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EXERCISE THERAPY IN PATIENTS WITH RHEUMATOID ARTHRITIS AND OSTEOARTHRITIS: A REVIEW

Joost Dekker,* Peter H. Mulder,* Johannes W. J. Bijlsma,† and Rob A. B. Oostendorp‡

* Netherlands Institute of Primary Health Care, P.O. Box 1568, 3500 BN Utrecht, The Netherlands
† Department of Rheumatology, University of Utrecht, The Netherlands
‡ National Institute for Research and Postgraduate Education in Physical Therapy, Amersfoort, The Netherlands

Abstract — Exercise therapy in patients with rheumatoid arthritis (RA) or osteoarthritis (OA) is controversial, because both improvement and deterioration of the patients' condition can be expected to occur. The literature was searched for studies on the outcome of exercise therapy in RA- and OA-patients. Twenty-four studies were identified, comprising nine controlled studies. In the present review, these studies are critically summarized. It was found that controlled studies have only reported improvements or non-significant results; deterioration of the patients' condition has not been reported. With regard to specific modalities of exercise therapy, it was found that aerobic exercise in RA-patients has been most thoroughly studied: improvements for specific categories of outcome (e.g., walking time and other sorts of observed disability) have been repeatedly reported, while for other categories of outcome (e.g., pain) non-significant results have been consistently reported. Several methodological deficiencies (concerning randomization, blinded evaluation and power) and assets (concerning compliance) in controlled studies are noted and evaluated. It is concluded that, despite several qualifications, the available evidence is in favor of exercise therapy in RA- and OA-patients. Neglected areas of research, including comparisons between subgroups of patients, are identified and suggestions for future research are given.

INTRODUCTION

The therapeutic potential of exercise in patients with rheumatoid arthritis (RA) and osteoarthritis (OA) has been increasingly recognized in the last three decades. RA is a chronic inflammatory disease, which primarily affects the joints; inflammation of non-articular organs and generalized symptoms may also occur. OA is characterized by disintegration of articular cartilage and formation of new bone. Both RA- and OA-patients frequently have decreased *physical fitness*. Poor physical fitness (as manifested in relevant impairments: reduced range of motion, reduced stability of joints, muscle weakness and low aerobic fitness) is due to the underlying disease process and its consequences, to side effects of medication, and to decreased physical activity (Semble, Loeser, & Wise, 1990). Poor physical fitness has been hypothesized to induce *pain* and *disability*. Although

Correspondence should be addressed to Dr J. Dekker.

a causal relationship remains to be demonstrated, it has indeed been found that poor physical fitness is associated with high levels of pain and disability in arthritis patients (Ekdahl and Broman, 1992; Dekker, Boot, Woude, Bijlsma, 1992; Dekker, Tola, Audemkampe, & Winckers, 1993). *Exercise therapy* aims at improvement of the patient's physical fitness and is therefore expected to cause a reduction of pain and disability in arthritis patients. Additionally, certain kinds of exercise (e.g., walking exercise) aim directly at a reduction of the patient's disability. This theory, which closely corresponds to the model described by Bouchard, Shephard, Stephens, Sutton, and McPherson (1990), is schematically represented in Figure 1.

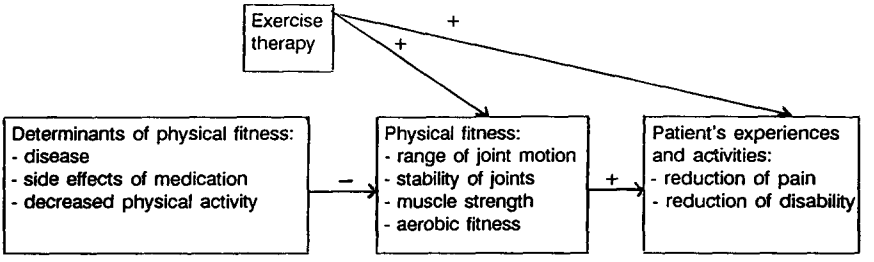

FIG. 1. Schematic representation of the rationale of exercise therapy in arthritis patients.

The expectation of beneficial effects of exercise therapy is not unquestioned, however. Exercise therapy is generally regarded as contraindicated in acute phases of RA, because it might then induce exacerbation of the inflammation (Kottke, Caspersen, & Hill, 1984). In addition, exercise — especially weightbearing exercise — might contribute to the destruction of joints, in both RA- and OA-patients. Finally, severe joint deformities, instability of joints, contractures, muscle weakness or pain may preclude the performance of exercise (Semble et al., 1990). If patients suffering such conditions do exercise, pain and disability are expected to worsen. Thus, while exercise is expected to have therapeutic value for arthritis patients, exercise may very well have negative effects also.

This controversy has stimulated research on the outcome of exercise therapy in RA- and OA-patients. Several reviews of this research have been published (Ike et al., 1989; Semble et al., 1990; Minor, 1991). However, these reviews have some major shortcomings. Two reviews are highly selective, emphasizing the authors' own studies (Ike et al., 1989;

Minor, 1991). The third review (Semble et al., 1990) largely covers the then available studies, but — like the other reviews — the authors failed to analyze these studies critically. (i) Former reviews failed to point out frequent methodological deficiencies. For example, former reviews have relied heavily on uncontrolled, within-group effects. (ii) Former reviews have summarized significant treatment effects, but these reviews failed to describe which effects were studied but were not found. For example, as will be demonstrated in the present review, exercise therapy has been shown to improve disability but no effect on pain has been found repeatedly. (iii) Exercise therapy comprises a range of different interventions. In former reviews no attempt has been made to determine whether these interventions have specific outcomes. Thus, a critical review concerning the question "which exercise therapy has which effects in patients with RA or OA?" seems to be indicated. Of course, one would also like to address the question "in which patients?". However, because of a lack of relevant data, this question will be dealt with in passing only.

METHOD

Studies

Computerized searches were performed in *Medline (Index Medicus)*, *Psychological Abstracts* and local libraries. Manual searches were also performed. A study was included in the review if (i) it was concerned with exercise therapy in patients with RA or OA, and (ii) it described at least one within-group or between-group effect. Abstracts were excluded.

