is of low quality [21]. Women with FM engaging in Nordic walking significantly improved their walking ability and activity limitations [69]. Aquatic exercise, i.e. performing exercise in waist high warm water has been shown to improve pain, stiffness, muscle strength, and overall well-being [70].

Resistance exercise

Progression in resistance exercise is defined as "the act of moving forward or advancing toward a specific goal" [71]. In order for the body to adapt and for improvement to occur, the program has to be altered systematically [72]. Gradually increased physiological demands will require the body to exert a

greater magnitude of force [71]. Among untrained persons, physiological adaptations may come about following a short period of resistance exercise, but for further improvement it is necessary to increase the demands. This can be accomplished by altering one or several of the following variables: exercise loads, exercise repetitions, exercise speed, rest periods, or training volume [71].

A repetition maximum (RM), is the maximum number of repetitions that can be performed with proper lifting technique. The heaviest resistance that can be used for one repetition is called one repetition maximum (1RM) [73]. Estimation of 1RM can, for health and safety reasons, be made by submaximal ratings, asking the participant to perform the maximal number of repetitions until perceived exhaustion at an individually adjusted given resistance [74].

Improved strength, is a well-known benefit of regular resistance exercise [71], and can facilitate a person's ability to perform daily activities and counteract activity limitations. There are few studies evaluating the effects of resistance exercise for women with FM [21], and one reason for this might be the risk of increased pain following isometric loads [18]. Pain in FM commonly builds hinders for all exercise at a strenuous level [19], and can also raise fear avoidance beliefs about physical activity [20]. As activity-induced pain is a common feature in FM, this might be a reason for the avoidance of heavier physical activities [75]. An additional hindrance might be being overweight, which is common in FM [36, 76], as a previous study indicated that obesity might negatively influence the outcomes of exercise [77].

Relaxation therapy

In study II relaxation therapy was used as an active control intervention, as relaxation therapy was assumed to improve overall wellbeing and to provide a meaningful and inspiring therapy, to control for the natural course and some aspects of attention and expectations. Relaxation therapy is frequently used as a component in multidisciplinary treatment [78] but there is limited evidence of the effects of relaxation therapy as sole treatment due to the paucity of studies [79]. Combining relaxation therapy with other treatment modalities seem to be more beneficial for pain relief in FM than relaxation therapy alone [79].

Gender

The main reasons for only including women in the studies are that fibromyalgia is several times more common in women than in men [34] and that men with FM report significantly higher self-rated physical function [80]. Most studies on FM comprise women only or a mix of women and men, where men are in minority. Since it appears to be a difference between ratings of physical capacity in men and women with FM, it might be preferable to study men and women separately.

AIM

The overall aim of this thesis was to seek deeper knowledge about muscle strength in women with FM, to examine the effects of person-centred progressive resistance exercise in women with FM, and to explore which factors were experienced to promote physical activity in women with FM.

SPECIFIC AIMS

The specific aims of the studies included in this thesis were:

Study I

The main objective of this study was to investigate to what degree muscle strength and walking ability were decreased in women with FM, compared to healthy women matched for age and level of education.
A secondary aim was to investigate whether muscle strength and walking ability were associated with age, symptom duration, activity limitations, and Body Mass Index (BMI) in women with FM and in healthy women.

Study II

To examine the effects of a progressive resistance exercise program, using a person-centred approach, on muscle strength, health status, and current pain intensity in women with FM.

Study III

To investigate factors that mediate change in muscle strength in women with fibromyalgia engaging in resistance exercise. We hypothesized that baseline muscle strength, age, disease duration, amount of leisure time physical activity, pain, fear avoidance, and Body Mass Index (BMI) may contribute to explain increase in muscular strength following resistance exercise in women with FM.

Study IV

The aim of the study was to gain deeper knowledge of factors experienced to promote physical activity in women with FM through qualitative interviews.

METHODS

The thesis comprises four studies. Different methods for data collection and analysis were used based on the research questions of each study. Study design, methods of recruitment, study population, number of participants, methods for data collection and analyses are described in Table 1.

Table 1 Overview of the research design

	Study I	Study II	Study III	Study IV
Study design	Controlled cross-sectional multi-center study	Randomized controlled multi-center study	Secondary within-group analysis of a randomized controlled multi-center study	Qualitative exploratory Interview study
Recruitment	Newspaper advertisements			Previous studies
Study population	Women with FM and healthy women	Women with FM		
Number of participants	N=211 FM (n=118) Healthy (n=93)	N=130 Resistance exercise (n=67) Relaxation therapy (n=63)	N=67	N=14
Data collection	Clinical examination Standardized interview on demographics Self-reported questionnaires Tests of physical capacity			Semi-structured individual in-depth interviews
Analysis	Non-parametric statistics	Non-parametric statistics Parametric statistics		Qualitative latent content analysis

Study populations

This thesis is a part of a larger project, called Painomic, initiated on a seminar arranged by The Swedish Rheumatoid Association, involving researchers in Stockholm, Gothenburg and Linköping. The main responsibility for the Painomic project is Professor Eva Kosek (Karolinska Institute).

Recruitment process study I-IV

Women with FM and healthy controls were recruited by newspaper advertisement in the local daily newspapers in Gothenburg, Stockholm, and Linköping. Patients were recruited to study II. In study I only baseline data were used and in study III baseline and post-test data were used. In study IV participants from the Gothenburg cohort were recruited, Figure 2.

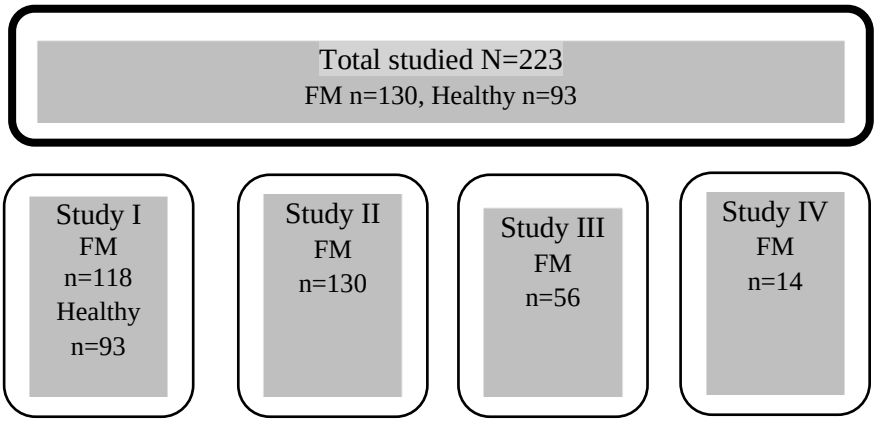

Figure 2 Study populations and number of participants included in study I-IV

Inclusion criteria for women with FM were to be of age 20-65 years and meeting the American College of Rheumatology (ACR) 1990 classification criteria for FM [10].

Comorbidity as an exclusion criterion was defined by anamnesis. Exclusion criteria were high blood pressure (>160/90 mmHg), osteoarthritis (OA) in hip or knee, confirmed by radiological findings and affecting activities of daily life such as stair climbing or walking, other severe somatic or psychiatric disorders, other dominating causes of pain than FM, high consumption of alcohol (alcohol use disorders identification test (AUDIT) score >6) [81], participation in a rehabilitation program within the past year, regular resistance exercise or relaxation exercise twice a week or more, inability to understand or speak Swedish, and not being able to refrain from analgesics, non-steroidal anti-inflammatory drugs (NSAID), or hypnotic drugs for 48 hours prior to examinations.

A total of 402 women with FM who notified their interest for participation in the study were telephone screened for possible eligibility and informed about the study procedure. Out of these, 177 women who were interested in participation were referred to a medical examination for further enrollment, and were screened for eligibility. One-hundred and thirty women with FM age 22-64 years fulfilled the inclusion criteria and formed the cohort of the study, Figure 3.

Matched controls were recruited in parallel from a cohort of a total of 130 healthy women age range 21-64 years. Exclusion criteria were any pain

condition, high blood pressure (>160/90 mmHg), osteoarthritis (OA) in hip or knee or other severe somatic or psychiatric disorders.

