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Review

Osteoarthritis of the knee: Why does exercise work? A qualitative study of the literature

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ABSTRACT

The effectiveness of exercise to reduce pain and improve functioning in osteoarthritis of the knee (OAk) is well substantiated. Underlying mechanisms are still under debate and better understanding of the pathways involved may contribute to more targeted treatment strategies. The present qualitative analysis of the literature aims to provide an overview of theoretical models that are put forward to explain the beneficial treatment effects of exercise in OAk. An inductive qualitative approach, based on the 'grounded theory' of Glaser and Straus, was used. Twenty-two studies emphasizing on exercise therapy for OAk, collected from three Cochrane reviews and nine guidelines of the Physiotherapy Evidence Database (PEDRO) published between 2000 and 2012, were included. The introduction and discussion parts of these papers were screened for explanations of exercise-induced benefits in OAk patients. Seventy-three key points were identified which were subdivided into 16 core theoretical concepts. Finally, 5 categories were formed: neuromuscular, peri-articular, intra-articular, psychosocial components, and general fitness and health. We referred to scientific evidence that was used in the included studies to describe and categorize the concepts. Future research on exercise in OAk should allow distinguishing the contribution of different potential pathways to the treatment effects.

1. Introduction

Osteoarthritis (OA) is characterized by a degeneration of articular cartilage in synovial joints. Pain and disability occur in 17% of people aged 45 years and over due to osteoarthritis in the knee (OAk) (Lawrence et al., 2008) and in 40% of people aged 65 years and over due to OAk or OA in the hip (Dawson et al., 2004; Mannoni et al., 2003). Because till now OA is an irreversible condition, the treatment is focused on reducing physical disability and handicap, and controlling pain while minimizing the potentially harmful side effects of medications (Zhang et al., 2007). In this context, exercise therapy is considered as an effective conservative treatment for OAk-related pain and disability (Fransen and McConnell, 2008), and recommended as 'first choice conservative treatment' by several clinical guidelines (Peter et al., 2010; Royal Australian College of General Practitioners, 2009 (South Melbourne); Zhang et al., 2008). However, underlying mechanisms for these beneficial exercise-induced effects are still scarcely understood. Understanding the pathways through which exercise influences pain and function in OAk patients may contribute to the design of a comprehensive treatment plan. Potential explanations for the favourable effects of exercise in OAk are frequently proposed in the introduction and discussion sections of scientific papers reporting the effects of exercise interventions. Sometimes these hypotheses are (partly) empowered by scientific data. To our knowledge, comprehensive overviews of these potential working mechanisms of physical exercise are lacking. The present literature study aims to provide an overview of the potential underlying mechanisms that are proposed in the literature to explain the exercise induced improvements in OAk pain and function.

2. Methods

A systematic literature search was performed and extracted data were further analyzed with a qualitative approach, based on the 'grounded theory' of Glaser & Strauss, which is inductive in nature (Strauss and Corbin, 1998). This approach implies 4 steps: (1) data gathering; (2) extracting key points from the collected data; (3) grouping key points into similar concepts; and (4) forming categories from the concepts. First, in order to gather information, we searched (last search on March 1st 2012) for scientific papers emphasizing on exercise therapy for OAk (systematic reviews and/or practice guidelines) using the search

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engines of the Cochrane Library (www.cochrane.org; keywords: osteoarthritis, exercise, and knee) and the Physiotherapy Evidence Database (Pedro, www.pedro.org.au; keywords: osteoarthritis, practice guideline, and body part: lower leg or knee). If exercise therapy was recommended in a practice guideline, the studies that were used to empower this recommendation were retrieved for further analysis and data extraction. All studies, reported in the included Cochrane reviews, were analyzed as well. In a first step, introduction and discussion sections of the included studies were systematically screened for potential underlying mechanisms for the effects of exercise on OAk symptoms. Secondly, these mechanisms were listed as key points. Thirdly, these key points were grouped into concepts by 2 researchers (DB and IB). Finally, concepts that may explain the exercise induced improvements in OAk pain and function were ordered in categories and the corresponding scientific foundations to empower the theoretical models were extracted from the papers.

3. Results

Three Cochrane reviews and nine guidelines were identified (see Table 1).