Description

The following items of information were obtained from the studies:

- Patients: number of patients; for RA-patients, the functional class according to ARA-criteria (Steinbrocker, Traeger, & Batterman, 1949); for OA-patients, the diseased joint; duration of disease.
- Interventions: the kind of exercise therapy; and the length of the intervention. Exercise therapy was classified as follows (cf. Gerber, 1990; Hicks, 1990; Jokl, 1990): (a) mobilizing or stretching exercise, which aims at preservation or improvement of range of joint motion. (b) Muscle strengthening exercise, which can be distinguished into various types. Isometric or static exercise uses a static contraction, without a change of muscle length or movement of the joint; only muscle tension is produced. Isotonic or dynamic exercise: it uses a constant load or resistance represented by a weight; the muscle length

changes and the joint moves. Isokinetic exercise is a dynamic exercise: the speed of joint motion is artificially fixed by means of an apparatus. (c) Aerobic or endurance exercise can occur in many different forms, e.g., jogging, swimming, cycling etc. Usually, training is geared to 60% of the maximum heart rate and higher, for 20 to 30 min. The further distinction between weightbearing (e.g., jogging) and non-weightbearing (e.g., cycling) exercise is important in the context of arthritis patients. (d) Recreational exercise includes swimming, dancing, walking etc. This exercise does not necessarily reach the aerobic level.

— Design: the contrast of treatment groups; the way patients were assigned to treatment groups; and when measurements were performed (pre-, post- or follow up-test).

— Measures: outcome measures, grouped into categories. These categories, and the reason for distinguishing them, were as follows. Outcome measures which directly reflect the patients' experiences and activities are generally considered to be of primary importance. For arthritis patients, measures of (1) pain and (2) disability are therefore of utmost importance (Anderson, Bradley, Young, McDaniel, & Wise, 1985; Dekker et al., 1992). A further distinction is made between (2a) disability observed by an independent person (e.g., walking time) and (2b) self-reported disability. Exercise therapy aims at an improvement of the patient's condition through improvement of physical fitness. Specifically, treatment aims at improvement of (3) aerobic fitness, (4) muscle strength, and (5) range of motion. Outcome measures concerning each of these categories are therefore highly relevant. A further distinction is made between (3a) oxygen uptake, (3b) exercise time during aerobic testing, and (3c) subjective experiences during aerobic testing; (4a) muscle strength of the lower extremities, (4b) muscle strength of the upper extremities, and (4c) subjective experiences during muscle strength testing; (5a) observed range of motion of the joint and (5b) subjective flexibility of joints. A further set of measures is concerned with (6a) joint status (tenderness, swelling), (6b) morning stiffness, (7a) laboratory measures of disease activity, and (7b) radiological measures of joint degeneration. These measures are highly relevant because they allow an evaluation of the effects of exercise on disease activity and joint destruction. Finally, there are measures concerning (8) general well-being, anxiety, and depression and (9) remaining variables.

— Outcome: for each (sub)category of outcome measures, it is described whether or not significant ($p < .05$) findings were observed. Both within-group and between-group effects from pre- to post-test and from pre- to follow up-test are described.

Methodological Evaluation

The items mentioned above allow an evaluation of four methodological core issues — whether the study was controlled, whether patients were randomly assigned to treatment groups, whether adequate statistics were reported, and the number of subjects (power). In addition, it was determined whether outcome was blindly evaluated and whether patients adhered to the exercise program (compliance).

RESULTS

Rheumatoid Arthritis

Twenty reports describing 18 studies on exercise therapy in RA-patients have been identified. These studies are described in Appendix 1. The results of these studies are summarized below. In Table 1 the between-group effects of the controlled studies are described.

Stretching exercise

A single study is specifically concerned with stretching exercise (Byers, 1985). In a well-controlled within-subjects design, stretching exercise was shown to improve both observed range of motion and subjective flexibility of joints (see Table 1). As will be described below, aerobic exercise has been repeatedly found not to improve range of motion. Thus, a specific effect of stretching exercise on range of motion seems to exist.

Muscle strengthening exercise

Isometric strengthening exercise has been studied in a single study (Machover & Sapecky, 1966). Within groups, a significant improvement of muscle strength was observed in the experimental group, but the control group showed a similar trend ($p < .10$). Unfortunately, between-group statistics were not reported. Effectively, the study is poorly controlled due to this omission.

Aerobic exercise

Aerobic exercise has been studied as part of a treatment package also comprising stretching, muscle strengthening, and/or recreational exercise. Within-group effects of such packages have been described in ten studies, both controlled and uncontrolled ones (Ekblom, Lövgren, Alderin, Fridström & Sätterström, 1975a,b; Nordemar, Edström, & Ekblom,

Table 1. Outcome of Controlled Studies

Authors	Study contrast	Outcome															
		1	2a	2b	3a	3b	3c	4a	4b	4c	5a	5b	6a	6b	7a	7b	8	9
I. *Rheumatoid Arthritis*																		
Stretching																		
Byers, 1985	Stretching exercise										+	+						
Aerobic exercise																		
Nordemar, 1981; Nordemar et al., 1981	Non-weight bearing aerobic exercise, recreational exercise and muscle strength training		+	+	0		0	+	+				+		0	+	0	+
Minor et al., 1989	(Reduced) weightbearing aerobic exercise	0	+	0	+	0			0		0		0	0			+	0
Ekdahl, Andersson, Moritz, & Svensson, 1990	Non-weightbearing aerobic and recreational exercise	0	+	0	+		+	+		0	0		+	+	0			
Miscellaneous																		
Deusen & Harlowe, 1987	Dance-like movements and relaxation										+							+
Kirsteins et al., 1991	Weightbearing slow rythmic motion, breathing and relaxation																	
Study I			0						0				0					
Study II			+						0				0					

II. *Osteoarthritis*															
Aerobic exercise Minor et al., 1989	(Reduced) weightbearing aerobic exercise	0	0	0	+	0		0		0		0	0		0	0
Recreational exercise Kovar et al., 1992	Recreational, strengthening and stretching exercise	+	+	+											0	0

1: pain; 2a: observed disability; 2b: self-reported disability; 3a: oxygen uptake; 3b: exercise time; 3c: subjective experiences during aerobic testing; 4a: muscle strength of the lower extremities; 4b: muscle strength of the upper extremities; 4c: subjective experiences during muscle testing; 5a: range of joint motion; 5b: subjective flexibility of joints; 6a: joint status; 6b: morning stiffness; 7a: laboratory measures; 7b: radiological measures; 8: measures of general well being, anxiety and depression; 9: remaining measures. A "+" indicates significant improvement; a "0" indicates a non-significant difference.