Study I

The women with FM and the healthy controls were individually matched to age and education. Initially the participants were classified in five-year age groups, while education categories were exact for years of education. After this matching, additional patients in the education level 10-12 were included. The final sample comprised 118 women with FM and 93 healthy women, Figure 2.

Study II

One-hundred and thirty women with FM fulfilled the inclusion criteria. After completing baseline examinations, the participants were randomized to resistance exercise (n=67) or relaxation therapy (n=63). A flow chart of the study process is shown in Figure 3.

Study III

Women with FM that participated in the resistance exercise intervention in study II and completed post-treatment examinations (n=56) were included in this study, Figure 2.

Study IV

The participants were recruited from a cohort of 40 women with FM who had previously (2010-2011) participated in supervised resistance exercise or relaxation therapy in West Sweden. Inclusion criteria were women with FM diagnosed according to the American College of Rheumatology (ACR) 1990 criteria [82], who had participated 10 times or more in either one of the interventions, as they were regarded to have experience of different types of physical activities. A total of 28 women (70%) fulfilled the inclusion criteria and were contacted by mail with information about the study. The letter was followed up with a telephone call to confirm participation and schedule the interviews. Twelve women agreed to participate in the study and were interviewed. Six women declined to participate because of time limitations or lack of energy. In order to reach at least two more patients another letter was sent to the women whom we did not reach by telephone (n=10) and two of these women were interviewed. In total 14 interviews were performed, Figure 2.

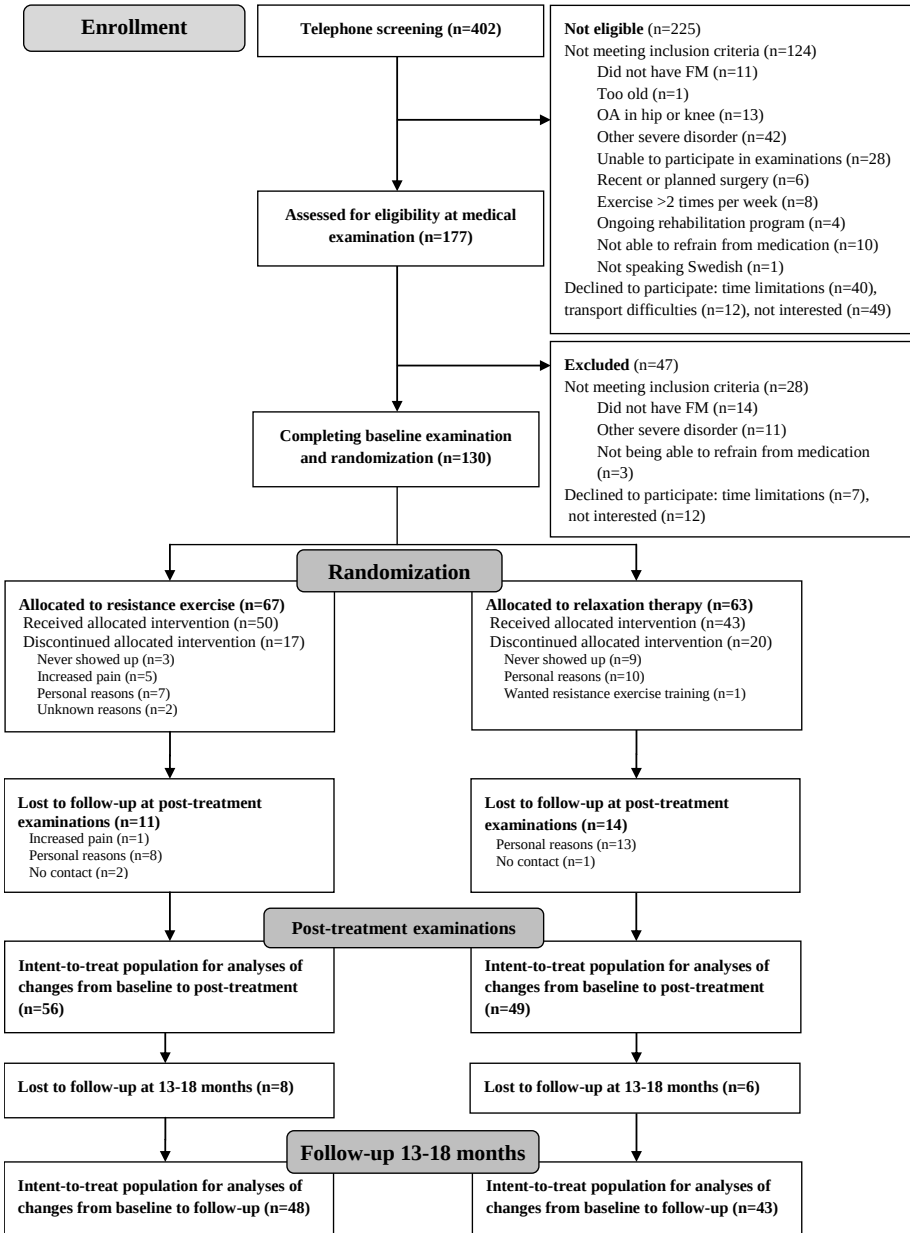

Figure 3 Flowchart of the study process of study II

Ethics

Ethical approval for study I-III was granted by the Regional Ethical Review Board in Stockholm, Sweden (2010). Ethical approval for study IV was granted by the Regional Ethical Review Board in Gothenburg, Sweden (2016). Written and oral informed consent was obtained from all participants.

Data collection

The measures used in the thesis are listed in Table 2 and presented in the following section.

Demographic data

In studies I-III information regarding socio-demographics, duration of symptoms, and pharmacological treatment was gathered in a standardized interview. In study IV information was gathered regarding socio-demographics and duration of symptoms.

Family status was divided into two categories referring to whether the person lived with another adult or not.

Ethnicity was divided into two categories referring to whether the person was born in Sweden or not.

Education was categorized as follows ≤ 9 years, 10-12 years, and > 12 years of education.

Work status was reported as percent of full time employment.

Pharmacological treatment was divided into five different categories: NSAID/paracetamol, opioids for mild to moderate pain, antidepressants, anticonvulsants and sedatives. When use was regular or as needed, it was registered as positive.

Body Mass Index (BMI) was calculated as [*weight (kg) / height (m)*^{2}]

Clinical examinations

Tender points were examined by manual palpation by a physician to verify diagnosis according to the ACR 1990 [10] criteria. The test-retest and inter-rater reliability has been found to be satisfactory [83, 84].

Table 2 Outcome measures used in study I-IV.

Measures	Study I	Study II	Study III	Study IV
Demographic data				
Age (years)	x	x	x	x
Symptom duration (years)	x	x	x	x
Family status	x	x		
Ethnicity	x	x		
Education	x	x		
Work status		x		
Pharmacological treatment	x	x		
BMI	x	x	x	
Clinical examinations				
Tender point count (nr)	x	x		
Tests of physical capacity				
Knee-extension force (N)	x	x	x	
Elbow-flexion force (kg)	x	x	x	
Hand-grip force (N)	x	x	x	
6MWT (m)	x	x		
Self-reported questionnaires				
FIQ (0-100)	x	x		
SF 36 PCS (0-100)		x		
SF 36 MCS (0-100)		x		
SF 36 PF (0-100)	x			
Current pain (VAS)	x	x	x	
LTPAI (h)	x	x	x	
FABQ work (0-42)		x		
FABQ physical (0-24)		x	x	
PDI (0-70)		x		
CPAQ (0-120)		x		
PGIC (1-7)		x		

BMI: Body Mass Index, FIQ: Fibromyalgia Impact Questionnaire, SF36 PCS: Short-form 36 Physical Component Scale, SF 36 MCS: Short-form 36 Mental Component Scale, VAS: Visual Analogue Scale, LTPAI: Leisure Time Physical Activity Index, FABQ: Fear Avoidance Beliefs Questionnaire, PDI: Pain Disability Index, CPAQ: Chronic Pain Acceptance Questionnaire, PGIC: Patient Global Impression of Change.