All guidelines recommend physical exercise as a conservative treatment for OAk. The selected reviews and guidelines are based on 70 original research papers (see Appendix A) that were published between 1989 and 2010. Twenty-two of these studies (published between 1991 and 2008) mention potential underlying mechanisms for the effects of exercise in OAk and referred to 117 other articles (see Appendix B) for scientific support for the proposed mechanism. From these 22 papers, 73 key points were extracted. Next, these key points were grouped into 16 concepts: "Muscle", "Proprioception, balance and motor learning", "Energy absorbing capacity", "Stability", "Connective tissue", "Bone", "Cartilage", "Inflammation", "Joint fluid", "Comorbidities", "Weight loss", "Aerobic fitness", "Increase of well-being", "Decrease of depression", "Placebo effect", and "Increase of self-efficacy". Finally, the concepts were ordered in 5 categories: (1) Neuromuscular components, (2) Peri-articular components, (3) Intra-articular components, (4) General fitness and health, and (5) Psychosocial components. Of all included papers, the effect of different exercise modes was investigated: strengthening exercises (some with additional modes including ROM, flexibility and balance) ($N = 14$) (Baker et al., 2001; Cochrane et al., 2005; Hinman et al., 2007; Huang et al., 2003b, 2005a; Jan and Lai, 1991; Mikesky et al., 2006; Miyaguchi et al., 2003; O'Reilly et al., 1999; Rogind et al., 1998; Schilke et al., 1996; Thorstensson et al., 2005; Topp et al., 2002; van Baar et al., 1998a), aerobic exercises ($N = 1$) (Fransen et al., 2001), tai chi ($N = 1$) (Hartman et al., 2000), a combination of strengthening, aerobic and ROM exercises ($N = 2$) (Deyle et al., 2000; Keefe et al., 2004), strengthening versus aerobic exercises ($N = 2$) (Penninx et al., 2001, 2002a) (see Tables 2–6). Two included papers were reviews (Lee et al., 2008; Pelland et al., 2004). Information on the mechanisms of exercise induced improvements was given for strengthening exercises ($N = 11$) (Baker et al., 2001; Deyle et al., 2000; Fransen et al., 2001; Huang et al., 2003a, 2005a; Jan and Lai, 1991; Keefe et al., 2004; Miyaguchi et al., 2003; Schilke et al., 1996; Thorstensson et al., 2005; Topp et al., 2002), aerobic exercises ($N = 4$) (Mikesky et al., 2006; Miyaguchi et al., 2003; O'Reilly et al., 1999; Penninx et al., 2002a) or for exercises in general ($N = 8$) (Cochrane et al., 2005; Hartman et al., 2000; Hinman et al., 2007; Lee et al., 2008; Pelland et al., 2004; Penninx et al., 2001; Rogind et al., 1998; van Baar et al., 1998a) (see Tables 2–6).

3.1. Neuromuscular components (see Table 2)

In this category, the proposed underlying mechanisms for the beneficial effect of exercise on pain or function of OAk are mainly focused on the decrease of the mechanical focal peak loading of the cartilage due to the impact of exercise on neuromuscular components: muscles, proprioception and motor learning, energy absorbing capacity and stability.

3.1.1. Muscle

Mikesky et al. suggested that the strength of contraction of the periarticular muscles (i.e. quadriceps and hamstrings for the knee joint) is an important contributing factor for the quality of the cartilage (Mikesky et al., 2006). Therefore, gaining strength through exercise may be beneficial. This statement is based on an assumption of Palmoski et al. (1980). Palmoski et al. studied morphologic changes of articular cartilage of dogs of which one knee was unloaded either by immobilization or amputation (Palmoski et al., 1979, 1980). In one of their studies the unloaded knee was immobilized with a cast for 6 days after which atrophy of the articular cartilage of the knee was observed (Palmoski et al., 1979). In another study, similar atrophy was seen in knees of dogs of which one paw was amputated 6 weeks earlier (Palmoski et al., 1980). Due to this amputation, the dogs were able to ambulate on three legs while the knee joint of the amputated leg could actively move, similarly to the contralateral (i.e. non-amputated) knee but without bearing weight. Based on these observations, Palmoski et al. concluded that joint movement alone may be insufficient to maintain the integrity of the articular cartilage and he suggested that the force of the quadriceps and hamstrings muscles could be involved (Palmoski et al., 1980). He hypothesized that most of the force

Table 1
Included guidelines and Cochrane reviews.

Source	Title
Australian Physiotherapy Association (Royal Australian College of General Practitioners, 2009 (South Melbourne))	Knee joint osteoarthritis position statement
Cochrane collaboration (Bartels et al., 2007)	Aquatic exercise for the treatment of knee and hip osteoarthritis
Cochrane collaboration (Fransen and McConnell, 2009)	Exercise for osteoarthritis of the knee
Cochrane collaboration (Brosseau et al., 2003)	Intensity of exercise for the treatment of osteoarthritis
European League Against Rheumatism (EULAR) (Pendleton et al., 2000)	EULAR recommendations for the management of knee osteoarthritis
Royal Dutch Society for Physical Therapy (KNGF) (Vogels et al., 2001)	Clinical practice guidelines for physical therapy in patients with osteoarthritis of the hip or knee
Osteoarthritis Research Society International (OARSI) (Zhang et al., 2008)	OARSI recommendations for the management of hip and knee osteoarthritis, part II: OARSI evidence-based, expert consensus guidelines
Ottawa Panel (Brosseau et al., 2011)	Ottawa Panel Evidence-Based clinical practice guidelines for the management of osteoarthritis in adults who are obese or overweight
Philadelphia Panel (Albright et al., 2001)	Philadelphia Panel evidence-based clinical practice guidelines on selected rehabilitation interventions for knee pain
(Royal Australian College of General Practitioners, 2009 (South Melbourne))	Guideline for the non-surgical management of hip and knee osteoarthritis
Dutch Medical Association (Swierstra et al., 2009)	Guideline 'Diagnostics and treatment of osteoarthrosis of the hip and knee'
(American Academy of Orthopaedic Surgeons, 2008)	Treatment of osteoarthritis of the knee (non-arthroplasty): full guideline