1976; Nordemar, Berg, Ekblom, & Edström, 1976; Nordemar, Ekblom, Zachrisson, & Lundquist, 1981; Harckom, Lampman, Banwell, & Castor, 1985; Karper & Evans, 1986; Lyngberg, Danneskiold-Samsoe, & Halskov, 1988; Minor, Hewett, Webel, Anderson, & Kay, 1989; Ekdahl, Ekman, Andersson, Melander, & Svensson, 1990; Ekdahl, Andersson, Ekman, & Svensson, 1992; Perlman et al., 1990). Within-groups, a significant improvement from pre- to post-test has been reported for all sub-categories of outcome measures in at least one study. The only exceptions are radiological measures (no significant change), self-reported muscle strength and subjective flexibility joints (not (statistically) evaluated). These within-group effects suggest quite an array of positive effects of the combination of these exercises.

There are six controlled studies concerning aerobic exercise. Three studies did report between-group effects, three other studies failed to do so. The between-group effects from pre- to post-test concerning the first three studies are summarized in Table 1. In the study of Nordemar (1981; Nordemar et al., 1981), the contrast between treatment groups consisted of non-weightbearing aerobic exercise in combination with recreational exercise and strengthening exercise. This combination caused a more favorable outcome for disability (observed and self-reported), muscle strength of the upper and lower extremities, joint status, radiological measures and remaining measures (training attitudes); no significant differences were observed for aerobic fitness, laboratory measures, and general well-being. In the study of Minor et al. (1989) the contrast between treatment groups consisted of (reduced) weightbearing aerobic exercise. Between groups, this exercise caused a more favorable outcome for observed disability, aerobic fitness (oxygen uptake) and general well-being; no significant differences were observed for pain, self-reported disability, exercise time, grip strength, trunk flexibility, joint status, and morning stiffness. In the study of Ekdahl, Andersson, Moritz, and Svensson (1990) the contrast between treatment groups consisted of non-weightbearing aerobic exercise and recreational exercise (in addition, the nature of strength training differed: dynamic vs static training). A more favorable outcome was reported for observed disability, aerobic fitness (oxygen uptake and perceived exertion), muscle strength of the lower extremities, joint status, and morning stiffness. No significant differences were found for pain, self-reported disability, range of joint motion, and laboratory tests. In a 3-month follow-up test an improvement in laboratory tests (Hb) was found; the other between-group effects appeared to be very stable.

These three controlled studies concern aerobic exercise which was or was not combined with recreational exercise and strengthening exercise. These studies can be summarized as follows. A favorable outcome

replicated at least once (i.e., reported in at least two studies) has been found for observed disability, oxygen uptake, muscle strength of the lower extremities, and joint status. No significant differences, reported consistently in at least two studies, have been found for pain, range of joint motion, and laboratory measures. Other significant improvements and non-significant differences have been reported, but these have not yet been replicated. Significant negative outcomes have not been reported.

Three other controlled studies failed to report between group statistics (Ekblom et al., 1975a,b; Harckom et al., 1985; Lyngberg et al., 1988). One of these studies reported significant improvements in the experimental group and no significant changes in the control group; one study reported significant improvements in both the experimental and control group; and one study reported significant improvement in the experimental group, but failed to statistically evaluate the control group.

Miscellaneous exercise

Two studies are concerned with water exercise programs, which consist of stretching, muscle strengthening, and possibly some aerobic exercise (Dial & Windsor, 1985; Danneskiold-Samsoe, Lyngberg, Risum, & Telling, 1987). Both studies are uncontrolled, reporting improvement from pre- to post-test for observed disability, oxygen uptake, muscle strength of the lower extremities, and range of motion. "Dance-like movements" and "slow rythmic motion", in combination with breathing and relaxation techniques, have been studied in three other studies (Deusen and Harlowe, 1987; Kirsteins, Dietz, & Hwang, 1991, study I and II). Weightbearing muscle strengthening and stretching exercises are the focus of these interventions. Within-group effects have not been reported. The between-group effects indicated favorable outcomes for observed disability, range of joint motion, and remaining measures (evaluation of exercise and rest) (see Table 1). These findings have not yet been replicated.

Osteoarthritis

Six studies concerning exercise in OA-patients have been identified. These studies are described in Appendix 2. The results of these studies are summarized below.

Stretching exercise

Stretching of hip muscles has been shown to improve range of hip motion (Leivseth, Torstensson, & Reikeras, 1989). However, this is an uncontrolled study.

Muscle strengthening exercise

Two studies are concerned with muscle strengthening exercise (Kreindler, Lewis, Rush, & Schaefer, 1989; Fisher, Pendergast, Gresham, & Calkins, 1991) and one study concerns diathermy and muscle strengthening exercise (Chamberlain, Care, & Harfield, 1982). The within-group effects showed improvement for pain, disability (both observed and self-reported), and muscle strength. The study of Fisher et al. (1991) is uncontrolled and the study contrast in Chamberlain et al. (1982) concerns diathermy, not exercise. The study of Kreindler et al. (1989) comprised a control group; in the control group no significant change was observed, but the authors failed to statistically evaluate the between-group effects.

Aerobic exercise

Minor et al. (1989) studied aerobic exercise in combination with stretching and strengthening exercise. Within-groups, patients treated with this combination improved on pain, disability (observed and self-reported), aerobic fitness, grip strength, trunk flexibility, joint status, morning stiffness, anxiety, and depression. The study contrast concerned aerobic exercise. Between groups, aerobic exercise caused a more favorable outcome for aerobic fitness only (see Table 1).

Recreational exercise

The contrast in the controlled study of Kovar et al. (1992) concerns recreational exercise (fitness walking) in combination with strengthening and stretching exercise. Between groups, this treatment package caused a more favorable outcome for pain and disability (observed and self-reported); there were similar trends for general well-being and medication use.