Tests of physical capacity

Isometric knee-extension force was measured with Steve Strong® (Stig Starke HBI, Göteborg, Sweden) a portable dynamometer. The participant was in a fixed seated position with back support, knee and hip in 90 ° of flexion and legs hanging freely. A non-elastic strap was placed around the ankle and attached to a pressure transducer with an amplifier. The subjects were instructed and verbally encouraged to pull the ankle strap with maximal force for 5 seconds. Three trials were performed for each test and there was a one minute rest between each trial. The best performance out of three trials was recorded. A mean value of the maximal force (N) in the right and left leg was calculated. The instrument has been used in previous studies of physical performance [85, 86]

and has shown satisfactory test-retest reliability for patients with a chronic condition [86].

Isometric elbow-flexion force in both arms, one by one was measured with *Isobex® (Medical Device Solutions AG, Oberburg, Switzerland)*, a portable dynamometer. The participant was in a seated position without back support, with the legs stretched out in front. The upper arm was aligned with the trunk and the elbow was placed in 90° of flexion. The maximum force (kg) obtained during a period of 5 seconds was recorded. Three trials were performed for each test and there was a one minute rest between each trial [34]. The best performance out of three trials was recorded. A mean value from the right and left arm was calculated. Isobex has shown satisfactory intra-rater and inter-rater reliability in assessing shoulder strength in healthy individuals [87].

Hand-grip force was measured with Grippit® (AB Detektor, Göteborg, Sweden), an electronic instrument measuring grip force (N) [88]. The mean force over a set period of time (ten seconds) was recorded. Two trials were performed for each hand and there was a one minute rest between each trial. The best performance out of two trials was recorded. A mean value of the force of the right and left hand was calculated. Grippit has shown satisfactory test-retest reliability for women with FM [88].

Six-minute walk test (6MWT) a performance based test that measures total walking distance (m) covered during a period of 6 minutes. The standardized instruction was to walk as fast as possible without running. The test has shown satisfactory intra-rater reliability in a Swedish FM population [89].

Self-reported questionnaires

Fibromyalgia Impact Questionnaire (FIQ) a disease-specific questionnaire that comprises ten subscales of disabilities and symptoms ranging from 1-100. The total score is the mean of ten subscales. A higher score indicates a lower health status [90]. This instrument has shown to have satisfactory test-retest reliability and good sensitivity in demonstrating therapeutic change [91].

Short-Form 36 (SF36), a generic instrument assessing health related quality of life comprises eight subscales ranging from 0-100. A higher score indicates better health related quality of life [92]. The subscales build two composite scores, the Physical Component Scale (PCS) and the Mental Component Scale (MCS). The SF36 has been reported to be useful in research of FM [93] and is validated for a Swedish population [94]. In study I the subscale SF36 *Physical function* was used. This subscale includes questions about vigorous activities such as lifting and

carrying heavy objects, climbing stairs and walking several blocks. A higher score indicates less activity limitations i.e. good physical function.

Current pain intensity was measured by Visual Analogue Scale (VAS), a plastic 0-100 visual analogue scale with a moveable cursor along a line and anchors at the extremes. The participant was asked to rate her current pain intensity ranging from no pain at all to the worst imaginable pain. VAS has been reported to be a useful measure of pain intensity in most settings [95].

Leisure Time Physical Activity (LTPAI) is a questionnaire assessing the amount of physical activity (light, moderate, vigorous) performed during a typical week (h). The total score is the sum of the hours [96]. The instrument has shown satisfactory test-retest reliability [96].

Fear Avoidance Beliefs Questionnaire (FABQ) is a questionnaire comprising two sub-scales that assess the extent to which fear and avoidance affect work beliefs (7 items range 0–42) and physical beliefs (4 items 0–24) in patients with chronic pain. A higher score represents greater fear avoidance beliefs [97]. The instrument has shown satisfactory test-retest reliability [97].

Pain Disability Index (PDI) is an instrument assessing the impact that pain has on the ability of a person to participate in essential life activities, such as social activities and recreation, on a scale from 0 to 70. The higher the score, the greater the person's disability due to pain [98, 99]. PDI has shown satisfactory test-retest reliability and is valid for patients with chronic pain [98-100].

Chronic Pain Acceptance Questionnaire (CPAQ) is an instrument that assesses the degree of pain related acceptance. It consists of 20 items ranging from 0 (never true) to 6 (always true). A higher score indicates a higher level of acceptance [101].

Patient Global Impression of Change (PGIC) is a seven-point numeric scale ranging from "very much improved" to "very much worse", where a lower score indicates greater improvement in symptoms. This instrument assesses perceived global impression of change from the patient's perspective. The instrument has been shown to be useful for measuring clinically significant change [102, 103].

Qualitative interviews

In this thesis qualitative interviews were performed to gain a deeper knowledge about how women with FM experience factors promoting physical activity in women with fibromyalgia.

Qualitative research provides opportunity for the researcher to understand health and disease from the perspective of those affected, and from the context of human diversity [104]. The researcher is regarded as an active part in the construction of new knowledge as the research process, from creating the research questions to interpreting and analyzing the data, is influenced by the previous experiences, hypotheses, and professional perspectives of the researcher [105, 106].

Procedures

Study I

Baseline data for women with FM recruited for study II were analyzed in this study. For healthy women data were collected using a standardized interview, performance based tests of physical capacity, and self-reported questionnaires, Table 2.

Women with FM were compared to the healthy women on demographic data and performance based tests of physical capacity. Correlations between muscle strength, walking ability, age, symptom duration, and activity limitations were analyzed for the women with FM, and for the healthy women.

Study II

The randomized controlled trial was carried out in Gothenburg, Stockholm, and Linköping. Data was collected at baseline and after 15 weeks of intervention, through clinical assessment, a standardized interview, performance based tests of physical capacity, and self-reported questionnaires, Table 2. Baseline and post-treatment examinations were performed by the same physiotherapists. The examiners were blinded to group allocation. Follow-up was conducted 13-18 months after inclusion in the study and included only self-reported questionnaires.

The participants were randomized to a person-centered progressive resistance exercise program or to an active control group performing relaxation therapy. Outcomes were analyzed according to intent-to-treat, implying that all participants were invited to post-treatment examinations, whether they had participated in the intervention or not. Only measured values were included in analyses.

The follow-up at 13-18 months comprised self-reported questionnaires which were sent to the participants by mail. The participants who did not return their questionnaires were contacted and reminded by telephone. After three

reminders, the data from the participants who had not returned the questionnaires were regarded as missing.

Primary outcome was isometric knee-extension force (N) measured with Steve Strong®. Secondary outcomes were health status measured with FIQ total score, current pain intensity measured with VAS (0-100), 6MWT (m), isometric elbow-flexion force (kg), hand-grip force (N), health related quality of life (SF36), pain disability (PDI), pain acceptance (CPAQ), fear avoidance beliefs (FABQ), and patient global impression of change (PGIC).

Person-centred progressive resistance exercise the resistance exercise program was performed twice a week for 15 weeks. It was conducted at physiotherapy clinics and at a local gym at four different sites in small groups comprising 5-7 participants, to promote interaction between participants and to facilitate physiotherapeutic guidance.

The intervention was preceded by an individual introductory meeting. The meeting was commenced with a dialogue between the participant and the physiotherapist about the participant's earlier experiences and thoughts of exercise, which could potentially be an obstacle for her ability to exercise despite her explicit intention to do so. The introductory meeting also included exercise instructions, testing and adjustment of loads and modifications of specific exercises, according to individual conditions and according to self-efficacy principles [107], of each participant's confidence in their ability to perform each exercise and to manage specific loads. The meeting resulted in a written protocol with descriptions of specific exercises and loads, which was used by each participant as an exercise program at each exercise session.

Each session included a 10 minute warm up, 50 minute standardized protocol including: leg-press, knee-extension, and knee-flexion using weight machine, biceps curl and hand grip strength using free weights, heel raise and core stability using body weight, and 10 minutes of stretching exercises. Exercises for explosive strength were added to the protocol 5 weeks, and 8 weeks into the intervention with rapid heel-raises and explosive knee-extensions respectively. Between each set the participant was instructed to rest for 1 minute to avoid increased pain. To promote the participant's sense of control, and to avoid possible negative effects related to exercise, the exercise was initiated at low loads, and possibilities for progressions of loads were evaluated every 3−4 weeks in dialogue between the physiotherapist and participant. When the participant was not ready to increase exercise loads, she continued exercising on the same loads until she was ready to do so. This mode of exercise was

anticipated to increase exercise self-efficacy, enhance the ability to choose the proper level of exercise and better manage symptoms.