Methodological Issues

Several methodological issues have to be raised. (i) Among the 24 studies on exercise therapy for RA- and OA-patients, there were nine controlled studies; ten studies were uncontrolled and five studies were controlled, but failed to statistically evaluate the between-group effects. (ii) In three of the controlled studies there exist difficulties with regard to the randomization of patients: some patients were allowed to change groups (Nordemar et al., 1981) or the assignment procedure has not been specified (Kirsteins et al., 1991, study I and II). However, it is not very likely that this has selectively favored positive findings: inadequate randomization has occurred in one study reporting mainly improvements

(Nordemar et al., 1981) and two studies reporting mainly non-significant effects (Kirsteins et al., 1991, study I and II); adequate randomization has occurred in four studies reporting mainly improvements (Byers, 1985; Ekdahl, Andersson, Moritz, & Svensson, 1990; Deusen & Harlow, 1987; Kovar et al., 1992) and two studies reporting mainly non-significant effects (Minor et al., 1989, RA- and OA-study). (iii) In order to evaluate the meaning of non-significant differences, information on the statistical power is highly relevant. In none of the nine controlled studies has this information been given. In these nine studies, the median number of patients equals 46 (range 28–102). This suggests adequate power with regard to large effects, but inadequate power with regard to small and medium effects. (For $n = 2*23$ and $a = .05$, the power of a study equals .85 for large effect sizes ($d = .80$); the power equals .51 for medium effect sizes ($d = .50$) and .16 for small effect sizes ($d = .20$); Cohen, 1988.) (iv) In four controlled studies, measurements were taken by a person uninformed of the treatment condition (Byers, 1985; Ekdahl, Andersson, Moritz & Svensson, 1990; Kirsteins et al., 1991, study I and II). In five other controlled studies, blinded evaluation has either not been mentioned (Nordemar et al., 1981; Minor et al., 1989, RA- and OA-study), the blinding procedure was not successful (Deusen & Harlowe, 1987), or there was no blinded evaluation (Kovar et al., 1992). Again, it is not very likely that this has selectively favored positive findings because inadequate blinding has occurred in three studies reporting mainly positive effects (Nordemar et al., 1981; Deusen & Harlow, 1987; Kovar et al., 1992) and two studies reporting mainly non-significant effects (Minor et al., 1989, RA- and OA-study); blinded evaluation has occurred in two studies reporting mainly positive effects (Byers, 1985; Ekdahl, Andersson, Moritz, & Svensson, 1990) and two studies reporting mainly non-significant effects (Kirsteins et al., 1991, study I and II). (v) Compliance of patients with exercise therapy was assessed in all nine controlled studies. Although the standardization of these assessments leaves something to be desired, this is a methodological asset of these studies. Six studies reported rather high levels of compliance, one study reported a low level of compliance (Deusen & Harlow, 1987), and in two studies no conclusion could be drawn due to missing data (Kirsteins et al., 1991, study I and II). However, because non-significant effects have been reported in studies with high levels of compliance, it is not very likely that non-significant effects can be attributed to a low level of compliance.

Patients

One would expect exercise therapy to be primarily beneficial for certain subgroups of patients. In the controlled and uncontrolled studies reviewed

above, RA-patients differed on disease-related characteristics such as functional class (class I, II, or III) and duration of disease (ranging from 3 months to 37 years). OA-patients differed with regard to the affected joint (hip, knee, or ankle) and duration of disease (ranging from 1 to 40 years). However, none of these studies analyzed subgroups of patients differing on these or other disease-related characteristics. Most studies (controlled and uncontrolled ones) did mention that patients were advised not to exercise during acute flare ups of RA and to (temporarily) reduce their exercise level if they noticed negative effects such as pain. Unfortunately, changes in exercise level were reported only in an anecdotal way. Minor et al. (1989, RA- and OA-study) reported that seven patients dropped out due to arthritis-related conditions; Lyngberg et al. (1988) reported that two patients reduced their exercise level; Perlman et al. (1990), Kirsteins et al. (1991, study I and II), and Kovar et al. (1992) all reported one withdrawal due to arthritis-related conditions. The other studies either stated that there were no exercise-related problems in individual patients or did not clearly address this issue.

DISCUSSION

The conclusions of this review on exercise therapy in patients with RA or OA can be summarized as follows: (i) In nine controlled studies only improvements or non-significant results have been reported; deterioration of the patients' condition has not been reported. Several qualifications of this conclusion should be mentioned. First, the controlled studies do not cover the entire range of modalities of exercise therapy for RA- and OA-patients, leaving the possibility of deterioration in areas not yet studied. Second, instead of non-significant results, small or medium effects may be observed in studies on larger patient samples, with more statistical power. These effects may concern either deterioration or improvement. Third, the possibility remains that subgroups of patients are adversely affected by exercise therapy. From a practical point of view, this is an important consideration: exercise therapy might be contraindicated in patients with severe contractures or pain, for example. Anecdotal evidence does suggest that exercise therapy is contraindicated in some patients. Fourth, the randomization of patients and the blinding of evaluators were deficient in some studies. Although the distribution of these deficiencies over the studies makes it unlikely that positive outcomes have been selectively favored, these deficiencies limit the validity of those studies. Fifth, (parts of) studies describing deterioration may not have been published. These qualifications limit the possibility of drawing conclusions from the present body of research. Nevertheless, despite these qualifications, it can be

concluded that the available evidence is in favor of exercise therapy for RA- and OA-patients. (ii) In RA-patients stretching exercise has been shown to improve range of joint motion. Aerobic exercise has repeatedly been found to improve observed disability, oxygen uptake, muscle strength of the lower extremities, and joint status. Dance-like and rythmic motion appears to improve observed disability, range of joint motion, and remaining measures (evaluation of exercise and rest), but these effects have not been replicated yet. (iii) In OA-patients a single controlled study on aerobic exercise has been identified, reporting improvement in oxygen uptake. A single controlled study on recreational exercise (fitness walking) reported improvement for pain and disability (observed and self-reported). (iv) Repeatedly observed non-significant effects of aerobic exercise in RA-patients concern pain and range of joint motion. Self-reported disability takes up a middle position: one study has reported improvement and two studies non-significant effects. The statistical power of these studies makes it unlikely that large effects for these outcome measures do exist, but small or medium effects may have gone unnoticed. A low level of compliance is an unlikely explanation of the non-significant effects. Inadequate measurement techniques are an unlikely explanation also, since techniques with proven validity have been used (Arthritis Impact Measurement Scales (AIMS), Stanford Health Assessment Questionnaire (HAQ) and goniometry).

The beneficial effects of exercise in RA-patients provide some support for the theoretical model described in Figure 1. In this model, exercise therapy is hypothesized to improve physical fitness and thereby to reduce pain and disability. In addition, (recreational) exercise therapy is thought to improve disability directly. Exercise therapy has indeed been shown to improve physical fitness (range of joint motion, muscle strength, and aerobic fitness); and, as expected, exercise has been repeatedly shown to improve observed disability, either through improvement of physical fitness or as a direct effect. However, the effects of exercise therapy on pain and self-reported disability have been less reliable, with some studies reporting improvements and other studies reporting non-significant effects. Physical fitness is possibly a primary determinant of actual disability, but only a secondary determinant of pain and self-reported disability. Other factors, such as negative affect (Watson & Pennebaker, 1989) may be important determinants of the subjective experience of pain and disability. This would explain the discrepancy between the effects for observed disability on the one hand and pain and self-reported disability on the other.

Analyses on subgroups of patients differing on disease-related characteristics have not been reported. From a theoretical point of view, this is a striking omission. Exercise therapy aims at improvement of

pain and disability, through improvement of range of joint motion, muscle strength and aerobic fitness (see Figure 1). Thus, beneficial effects can be specifically expected in patients with reduced range of joint motion, reduced muscle strength, or reduced aerobic fitness. In other patients, there is no particular reason to expect beneficial effects. In addition, (recreational) exercise aims at a direct improvement of disability. Again, a beneficial effect is to be specifically expected in patients with a high disability level, not in other patients. But, despite these theoretical considerations, the studies reviewed above have tacitly assumed beneficial effects to occur in all patients. For theoretical reasons, this is a very unlikely assumption.

This review has revealed neglected areas of research. In RA-patients, controlled research has focused on aerobic exercise; neglected areas include stretching and muscle strengthening exercise, with only a single controlled study in these areas (Byers, 1985). In OA-patients, only two controlled studies, focusing on aerobic exercise and recreational exercise, are available (Minor et al., 1989; Kovar et al., 1992). It has been argued that exercising of activities closely resembling daily activities is most effective (Gerber, 1990). Although some studies incorporate elements of this approach, only one fully-fledged study is available (Kovar et al., 1992). Finally, as already mentioned, there is no research which compared subgroups of patients differing on disease-related characteristics. Research in all of these areas is needed in order to further the understanding of exercise therapy in RA- and OA-patients. It is strongly recommended that future studies use well-controlled designs. Uncontrolled studies are appropriate when the therapeutic value of (exercise) therapy is entirely unknown; however, later on, controlled studies are indispensable. In addition, it is recommended that future studies use a wide range of outcome measures. These measures should cover both outcome categories where improvement is to be expected (e.g., observed disability) and categories where deterioration might occur (e.g., disease activity, joint status). Outcome measures might also include stability of joints, which appears not to have been evaluated to date.

The final conclusion of this review seems to be that a careful analysis of specific interventions and categories of outcome, in combination with a theoretical notion of how exercise affects health in arthritis patients, considerably contributes to the understanding of exercise therapy in RA- and OA-patients.

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APPENDIX 1

Studies on Exercise Therapy in Patients with Rheumatoid Arthritis

Authors	Patients	Interventions	Design	Measures	Outcome
Machover & Sapecky, 1966	$N = 11$	I. Treatment of the weaker *quadriceps muscle:* a. Isometic strength training on an apparatus b. Active range of motion exercises and infrared heat II. Treatment of the contralateral muscle: b. Active range of motion exercises and infrared heat Length: 7 weeks	I (a + b) vs II (b) Pretest – post-test	4a. Muscle strength (isometric knee extension)	*Within groups*: Group I: significant improvement for 4a Group II: trend ($p < .10$) towards improvement for 4a *Between groups*: Not reported
Ekblom et al., 1975a	$N = 34$ Duration: 9.6 years (range 3–18 years) Class: II or III	Group I: a. Interval training on bicycle, 50–70% of pre-training maximal workload b. Strength training on table c. "Ordinary" strength- and joint mobility training Group II: c. "Ordinary" strength- and joint mobility training Length: 5 weeks	Group I (a + b + c) vs group II (c) Assignment of patients "in a non-selective manner"	2a. Observations of walking time,using the stairs, stepping up on foot stools b. Pain during these observations 3a. Oxygen uptake c. Perceived exertion 4a. Muscle strength (isometric knee extension and flexion; dynamic knee extension) b. Muscle strength (isometric elbow flexion) c. Pain during testing of muscle strength 6a. Joint status (swelling, exudate and pain) 7a. Various blood measures	*Within groups*: Group I: significant improvement for 2a, 3a and c, and 4a and b; no significant change for 2b, 6a and 7a; "more pain" for 4c. Group II: significant improvement for 4a and b; no significant change for 2a and b, 3a and c, 6a and 7a; "unchanged" for 4c. *Between groups*: Not reported

Authors	Patients	Interventions	Design	Measures	Outcome
Ekblom et al., 1975b	$N = 30$ (cf. Ekblom et al., 1975a)	Group I and II: cf. Ekblom et al., 1975a. From an account of the physical training during follow-up period, group I was divided into 3 subgroups and group II into 2 subgroups	Comparison of 5 sub-groups Post-test – follow up test (6 months after post-test)	2(a, b), 3(a, c), 4(a, b, c) and 6a: cf. Ekblom et al., 1975a	*Within groups*: Group I: significant deterioration in two sub-groups for 3a and/or 4a Group II: significant improvement in one sub-group for 2a *Between groups*: Not reported
Nordemar, Edström, & Ekblom, 1976	$N = 10$ Class: II or III	Identical to the treatment of group I (a, b and c) in Ekblom et al. (1975a); and: d. Walking in a park and on stairs Length: 6 weeks	One group design Pretest – post-test	2a. Observation of walking time and using the stairs 3a. Oxygen uptake c. Perceived exertion 4a. Muscle strength (isometric, knee) b. Muscle strength (isometric, elbow) 6a. Joint status (tenderness/pain) 7a. Size of muscle fibres (type I and II)	*Within groups*: Significant improvement for 2a, 3a and c, and 4a; no significant change for 4b; no statistical tests reported for 6a and 7a (probably no change in 6a, and improvement in 7a). *Between groups*: Not applicable
Nordemar, Berg Ekblom, & Edström, 1976	$N = 10$ Duration: range 3–18 years Class: II or III	a. Training on a bicycle, swimming or brisk walking, supposedly at 50–70% at their VO_2 max. b. Quadriceps strength training Length: 7 months	One group design Pretest – post-test	2a, 3a and c, 4a and b, 6a and 7a: cf. Nordemar, Edström & Ekblom, 1976 7b. Radiographic assessment of the knees	*Within groups*: Significant improvement for 2a and 4a; no significant change for 3a, 4b and 7b; no statistical tests reported for 3c, 6a and 7a *Between groups*: Not applicable