Estimation of one repetition maximum (1RM) was made by submaximal ratings of perceived exertion for health and safety reasons [74]. The participants were asked to perform their maximum number of repetitions until perceived exhaustion at an individually adjusted, given resistance. 1RM was based on the number of repetitions performed. The exercise was initiated at low loads corresponding to 40% of 1RM (1–2 sets, 15–20 repetitions) and progressed up to 80% of 1RM (1–2 sets, 5–8 repetitions) during the 15 weeks.

Active control group the relaxation therapy was performed twice a week for 15 weeks. It was conducted at physiotherapy clinics at four different sites in groups comprising 5-8 participants, and was preceded by an individual introductory meeting at the clinic, which included instructions and allowed for preparations and modifications of practical matter, such as positioning and the use of mattresses and pillows to reach a good level of comfort. The relaxation therapy was performed as autogenic training [79], which refers to a series of mental exercises including relaxation and autosuggestion. The physiotherapist guided the participants through their bodies, during approximately 25 minutes, by focusing their minds on the bodily experience of relaxation and letting the body part in focus rest on the ground. This was repeated for each specific body-part, aiming at feeling as relaxed as possible in the whole of the body at the end of the session. After each session the participants were invited to share experiences and ask each other and the physiotherapist questions, and continued thereafter with the stretching exercises.

Study III

Baseline and post-treatment data regarding women with FM recruited to study II that had participated in the resistance exercise intervention were analyzed in this study. Data were collected in Gothenburg, Stockholm, and Linköping. Outcomes were assessed at baseline and immediately after the 15-week intervention period. Examinations included self-administered questionnaires, performance-based tests of muscle strength and assessment of current pain intensity, Table 2.

Explanatory factors for change in muscle strength and predictors for the final value of muscle strength were analyzed.

Study IV

Interview data was gathered through semi structured individual interviews that took place in the Physiotherapy premises at Sahlgrenska University Hospital,

April-November 2016. The interviewer followed an interview guide with open-ended questions. All interviews began with a joint open introduction and the question: "We are interested in gaining more knowledge of the factors that women with FM experience promotes or hinders them to be physically active or exercise. Can you tell me how you exercise today?" The interviewer followed the respondent's reasoning and the study questions and invited the participant to add, confirm, and clarify any aspects discussed. The interviews lasted for approximately one hour. The interviews were recorded and then transcribed verbatim by an experienced medical secretary.

ANALYSIS

Statistical analyses

Data were computerized and analyzed using the Statistical Package Software for the Social Sciences (SPSS version 22.0, Armonk, NY, USA) in study I-III. A summary of the statistical tests used in the thesis is shown in Table 3.

All significance tests were two-sided and conducted at the 5 % significance level. Non-parametric and parametric statistics were used in the studies of the thesis. Descriptive data are presented as mean (SD), median (min; max) for continuous variables or the number (n) and percentage (%) for categorical variables.

Between-group comparisons were made in study I and II. The Mann-Whitney U test was used for continuous variables, Fisher's exact test was used for dichotomous variables, and the Mantel Haenzel chi-square test was used for ordinal categorical variables.

Within-group comparisons were made in study II. The Wilcoxon signed rank test was used for comparison between baseline and post-test within groups for continuous variables.

Spearman correlation analysis was used in study I for analyzing correlations between isometric knee-extension force, isometric elbow-flexion force, isometric hand grip force, walking ability, and activity limitations. The following classification was used to interpret the absolute (irrespective of sign) correlation values, given that *p*-values were less than 0.05: *r*s 0.01–0.25 indicates weak relationship, *r*s 0.25–0.50 indicates a moderate-level relationship, *r*s 0.50–0.75 a moderate-to-good relationship, while a correlation above *r*s 0.75 indicates a very good-to-excellent relationship [108]. In study II correlations with patient global impression of change (PGIC) were analysed. In study III Spearman correlation coefficient was used for correlation between the dependent variables of change

in muscle strength and baseline measures, and measures of change in the independent variables as well as for correlation between the final values of muscle strength and baseline values in the independent variables. Variables with a *p*-value < 0.2 on analysis of correlation were included in further analyses.

Linear forward stepwise multiple regression analysis was performed in study III to analyze explanatory factors for change in muscle strength and predictors for final value of muscle strength. Variables with a *p*-value < 0.2 on analysis of correlation were included in further analyses using multiple linear forward stepwise regression analysis. The assumptions of normality were confirmed by checking the residual scatterplots and histograms of each variable, respectively. Multicollinearity was examined by tolerance and variance inflation factor. The number of variables included in each model was limited to the number of women in the group, one variable per every 10 women.

Upper limit of expected number of false significances was calculated to control possible type I errors in study II The expected number of false significant results was calculated by the following formula: (number of tests-number of significant tests) $\times\alpha/(1-\alpha)$ where α is the significance level [109].

Effect size was calculated for variables showing a significant change. Effect size for between-group analyses was calculated by dividing the mean difference between the post-treatment score and baseline score in the intervention group and in the control group by the pooled SD for difference. Effect sizes from 0.20 to <0.50 were regarded as small, while effect sizes from 0.50 to <0.80 were regarded as moderate [110].

Sample size was calculated for study II. No previous data were found for isometric knee-extension force in FM using the selected dynamometer (the primary outcome), but the same methodology had been applied in a study of women with chronic disease. Their mean isometric knee-extension force was 263 N, SD 100 [86]. Based on that report, 59 participants per group would be satisfactory to detect a 20 % difference with 80 % power when the significance level was set to 5 %. Due to risks of possible drop-outs a total of 130 participants were recruited.

Table 3 Overview of statistical tests included in the thesis

Statistical tests	Study I	Study II	Study III	Study IV
Descriptive statistics for continuous variables Mean (SD) Median (min;max)	x	x	x	x
Descriptive statistics for categorical variables Number (n) and percent (%)	x	x	x	
Comparison between groups for continuous variables Mann-Whitney U-test	x	x		
Comparison between two groups for dichotomous variables Fisher´s exact test	x	x		
Comparison between two groups for ordinal categorical variables Mantel-Haenzel chi-square test		x		
Within-group comparison for change over time Wilcoxon signed rank test		x		
Estimate of magnitude of change between two groups Effect size		x		
Analyses of correlations Spearman´s correlation analysis	x	x		
Analysis of explanatory factors for continuous variables Stepwise multiple linear regression analysis			x	

Qualitative content analysis

First, the interviews were read through several times in order to obtain a sense of the whole. The unit of analysis consisted of whole interviews, and no parts were excluded from the analyses. Second, guided by the research question of experience of factors promoting health enhancing physical activity, meaning units were derived from the text, condensed and abstracted [111]. The abstracted meaning-units were then developed into sub-categories and categories. The analysis process moved continuously back and forth between the whole and parts of the text, Figure 4 [111]. Tentative sub-categories and categories were discussed and elaborated between all authors until consensus was reached. Co-operation between the researchers was assumed to increase the credibility of the analysis.

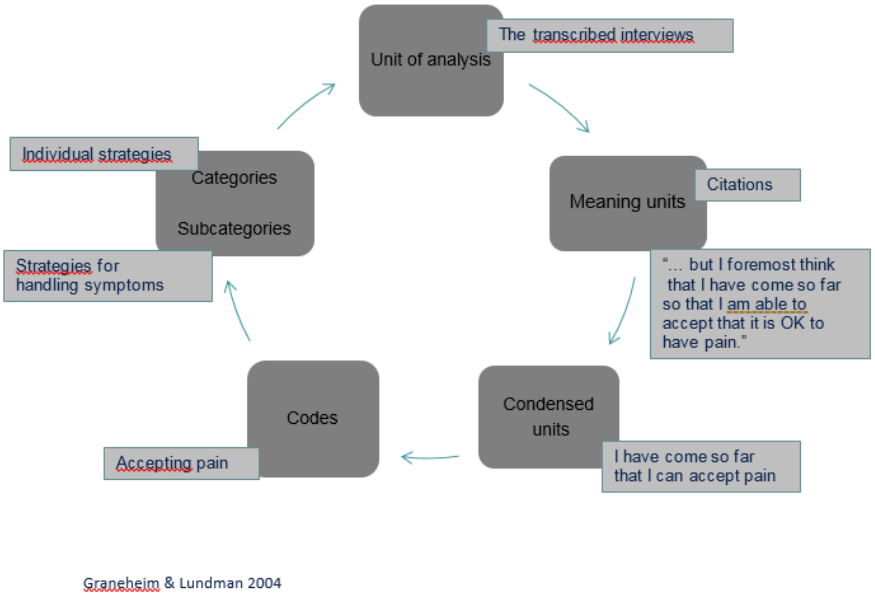

Figure 4 The process of the content analysis, starting from Unit of analysis.