Authors	Patients	Interventions	Design	Measures	Outcome
Nordemar et al., 1981	$N = 46$ Duration: 16 years in group I, 14 years in group II Class, I, II or III	Group I a. Training on a bicycle for cardiovascular fitness, swimming, skiing, cycling, dancing, gymnastics, golf, far-walking, jogging and other organized training sports. b. Strength training for the lower extremities c. Individual physiotherapy (strength and mobility training) Group II: c. Individual physiotherapy (strength and mobility training) Length: on average 5 years (range 4–8 years)	Group I (a + b + c) vs group II (a) The study started with random assignment, but 10 patients were allowed to change groups Pretest – post-test	2a, 3a and c, 4a and b, 6a and 7b: cf. Nordemar, Edström & Ekblom, 1976; Nordemar, Berg, Ekblom & Edström, 1976 7a. Laboratory findings (Hb, ESR, SCAT) 9. Pharmacological treatment, orthopaedic operations, days in hospital and sick-leave	*Within groups*: Group I: significant improvement for 2a (footstool) and 4b; no significant change for 2a (stairs, walking), 3a and c, and 4a Group II: no significant changes for 2a, 3a and c, 4a and b Measures 6a, 7a and b, and 9 not (statistically) evaluated within groups *Between groups*: Significantly more favorable outcome in group I than in group II for 2a (stairs), 4a and b, 6a, 7b, and 8 (days in hospital and sick-leave) No significant differences between groups for 2a (walking, footstool), 3a and c, 7a and 8 (pharmacological treatment and orthopedic operations)
Nordemar, 1981	See above	See above	Contrast and assignment: see above Post-test only	Questionnaire on: 2b. Activities of daily living, activity level 8. Feelings 9. Training attitudes and opinion on etiology of disease	*Within groups*: Not applicable *Between groups*: Significantly more favorable outcome in group I than in group II for 2b and 9 (attitudes) No significant differences between groups for 8 and 9 (opinion on etiology)

Authors	Patients	Interventions	Design	Measures	Outcome
Byers, 1985	$N = 30$	Range of motion exercises of various joints, including the hands Length: two days	Within-subjects design, with two within-subjects factors: exercises in the morning; with or without exercises in the evening, in a random order Measurements were obtained prior to (5a) and immediately following (5b) the morning exercises.	5a. Observation of finger mobility; observation of elastic stiffness of the finger 5b. Subjective finger stiffness	*Within groups*: Significant improvement when evening exercises were performed for 5a and b and after morning exercises for 5a *Between groups*: Not applicable
Harckom et al., 1985	$N = 20$ Class: II	Group I: a. Interval training on bicycle at 70% of the pretraining maximal heart rate. Three sub-groups were formed, differing in intensity of training b. Range of motion exercises Group II: No intervention Length: 12 weeks	Group I (a + b) vs group II Random assignment Pretest – post-test	2a. Observation of walking time b. Self-report of self-care, ambulation, activities of daily living 3a. Oxygen uptake b. Exercise time on bicycle 4a. Muscle strength (isotonic knee extension and flexion; isometric knee extension) b. Grip strength 6a. Joint status (pain and swelling)	*Within groups*: Group I: significant improvement for 3a and b, and 6a; no significant changes for 2a and b, and 4a and b Group II: no significant changes for 2a and b, 3a and b, 4a and b, and 6a *Between groups*: Not reported

Authors	Patients	Interventions	Design	Measures	Outcome
Dial & Windsor, 1985	$N = 12$ Duration: 6.5 years (range 3 months – 25 years) Class: II or III	a. Range of motion exercises, water ambulation, use of flotation equipment for kicking and water games b. Health education Length: 8 weeks	One group design Two pretests (1 month and 1 week *prior to the* intervention and two post-tests (1 week and 1 month following the intervention)	2a. Observation of functional status b. Self-report on various items 4b. Grip strength 5a. Range of joint motion (8 *items*) 6b. Morning stiffness	*Within groups*: Significant improvement from pretest to post-test for 2a and 5a; no significant change for 4b and 6b; no statistical test performed for 2b (*probably improvement*) With exception of two items, no significant changes from pretest to pretest, nor from post-test to post-test for 2a, 4b, 5a, and 6b; no statistical test performed for 2b *Between groups*: Not applicable
Karper & Evans, 1966	$N = 1$ Duration: 19 years Class: II	Training on cycle, at approximately 65% of pretraining maximum heart rate and gradually increasing. Length: 14 weeks	Single subject design Pretest – post-test	1. Pain 3a. Oxygen uptake c. Perceived exertion 8. "Self-satisfaction"	*Within groups*: Significant improvement for 3c; no statistical tests performed for 1, 3a, and 8 (probably improvement) *Between groups*: Not applicable
Danneskiold-Samsoe et al., 1987	$N = 8$ Duration: 14 years (range 3–22 years) Class: II or III	Water exercise program, with emphasis on strength training of the muscles of the lower extremities Length: two months	One group design Pretest – post-test – follow-up test (2 *months after* post-test)	3a. Oxygen uptake 4a. Muscle strength (isometric and isokinetic knee extension)	*Within groups*: Significant improvement from pre- to post-test for 3a and 4a (isometric and low-velocity isokinetic) No significant changes from pre-to follow-up test for 4a (3a not evaluated) *Between groups*: Not applicable