RESULTS

A summary of the results from the studies are presented in the following section. Characteristics of the study populations in study I-IV are presented in Table 4. Study I and IV has yet to be published and therefore the results are presented briefly.

Table 4. Characteristics of the study populations

Variables	Study I		Study II		Study III	Study IV
	Women with FM	Healthy women	Resistance exercise	Relaxation therapy		
Subjects (n)	118	93	67	63	67	14
Age (years)	51.0 (9.51)	51.2 (9.64)	50.8 (9.05)	52.1 (9.78)	50.8 (9.0)	60.5 (38;65)
Symptom duration (years)	10.2 (7.95)	n.a	11.1 (8.53)	9.4 (7.33)	11.1 (8.5)	15.0 (7;32)
Tender points (nr)	15.6 (1.99)	n.a	15.8 (1.92)	15.5 (2.00)	15.8 (1.92)	
Current pain (VAS)	50.5 (21.16)	2.98 (6.62)	49.3 (23.9)	52.4 (18.3)	49.3 (23.9)	
Activity limitations (FIQ total 0-100)	60.4 (15.6)	6.3 (8.7)	60.5 (14.4)	61.1 (17.3)	60.5 (14.4)	
LTPAI	5.7 (5.64)	6.98 (4.62)	5.6 (4.80)	5.8 (6.25)	5.6 (4.80)	
BMI	27.9 (5.28)	24.70 (3.48)	27.4 (5.29)	28.7 (5.32)	27.3 (5.3)	

Data is presented as Mean (SD), Median (min;max). VAS: Visual Analogue Scale, FIQ: Fibromyalgia Impact Questionnaire. LTPAI: Leisure Time Physical Activity Index, BMI: Body Mass Index.

Controlled, cross-sectional multi-center study of physical capacity and associated factors in women with fibromyalgia (Study I).

The women with FM showed significantly lower isometric knee-extension force, isometric elbow flexion force, isometric hand-grip force, and walking ability

($p<0.001$) than the healthy women. The women with FM displayed 20-36% lower muscle strength than the healthy women and walked 16% shorter distances in the 6MWT than the healthy controls.

The investigated physical capacity variables intercorrelated significantly for the women with FM (r_s:0.25-0.75) and the healthy controls (r_s: 0.44-0.74).

In the women with FM both isometric knee extension force and 6MWT correlated significantly with age, BMI, symptom duration and SF36 subscale *Physical function*; the strength of the correlations was weak to moderate. Isometric elbow-flexion force and hand-grip force correlated with symptom duration. The strength of the correlations was weak to moderate.

In the healthy women isometric knee-extension force and isometric hand grip force correlated significantly with age, the strength of the correlations were weak to moderate. Isometric elbow flexion force correlated significantly with BMI and SF36 subscale *Physical function*, the strength of the correlations were weak to moderate. 6MWT correlated significantly with age, BMI, and SF36 *Physical function* and the strength of the correlations were moderate.

Resistance exercise improves muscle strength, health status and pain intensity in fibromyalgia- a randomized controlled study (Study II).

All participants were invited to a post-treatment examination according to an intent-to treat design and 81% of the total sample completed the test, 56 (84%) belonging to the resistance exercise group and 49 (76%) in the active control group, Figure 3. Seventeen participants (25%) in the resistance exercise group, and 20 (32%) in the active control group discontinued the intervention for various reasons, Figure 3. No significant differences were found when comparing the baseline characteristics between the women who completed the post-treatment examinations and the women who failed to complete the post-treatment examinations.

Adverse effects were reported by 5 participants (3,8%), all in the resistance exercise group, who chose to discontinue the intervention due to increased pain, two of these participants completed post-treatment examinations.

Mean attendance rate at the resistance exercise sessions was 71% and at the relaxation therapy sessions 64% (range 0 to 100% in both groups). Forty-two participants (62.7%) in the resistance exercise group reached exercise loads of 80% of 1 RM while 7 participants (10.4%) reached exercise loads of 60% of 1

RM. The women in the resistance exercise group that managed to reach exercise loads of 80% of 1 RM (n=42, 63%) showed significantly better physical capacity represented by 6MWT (p= 0.040) and health status represented by FIQ total score (p= 0.029) at baseline than the women in the resistance exercise group that did not reach exercise levels of 80% of 1 RM.

Primary outcome

Significantly greater improvement (p = 0.010) was found for isometric knee-extension force in favor of the resistance exercise group as compared to the active control group. The effect size of change in isometric knee-extension force for the intervention group was 0.55. The changes ranged from -51 % to 126 % on the individual level, implying large variation among the participants, Table 5.

Secondary outcomes

Significantly greater improvement was observed in health status (FIQ total score) (p = 0.038), current pain intensity (VAS) (p = 0.033), 6MWT (p = 0.003), isometric elbow-flexion force (p = 0.020), pain disability represented by the PDI (p = 0.005), and pain acceptance represented by the CPAQ (p = 0.043) in the resistance exercise group compared to the active control group, Table 5. Significant improvements were observed in the health related quality of life (SF-36 PCS and MCS) (p = 0.007) within the resistance exercise group, reflecting what is considered to be a clinically important difference [112]. There was no significant difference between groups in hand-grip force; both the exercise intervention group and the active control group improved their strength significantly (p <0.001, p = 0.013) and no differences within groups or between groups were found for fear avoidance beliefs represented by the FABQ, Table 5. The effect size of the change was small to moderate, 0.41 in the FIQ total score, 0.46 in current pain intensity, 0.45 in the 6MWT, 0.36 in isometric elbow flexion force, 0.53 in the PDI, and 0.45 in the CPAQ for the intervention group compared with the active control group.

Table 5.Between-group analysis and within-group analysis of the primary and secondary outcomes (study II)

Measures	Resistance exercise (experimental)				Relaxation therapy (control)				Between group analysis for change
	Baseline (n=67)	Post-test (n=56)	Posttest-baseline (n=56)	Within-group analysis	Baseline (n=63)	Post-test (n=49)	Posttest-baseline (n=49)	Within-group analysis	
	Mean (SD) Median(min;max)	Mean (SD) Median (min;max)	Δ (SD) Δ (min;max)	p- value	Mean (SD) Median(min;max)	Mean (SD) Median (min;max)	Δ (SD) Δ (min;max)	p-value	p-value
Primary outcome									
Isometric knee-extension force (N)	330.1(109.4) 326 (111;643)	356.2 (118.9) 342 (105;663)	30.4 (71.9) 31 (-157;178)	**0.002**	298.8 (107.8) 287 (51;534)	276.4 (112.9) 278 (41;595)	-8.8 (70.0) -10 (-222;132)	0.644	**0.010**
Secondary outcomes									
FIQ total (0-100)	60.5 (14.4) 59 (31;95)	54.4 (18.2) 55 (11;88)	-5.7 (15.0) -3 (-51;20)	**0.009**	61.1(17.3) 61 (17;88)	59.3 (16.0) 61 (21;86)	0.1 (12.9) 1 (-34;25)	0.71	**0.038**
Current pain intensity (VAS)	49.3 (23.9) 50 (5;100)	38.6 (25.2) 31 (0;95)	-11.5 (25.1) -13 (-83;48)	**0.002**	52.4 (18.3) 51 (10;88)	53.4 (20.0) 56 (10;86)	-1.5 (16.5) -2 (-51;30)	0.63	**0.033**
6MWT (m)	556.6 (75.1) 566 (360;766)	579.7 (73.7) 582 (340;762)	18.4 (65.1) 24 (-290;196)	**0.002**	540.7 (64.5) 530 (362;660)	533.9 (73.1) 537 (366;656)	-5.6 (43.5) 1 (-125;101)	0.51	**0.003**
Isometric elbow flexion force (kg)	13.0 (5.4) 13 (2;32)	14.8 (5.6) 15 (2;27)	2.4 (3.3) 2 (-5;12)	**<0.001**	10.9 (5.2) 10 (2;24)	11.7 (5.6) 12 (3;27)	1.2 (3.3) 1 (-7;13)	**0.020**	**0.020**
Hand-grip force (N)	161.8 (68.7) 164 (34;319)	181.1 (61.5) 185 (38;327)	20.1 (36.1) 14 (-32;158)	**<0.001**	139.4 (61.7) 134 (40;311)	147.2 (66.7) 146 (39;327)	14.0 (37.9) 9 (-101;98)	**0.013**	0.49
SF36 PCS (0-100)	31.2 (7.9) 31 (12;50)	34.5 (9.1) 35 (14;54)	3.3 (7.2) 3 (-13;18)	**0.004**	29.9 (8.1) 30 (10;50)	30.7 (8.3) 30 (17;47)	0.8 (5.7) 1 (-13;13)	0.28	0.11
SF36 MCS (0-100)	37.7 (12.2) 37 (10;61)	42.0 (12.6) 44 (12;62)	3.3 (10.3) 3 (-23;35)	**0.007**	39.6 (12.1) 42 (16;59)	38.8 (12.9) 41 (13;61)	-0.4 (9.5) 0 (-22;23)	0.86	0.054
PDI (0-70)	35.3 (12.2) 36 (8;69)	32.2 (13.1) 34 (7;67)	-3.8 (10.6) -5 (-29;23)	**0.006**	35.0 (12.5) 34 (7;61)	35.7 (12.4) 38 (9;58)	1.4 (9.0) 0 (-19;21)	0.27	**0.005**
CPAQ (0-120)	63.6 (16.1) 63 (19;106)	69.6 (15.2) 69 (34;98)	5.7 (13.1) 6 (-27;46)	**0.002**	62.4 (17.1) 61 (15;107)	63.4 (19.1) 60 (30;113)	0.1 (11.8) 2 (-38;23)	0.79	**0.043**
$FABQ_{physical}$ (0-24)	9.7 (6.1) 9 (0;24)	8.9 (6.1) 8 (0;22)	-0.8 (7.0) -1 (-19;19)	0.36	11.2 (6.1) 11 (0;24)	10.3 (6.3) 9 (0;24)	-1.3 (5.6) 0 (-18;10)	0.24	0.92
$FABQ_{work}$ (0-42)	17.2 (12.7) 16 (0;42)	17.8 (13.1) 16 (0;42)	0.4 (8.9) 0 (-27;29)	0.83	15.9 (12.1) 12 (0;42)	16.67 (12.5) 14 (0;42)	1.2 (8.1) 0 (-19;30)	0.54	0.79

6MWT: six-minute walk test, FIQ: fibromyalgia impact questionnaire, VAS: visual analogue scale, SF36: short-form 36, PDI: Pain Disability Index, CPAQ: Chronic Pain Acceptance Questionnaire, FABQ: fear avoidance beliefs questionnaire. Missing values at baseline: Resistance exercise group: SF36 PCS and SF36 MCS: n=1, $FABQ_{work}$: n=6, $FABQ_{physical}$: n=1. Relaxation therapy group: CPAQ: n=1, $FABQ_{work}$: n=8. Missing values at post-test: Resistance exercise group: SF36 MCS and PCS: n=3, $FABQ_{work}$: n=7, $FABQ_{physical}$: n=2. Relaxation therapy group: FIQtotal: n=1, SF36 PCS and MCS: n=2, $FABQ_{work}$: n=9.

PGIC differed significantly (p = 0.001) in favor of the resistance exercise group as compared with the active control group at post-treatment examinations. A total of 62.5 % of the participants in the resistance exercise group and 32.7 % in the active control group reported improvement in symptoms. PGIC ratings correlated significantly with improvements in current pain intensity (VAS) (rs 0.38, p = 0.004) and SF-36 PCS (rs 0.54, p <0.001) in the resistance exercise group.
A total of 91 (70 %) participants completed the follow up at 13-18 months, 48 (72 %) in the resistance exercise group and 43 (68 %) in the active control group, respectively. No significant differences between the resistance exercise group and the active control group were found at follow up after 13–18 months when compared to baseline measures of these outcomes. The only significant within-group improvement at follow up in the resistance exercise group was for pain acceptance (CPAQ) (p = 0.044).

Pain and fear avoidance partially mediate change in muscle strength during resistance exercise in women with fibromyalgia (Study III).

Explanatory factors for change in muscle strength. Variables included in the regression model for change in knee-extension force were BMI, age, baseline values for hand-grip force, knee-extension force, fear avoidance beliefs and change in pain intensity.

Change in knee-extension force (n = 56) was partly explained by fear avoidance beliefs about physical activity at baseline, together with change in pain intensity, knee-extension force at baseline, age and BMI. This model explained 40% of the change in knee-extension force (p = 0.013), Table 6.

Variables included in the regression model for change in elbow-flexion force were BMI, baseline values for hand-grip force, elbow-flexion force, pain intensity and fear avoidance, and change in pain intensity. Change in elbow-flexion force (n = 56) was partly explained by pain intensity at baseline, together with baseline fear avoidance beliefs about physical activity, BMI and elbow-flexion force at baseline. This model explained 32% of the change in elbow-flexion force (p = 0.043), Table 6.

Variables included in the regression model for change in hand-grip force were BMI, baseline values for fear avoidance and hand-grip force and change in pain intensity. Change in hand-grip force (n = 52) was partly explained by hand-grip force at baseline, change in pain intensity and baseline fear avoidance beliefs about physical activity. This model explained 37% of the change in hand-grip force (p = 0.009), Table 6.

Table 6. Explanatory models for change in muscle strength

Explanatory model for change in knee-extension force		R square	Unstandardized coefficients B (Std. Error)	p-value
	Constant		185.387(75.392)	0.017
1	FABQ physical		-4.038 (1.319)	0.004
2	Δ pain intensity		-0.903 (0.318)	0.006
3	knee-extension force		-0.309 (0.082)	<0.001
4	age		-2.617 (0.967)	0.009
5	BMI		3.976(1.548)	0.013
		0.403		
Explanatory model for change in elbow-flexion force		**R square**	**Unstandardized coefficients B (Std. Error)**	**p-value**
	Constant		-1.507(2.466)	0.544
1	pain intensity		0.052 (0.017)	0.003
2	FABQ physical		-0.180 (0.062)	0.005
3	BMI		0.186(0.074)	0.015
4	elbow flexion force		-0.158(0.076)	0.043
		0.321		
Explanatory model for change in hand-grip force		**R square**	**Unstandardized coefficients B (Std. Error)**	**p-value**
	Constant		73.501(13.438)	<0.001
1	hand grip force		-0.246 (0.061)	<0.001
2	Δ pain intensity		-0.510 (0.181)	0.007
3	FABQ physical	**0.371**	-1.909 (0.700)	0.009

FABQ: Fear Avoidance Beliefs Questionnaire, BMI: Body Mass Index

Predictors for final muscle strength values. Variables included in the regression model for final knee-extension force were: age, symptom duration, BMI, pain, fear avoidance beliefs about physical activity and baseline knee-extension force.

Final knee-extension force (n = 56) was partly predicted by knee-extension force at baseline, fear avoidance beliefs about physical activity, age and BMI. This model predicted 75% of the final knee-extension force (p = 0.018), Table 7.

Variables included in the regression model for final elbow-flexion force were: age, symptom duration, BMI, LTPAI, fear avoidance and baseline value for elbow-flexion force. Final elbow-flexion force (n = 56) was partly predicted by baseline elbow-flexion force, BMI and fear avoidance beliefs about physical activity. This model explained 72% of the final elbow-flexion force (p = 0.030), Table 7.

Variables included in the regression model for final hand-grip force were age, symptom duration, LTPAI, fear avoidance and baseline hand-grip force. Final hand-grip force (n = 52) was partly predicted by baseline hand-grip force and age. This model predicted 75% of the final hand-grip force (p = 0.023), Table 7.