Authors	Patients	Interventions	Design	Measures	Outcome
Deusen & Harlowe, 1987	$N = 46$ Duration: 10.9 years (*SD*: 2.2 years, range 0–38 years)	Group I: a. "Dance-like movements", which incorporate joint motion b. Relaxation techniques Group II: No intervention Length: 8 weeks	Group I (a + b) vs group II Random assignment Pretest – post-test – follow-up (4 months after post-test)	5a. Range of joint motion (upper and lower extremity) 9. Evaluation of exercise and rest	*Within groups*: Not reported *Within groups*: Significantly more favorable outcome in post-test in group I than in group II for 5a (lower extremity) and 9 Significantly more favorable outcome in follow-up-test for 5a (upper extremity); no significant difference for 9
Lyngberg et al., 1988	$N = 20$ Duration: 13 years (range 2–31 years) Class: I or II	Intervention I: a. Training on bicycle at 50–70% of maximum pulse increment b. Dynamic muscle strength exercises c. Stretching exercises' d. "Normal mobilization programme" Intervention II: d. "Normal mobilization programme" Length: 8 weeks	Cross-over design with two groups: * group A: intervention I and then intervention II * group B: intervention II and then intervention I Random assignment Pretest, test at cross-over point, post-test	3a. Oxygen uptake 4a. Muscle strength (isokinetic knee extension and foot plantar flexion) 6a. Joint status (swelling and tenderness) 7a. Laboratory measures (Hb and various other tests)	*Within groups*: Intervention I: significant improvement for 6a (swelling) and 7a (Hb); no significant change for 6a (tenderness); no statistical test performed for 3a and 4a (probably improvement) Intervention II: no statistical test performed for 3a, 4a, 6a and 7a. *Between groups*: Not reported

Authors	Patients	Interventions	Design	Measures	Outcome
Minor et al., 1989	$N = 40$ (and 80 OA) Duration: 10.8 years (*SD*: 7.9 years, range 0.5–29 years)	Group I: a. Exercises in a pool or walking exercises, at 60–80% of pretraining maximum heart rate (there were separate walk and pool groups, but they were combined in the analysis) b. Isometric muscle strengthening exercises c. Range of motion and stretching exercises Group II b. Isometric muscle strengthening exercises c. Range of motion and stretching exercises Length: 12 weeks	Group I (a + b + c) vs group II (b + c) Random assignment Pretest – post-test – two follow-up tests (at 3 and 9 months after post-test)	1. Pain 2a. Observation of walking time b. Self report of physical activity 3a. Oxygen uptake b. Exercise time on treadmill 4b. Grip strength 5a. Trunk flexibility 6a. Joint status (swelling, tenderness) b. Morning stiffness 8. Anxiety and depression 9. Physical self-concept	*Within groups*: Group I: significant improvement from pre- to post-test for 2a and b, 3a and b, 4b, 5a, 6a and b, 8 and 9; no significant change for 1 Group II: significant, improvement from pre- to post-test for 1 and 4b; no significant changes for other measures Changes from pre- to follow-up tests were not reported separately for RA-patients *Between groups*: Significantly more favorable outcome from pre- to post-test in group I than in group II for 2a, 3a and 8, no significant differences for other measures Changes from pre- to follow-up tests were not reported separately for RA-patients
Ekdahl, Andersson, Moritz, & Svensson, 1990	$N = 67$ Duration: 10.6 years (*SD* 7.8 years, range 1–37 years) Class: II	Group I: a. Training on a bicycle, starting at 50% of maximal aerobic capacity and increasing steadily b. Dynamic muscle strength exercises (both against body weight and with a pulley) c. Exercises on a jumping mat d. Stretching exercises e. Home program in accordance with a–d	Group I (a–e) vs group II (d, f, g) Random assignment Pretest, post-test and follow-up test (3 months after post-test)	1. Pain 2a. Observation of walking time and using the stairs b. Self-report of activities of daily living 3a. Oxygen uptake c. Perceived exertion and pain during aerobic testing 4a. Muscle strength (isometric hip and knee in various directions; isokinetic knee in two directions; and muscle function)	*Within groups*: Not (clearly) reported *Between groups*: Significantly more favorable outcome from pre- to post-test in group I than in group II for 2a (walking), 3a and c (exertion), 4a, 6a and b; no significant difference for 1, 2b, 4c, 5a, and 7a Significantly move favorable outcome from pre- to follow-up test

Authors	Patients	Interventions	Design	Measures	Outcome
		Group II: d. Stretching and range of motion exercises f. Static muscle strengthening exercises 9. Home program in accordance with d and f Length: 6 weeks		c. Perceived exertion and pain during muscle testing 5a. Range of joint motion 6a. Joint status (pain) b. Morning stiffness 7a. Laboratory tests (Hb and other tests)	in group I than in group II for 2a (stairs), 3a, 4a, 6a and b, and 7a (Hb); no significant differences for 1, 2b, 3c, 4c, and 5a
Ekdahl, Ekman, Andersson, Melander, & Svensson, 1990	$N = 8$ Class II Duration: 14.6 years (*SD* 10.1 years, range 4–35 years)	Identical to Group I in Ekdahl, Andersson, Monitz, & Svensson, 1990 Length: 6 weeks clinical and home program, and subsequently 52 weeks home program	One group design Pretests (3 and 0 weeks before), intermediate test (3 weeks), post-tests (6 and 58 weeks)	1, 2a and b, 3a, 4a, 5a, 6a and b: see Ekdahl, Andersson, Monitz, & Svensson, 1990 7a. Laboratory tests (corticotropin releasing factor (CRF), beta-lipotropin (LPH), beta-endorphin (EP), ESR, C-reactice protein and Hb)	*Within groups*: Significant improvement from 0 to 6 weeks for 2a, 3a, 4a, 5a, 6a and b; significant improvement from 3 to 6 weeks for 7a (EP); no significant changes for 1, 2b, 7a (all measures except EP) Significant improvement from 0 to 58 weeks for 7a (CRF and LPH); no significant changes for 1, 2b, 6b, 7a (all measures except CRF and LPH); measures 2a, 3a, 4a, 5a, and 6a not evaluated *Between groups*: Not applicable
Ekdahl et al., 1992	See above	See above	Follow-up test at 110 weeks	1, 2b, 6b and 7a: see above	*Within groups*: Significant improvement from 3 to 110 weeks for 7a (EP); significant deterioration from 58 to 110 weeks for 7a (CRF); no significant changes for 1, 2b, 6b and 7a (all measures except EP and CRF) *Between groups*: Not applicable