Table 7. Predictive models for final muscle strength

Predictive model for final knee-extension force	R square	Unstandardized coefficients B (Std. Error)	p-value
Constant		182.20(80.44)	0.028
1 Knee-extension force		0.704(0.087)	<0.001
2 FABQ physical		-3.472(1.392)	0.016
3 Age		-2.576(1.032)	0.016
4 BMI		4.034(1.652)	0.018
	0.746		
Predictive model for final elbow-flexion force	**R square**	**Unstandardized coefficients B (Std. Error)**	**p-value**
Constant		0.696(2.558)	0.787
1 Elbow flexion force		0.852(0.082)	<0.001
2 BMI		0.184(0.080)	0.026
3 FABQ physical		-0.147(0.066)	0.030
	0.721		
Predictive model for final hand-grip force	**R square**	**Unstandardized coefficients B (Std. Error)**	**p-value**
Constant		127.247(31.504)	<0.0001
1 Hand-grip force		0.708(0.068)	<0.001
2 Age	**0.752**	-1.190(0.508)	0.023

FABQ: Fear Avoidance Beliefs Questionnaire, BMI: Body Mass Index

Factors promoting physical activity in women with fibromyalgia- a qualitative interview study (Study IV)

The participants described their current activity level as light to moderate. They liked to take walks outdoors, exercise in warm water; some went to a gym or rode a bike. Several of the participants accentuated the importance of being physically active in everyday life.

The results show that regular physical activity was promoted by:

Will to be physically active
The participants described being driven by the will to be physically active. Most of the participants expressed a need to be physically active knowing that it was good for them. Several participants described that the will to be physically active was strengthened by their fear of getting worse. Positive experiences of physical activity and the self-image of being a physically active person prior to being ill appeared to further strengthen the will. The participants described positive effects experienced during and after physical activity. They also expressed that although there was a will and a need to be physically active they had to struggle to keep up motivation.

Adjustment
The participants described a need of adjustment to be able to be physically active. They accentuated the need of support in finding the right level of exercise and they referred to the specific exercises chosen, to the loads and to the pace, they needed support in creating the optimal conditions to be physically active without risking increased pain.

Managing pain
The participants described how they had to relate to and manage their pain and how they had to use different strategies to manage pain during and following physical activity.

Contextual factors
Participants expressed that there were several contextual factors that affected their possibilities of being physically active. It was important for them to find their way, to do something enjoyable. They also accentuated the importance of exercise being accessible and continuous. Some of the participants used some kind of external support to motivate themselves. Several participants who were working expressed that it was difficult to find the time and the energy to be physically active.

DISCUSSION

MUSCLE STRENGTH

Muscle strength is a fundamental component of physical capacity which refers to the capability of an individual to have the physical requirements for work and daily activities [113]. High muscle strength is consistently associated with lower levels of pain and lower scores on psychological factors associated with pain [63].

Muscle strength in the women with FM was found to be reduced by between 20-36% and walking ability was reduced with 16% compared to healthy women (study I). Symptom duration in the women with FM was associated with reduced knee-extension force, elbow-flexion force, hand-grip force, and walking ability. This implies that disease-related factors, such as duration of pain, probably contribute to the decrease of muscle strength and walking ability in women with FM. Although physical capacity decreases with age, it seems that a longer duration of FM symptoms further deteriorates physical capacity. The finding that symptom duration affects physical capacity is an important knowledge for clinicians as a previous study showed that symptom duration was a predictor of falls in women with FM probably due to reduced lower limb muscle strength [12].

The women with FM in study I displayed significantly lower knee-extension force than the healthy women. Knee-extension force and walking ability were both associated with SF36 *Physical function* subscale which covers items in daily activities, such as walking stairs and walking several blocks. It is reasonable to assume that these activity limitations are associated to impaired muscle strength and walking ability.

Knee-extension force showed a moderate association to walking ability, a finding that is in line with previous studies [114, 115]. Reduced lower limb muscle strength, especially knee-extensor strength, has been shown to associate with impaired balance [115] increasing the risk for falls [116], and is associated to problems with walking ability and balance in women with FM, and a high incidence of falls (50%) is reported in this population [36].

As age and socioeconomic factors, such as education level, have been associated to health, our sample (study I) was compared to healthy women, who were matched to age and level of education. Well educated people are suggested to be

more prone to exercise and to have a healthy lifestyle [39]. Previous studies have also shown an association between higher presence of FM and low levels of education [9, 40]. Although the groups in study I were matched there was still a significant difference in physical capacity, between the two groups, especially regarding muscle strength. This implies that there are disease-related physiologic or neuromuscular factors that affect physical capacity in women with fibromyalgia.

RESISTANCE EXERCISE

Muscle-strengthening activity, such as resistance exercise, is recommended for the general population in order to promote health and physical independence [61], and also to prevent the development of degenerative age-related chronic conditions [62]. The prevention of loss of muscle mass and physical function might be considered even more important in women with FM given their impaired muscle strength.

The main findings of study II were significant improvements in isometric knee-extension force, current pain intensity, and other aspects of health in the resistance exercise group compared to the active control group. These results were supported by significant within-group improvements in the resistance exercise group.

The significant between-group differences found in elbow-flexion force in favor of the resistance exercise group were supported by significant within-group improvements in the resistance exercise group. To our knowledge this is the first resistance exercise study showing that women with FM can improve their biceps strength by resistance exercise.

The improvement in current pain intensity in the resistance exercise group represented an improvement of 23 %, which is considered a clinically important difference, as a reduction of 15 % represents a minimal clinically important difference [117]. The improvements in pain intensity are in line with reports from previous studies of improvements in pain following resistance exercise in FM [118-121]. Also, the improvements in FIQ total score support previous findings in studies of women with FM engaging in resistance exercise [120, 121].

Patient global impression of change (PGIC) differed significantly in favor of the resistance exercise group. PGIC correlated with improvements in current pain intensity and SF36 physical component score, which implies that the participants' overall impressions of change reflect clinically important improvements in disease-related health problems.

Further, significantly improved pain acceptance (assessed by the CPAQ), was found in the resistance exercise group compared with the active control group. Acceptance of pain is assumed to be associated with less disability and better functioning in patients with chronic pain [101], and the results of this study indicate that pain acceptance can be improved when engaging in exercise. Pain acceptance (CPAQ) was the only significant improvement found at follow up after 13–18 months in the resistance exercise group, which implies that the intervention promoted a process of pain acceptance that has long-term effects. However this finding should be interpreted with caution due to the fact that multiple comparisons were conducted.

The progression of the resistance exercise program proved to be a successful mode of exercise for most participants, as the majority tolerated the exercise well and few participants experienced aggravated symptoms. Sixty-three percent of the participants managed to attain exercise loads of 80 % of 1RM. At baseline, these participants presented with better physical health in terms of 6MWT, and health status in terms of FIQ total score than those who did not reach loads of 80 %, implying that personal instructions and progression of exercise loads need to be adjusted to the participants' physical resources and health status.

In study III 40% of the improvement in knee-extension force was explained by less fear avoidance at baseline, change in pain intensity, higher baseline knee-extension force, lower age and higher BMI. There may be several possible explanations, such as that the participants with lower degree of fear avoidance ventured to exercise on loads sufficient to improve muscle strength. Decrease in pain during the exercise period probably further encouraged the participants to exercise at higher loads.

Thirty-two percent of the improvement in elbow-flexion force was explained by lower baseline pain intensity, together with lower baseline fear avoidance, higher BMI and higher baseline elbow-flexion force. Thus, baseline pain and baseline fear avoidance appear to be important factors to take into consideration when planning resistance exercise for muscles involved in elbow flexion. Muscle strength is substantially reduced in upper extremities in FM [16, 122], which warrants further development of exercise programs for these muscle groups.

Improvement in hand-grip force was explained to 37% by lower fear avoidance and lower hand-grip force at baseline, together with decrease in pain during the exercise period. Exercise of large muscle groups might have contributed to the improvement in hand-grip force. Hand-grip force reflects a person's general

physical capacity [123], and is suggested to be a generic measure of physical function and activity limitations in FM [124].

In all 3 analyses of change in muscle strength, either baseline pain, or change in pain, was an explanatory factor, indicating its importance for the rehabilitation process of women with FM. Managing pain during the exercise period is important and the risk for exercise-induced pain can be reduced by gradual introduction to heavier loads [125]. Several clinical studies indicate that an adequately designed exercise program decreases pain over time among people with FM [64], and several components related to exercise may contribute to the decrease in pain.

In our sample the levels of fear avoidance were relatively low at baseline, with only 23% of the participants displaying high fear avoidance, i.e. FABQ physical >14 (0–24). The results of study III show that, even though baseline values are rather low, fear avoidance seems to be an important factor to address when treating patients with FM.

Symptom duration and baseline physical activity level did not have any explanatory value for change in muscle strength. This indicates that all persons with FM with interest in improving their physical capacity by means of resistance exercise should be encouraged to try this mode of exercise.

A probable reason for the lack of other long-term effects is that physical activity levels declined to baseline levels after the end of the intervention period. This implies that the participants had difficulties with maintaining regular resistance exercise without supervision. A similar lack of long-lasting effects and difficulties among women with FM to maintain their levels of resistance exercise after the end of intervention have previously been reported [121].

PROMOTING FACTORS

Being physically active is challenging for women with FM due to their impaired physical capacity, pain, fatigue, and also due to activity induced pain. The findings of study IV show that women with FM had the will to be physically active because they had the knowledge and the experience that it would make them feel better and that it was good for them. This has also been shown in another study where participants with musculoskeletal pain described how being physically active made them feel better both physically and mentally and helped them to better manage pain [126].

There were several factors on a personal level that could promote the ability to be physically active, like support and understanding, and assistance in adjusting the level of physical activity. This finding is supported by earlier studies showing that patients with chronic pain express the need for individually tailored support and continuous guidance, preferably in health care, in finding a suitable activity, and to increase motivation [126, 127].

Women with FM form a heterogeneous group, comprising several subgroups [128] of which some try to avoid physical activities due activity-induced pain. However, the focus of study IV was the women with FM who from time to time engage themselves in physical activity. In fact, according to our clinical experience, a large majority of women with FM, belonging to primary health care, are interested in, and manage to perform physical activity, therefore it is important to search for new knowledge regarding how health care professionals could support these persons in finding their promoting factors for physical activity.

PERSON-CENTREDNESS

Resistance exercise is difficult for women with FM due to activity-induced pain and the behavioral consequences of this, such as fear and avoidance of physical activities [129]. Previous studies indicate that there seems to be a reciprocal relationship between physical function and self-efficacy, implying that improving physical function improves self-efficacy and vice versa [130]. Self-efficacy was not analyzed but the results from study III show that decreased pain and low fear avoidance contributed to the improvement in muscle strength in study II following the resistance exercise intervention. This emphasizes the importance of adjusting the program to each individual and stresses the importance of carefully selected loads and exercises intended to increase muscle strength without increasing pain and fear avoidance. Using person-centred principles in rehabilitation, to strengthen a person's confidence and resources [131, 132] seems to be effective in changing avoidance behavior towards physical activity.

Previous studies of pool exercise [133, 134], Nordic walking [69] and resistance exercise [21, 135] for women with FM show positive effects on disease specific symptoms, level of physical activity, physical capacity and health related quality of life. The exercise studies show that persons with FM can exercise in the same environment as healthy individuals, though with lower loads, longer pauses between sets and sometimes with adjusted exercises and exercise equipment. Likely factors for success appear to be that the resistance exercise sessions were supervised by a physiotherapist who guided the participants in adjusting the

level of exercise to individual resources and limitations and also encouraged the participants to progressively increase the loads. Significantly improved pain disability following the resistance exercise intervention (study II) indicate improvement in participation in everyday life activities, which reflects that the intervention focusing on enhancement in self-confidence and pain management during the exercise sessions was successful. In this study, the person-centered intervention started with partnership building based on each participant's narrative and included sharing information, deliberation, decision-making, and documentation. All changes to the exercise program and the increases in loads were made together with the participant, in partnership, thus enhancing the ability to manage pain and other symptoms. It seems like partnership is the critical element in a person-centred approach.

METHODOLOGICAL CONCERNS

Recruiting participants through newspaper adverts may have resulted in recruiting participants who were more motivated and this might have biased the results. To minimize this risk the advert was designed to recruit participants to both interventions so that the participants were blinded to which was the control intervention. In study II there were numerous criteria for exclusion due to the nature of the intervention and also due to other examinations performed in the Painomic-project. This could have resulted in participants not being representative for the general population with FM. However when comparing our sample to other studies comprising women with FM, it seems that they are representative for patients found in primary health care regarding level of pain and activity limitations. The women who participated in study IV had five years earlier participated either in supervised resistance exercise or relaxation therapy, and their positive view on physical activity might be associated to this fact, and may not reflect the viewpoint of all women with FM. However, the focus of study IV was those with FM who from time to time engage themselves in physical activity, why the purposive selection of respondents is assumed adequate.

CLINICAL IMPLICATIONS

The results from this thesis show that women with FM are challenged not only by pain and other disease related symptoms, but also by reduced physical capacity and activity limitations in daily life. From a clinical point of view it appears to be important to assess muscle strength and walking ability and to discuss the problem with the patient. Knowledge of their reduced physical capacity and the consequences of it, might motivate patients to engage in

physical activity in order to improve physical capacity and reduce activity limitations.

The positive results of study II showed that a supervised progressive resistance exercise program based on person-centred principles, with individually adjusted loads and progression according to each participant's resources, is safe and successful. This program can be recommended to the general population of women with FM, however it appears that strategies to support long-term regular exercise should be developed to ensure longstanding health effects.

Decreased pain and low fear avoidance contributed to the change in muscle strength in study III following the resistance exercise intervention. This emphasizes the importance of adjusting the program to each person's resources and limitations together in partnership. It also stresses the importance of carefully selected loads and exercises intended to increase muscle strength without increasing pain and fear avoidance. This conclusion is supported by the promoting factors expressed in the interviews in study IV where the participants underlined the importance of support in choosing the right level of exercise and managing pain.

CONCLUSION

Physical exercise is important and part of first choice management of FM, and has in this thesis been shown to improve physical capacity and reduce pain when appropriately prescribed. Several factors interact during a complex intervention, for example how exercise is planned, adjusted and progressed in order to reduce the risk of increased pain. There seems to be a reciprocal relationship between physical function and pain, implying that improving physical function improves pain and vice versa. This underlines the importance of individually adjusted exercise programs with carefully selected loads and exercises to avoid increased pain and decrease fear avoidance.

The benefits of regular progressive resistance exercise shown in this thesis imply that individually adjusted resistance exercise can be recommended as a safe and effective exercise option for women with FM. The person-centered approach, working in partnership with the participants, promoting the participants self-control, enhancing self-efficacy, improving management of symptoms and increasing the ability to choose proper levels of exercise seemed to be a key component.

Physical activity is challenging for women with fibromyalgia due to impaired physical capacity, pain, fatigue, and also due to activity induced pain. The findings of this thesis showed that women with FM had a strong will to be physically active because they had the knowledge and the experience that it made them feel better and that it was good for them. There were several factors on a personal level that could promote the ability to be physically active, like support and understanding and assistance in adjusting the level of physical activity. The participants also stressed the importance of accepting, managing and not being afraid of the pain. Most of the participants expressed the importance of setting their own limits.

According to our clinical experience, a large majority of women with FM, belonging to primary health care, are interested in and manage to perform physical activity. Therefore it is important for physiotherapists to support these persons in finding their promoting factors for physical activity, to choose suitable exercises and to adjust exercise loads according to resources and limitations in partnership with the patient. This person-centred approach would enhance the patient's ability to be physically active and might increase the possibility for the patient to maintain long-term physical activity habits.

FUTURE PERSPECTIVES

We found that women with FM can improve their muscle strength, pain and general health by engaging in resistance exercise but they seem to have difficulties in continuing with exercise of higher intensities without long-term support. It would be interesting to investigate if it is possible to develop methods to enable long-term support for women with FM to be physically active on a level needed to achieve health-enhancing effects.

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