Authors	Patients	Interventions	Design	Measures	Outcome
Perlman et al., 1990	$N = 43$ Class: I, II or III	a. "Warm-ups" b. Dance-baced exercises, intended at 60–75% of the maximum heart rate c. Flexibility and muscle-strengthening exercises d. Problem-solving discussions Length: 16 weeks	One group design Pretest – post-test	1. Pain 2a. Observation of walking b. Self-report of physical activity 6a. Joint status (swelling and pain) 8. Self-report of psychological functions; perceived health and quality of life	*Within groups*: Significant improvement for 1, 2a and b, 6a and 8 *Between groups*: Not applicable
Kirsteins et al., 1991 Study I	$N = 47$ Class: II or III	Group I: a. Breathing and relaxation b. Isometric and isotonic strengthening exercises, producing approximately 50% increase in heart rate; weight-bearing "rythmic motion" Group II: No intervention Length: 10 weeks	Group I vs. group II No random assignment Pretest – post-test	2a. Observation of walking time 4b. Gripstrength 6a. Joint status (tenderness)	*Within groups*: Not reported *Between groups*: No significant differences for 2a, 4b, and 6a
Study II	$N = 28$ Class: II or III	Group I and II: see above	See above	See above	*Within groups*: Not reported *Between groups*: Significantly more favorable outcome in group I than in group II for 2a; no significant differences for 4b and 6a

APPENDIX 2

Studies on Exercise Therapy in Patients with Osteoarthritis

Authors	Patients	Interventions	Design	Measures	Outcome
Chambelain et al., 1982	$N = 42$ OA of the knee	Group I: a. Diathermy b. Strength and endurance exercises of the knee extensors Group II: b. Strength and endurance exercises of the knee extensors Length: 4 weeks	Group I (a + b) vs. group II Random assignment Pretest, post-test, follow-up tests (2 and 6 weeks after post-test)	1. Pain 2a. Observation of maximum weight lift and number of knee swings b. Self-report on functional activities 5a. Range of knee motion	*Within groups*: Group I: significant improvement from pre- to post-test for 2a and b; no significant change for 1 and 5a Group II: significant improvement from pre- to post-test for 1, 2a and b Pre-follow-up test not reported *Between groups*: Significantly more favorable outcome from pre-to post-test in group II than in group I for 1 No significant differences from pre- to post-test for 2a and b, and 5a Pre-follow-up test not reported
Leivseth et al., 1989	$N = 6$ OA of the hip Duration: 9.2 years (range 3–20 years)	Stretching of the adductor hip muscles, without hip movement Length: 4 weeks	One group design Pretest, post-test	5a. Range of hip motion (abduction) 7a. Size of muscle fibres	*Within groups*: Significant improvement for 5a; 7a not statistically evaluated *Between groups*: Not applicable
Kreindler et al., 1989	$N = 32$ OA of the knee	Group I: a. "Traditional" muscle strengthening exercises	Group I (a) vs. Group II (a + b) vs. Group III (c + d) vs.	4a. Muscle strength	*Within groups*: Group I, II and III: significant improvement from pre- to post-test for 4a Group IV: no significant changes

Authors	Patients	Interventions	Design	Measures	Outcome
		Group II: a. "Traditional" muscle strengthening exercises b. Isokinetic exercises on a machine Group III: c. Setting exercises d. Isokinetic exercises on another machine Group IV: No intervention Length: 6 weeks	Group IV Assignment in order of application Pretest, post-test, follow-up (6 weeks after post-test)		from pre- to post-test for 4a Changes from pre- to follow-up test not statistically evaluated *Between groups*: Not statistically evaluated
Minor et al., 1989	$N = 80$ (and 40 RA) OA of the hip, knee or ankle Duration: 14.6 years (*SD*: 10.7 years, range 1–40 years)	Group I: a. Exercises in a pool or walking exercises, at 60–80% of pretraining maximum heart rate (there were separate walk and pool groups, but they were combined in the analysis) b. Isometric muscle strengthening exercises c. Range of motion and stretching exercises Group II: b. Isometric muscle strengthening exercises c. Range of motion and stretching exercises Length: 12 weeks	Group I (a + b + c) vs. Group II (b + c) Random assignment Pretest, post-test, two follow-up tests (at 3 and 9 months after post-test)	1. Pain 2a. Observation of walking time b. Self report of physical activity 3a. Oxygen uptake b. Exercise time on treadmill 4b. Grip strength 5a. Trunk flexibility 6a. Joint status (swelling, tenderness) b. Morning stiffness 8. Anxiety and depression 9. Physical self-concept	*Within groups*: Group I: significant improvement from pre- to post-test for 1, 2a and b, 3a and b, 4b, 5a, 6a and b, and 8; no significant change for 9 Group II: significant improvement from pre- to post-test for 5a; no significant change for other measures Changes from pre- to follow-up test were not reported separately for OA-patients *Between groups*: Significantly more favorable outcome from pre- to post-test in group I than in group II for 3a; no significant differences for other measures Changes from pre- to follow-up test were not reported separately for OA-patients

Authors	Patients	Interventions	Design	Measures	Outcome
Fisher et al., 1991	$N = 15$ OA of the knee	Isometric and isotonic knee extension exercises on an apparatus Length: 16 weeks	One group design Pretest, intermediate-test, post-test, two follow-up test (4 and 8 months after post-test)	1. Pain 2a/b. Observation of walk time; composite scores of observed functional activities and symptoms b. Self-report on dependence and difficulty 4a. Muscle strength and endurance (isometric knee extension) and speed of contraction (knee extension)	*Within groups*: Significant improvement from pre- to post-test for 1, 2a and b, and 4a Significant improvement from pre- to both follow-up tests for 1, 2a and b, and 4a
Kovar et al., 1992	$N = 102$ OA of the knee	Group I: a. Indoor supervised fitness walking b. Education aiming at promoting fitness walking c. Strengthening exercise d. Stretching exercise Group II: No intervention	Group I (a + b + c + d) vs. Group II Random assignment Pretest, post-test	1. Pain 2a. Observation of walking distance b. Self report of physical activity 8. General arthritis impact 9. Use of medication	*Within groups*: No systematic, statistical evaluation *Between groups*: Significantly more favorable outcome in group I than in group II for 1, 2a and b. Similar trend ($p < .10$) for 8 and 9.