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Improvement in upper leg muscle strength underlies beneficial effects of exercise therapy in knee osteoarthritis: secondary analysis from a randomised controlled trial

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Abstract

Objectives Although exercise therapy is effective for reducing pain and activity limitations in patients with knee osteoarthritis (OA), the underlying mechanisms are unclear. This study aimed to evaluate if improvements in neuromuscular factors (i.e. upper leg muscle strength and knee proprioception) underlie the beneficial effects of exercise therapy in patients with knee OA.

Design Secondary analyses from a randomised controlled trial, with measurements at baseline, 6 weeks, 12 weeks and 38 weeks.

Setting Rehabilitation centre.

Participants One hundred and fifty-nine patients diagnosed with knee OA.

Intervention Exercise therapy.

Main outcome measures Changes in pain [numeric rating scale (NRS)] and activity limitations [Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) physical function subscale and get-up-and-go test] during the study period. Independent variables were changes in upper leg muscle strength and knee joint proprioception (i.e. motion sense) during the study period. Longitudinal regression analyses (generalised estimating equation) were performed to analyse associations between changes in upper leg muscle strength and knee proprioception with changes in pain and activity limitations.

Results Improved muscle strength was significantly associated with reductions in NRS pain {B coefficient −2.5 [95% confidence interval (CI) −3.7 to −1.4], meaning that every change of 1 unit of strength was linked to a change of −2.5 units of pain}, WOMAC physical function (−8.8, 95% CI −13.4 to −4.2) and get-up-and-go test (−1.7, 95% CI −2.4 to −1.0). Improved proprioception was not significantly associated with better outcomes of exercise therapy ($P > 0.05$).

Conclusions Upper leg muscle strengthening is one of the mechanisms underlying the beneficial effects of exercise therapy in patients with knee OA.

Keywords: Exercise therapy; Neuromuscular mechanisms; Muscle strength; Proprioception; Longitudinal analysis

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Introduction

Although it has been reported that exercise therapy is effective for reducing pain and activity limitations in patients with knee osteoarthritis (OA) [1–3], the underlying mechanisms of these effects are unclear. Various mechanisms have been suggested, including neuromuscular (i.e. muscles and proprioceptive system), peri-articular, intra-articular and psychosocial mechanisms or via general health [4]. As exercise programmes for patients with knee OA primarily focus on muscle strengthening [5–8], the neuromuscular mechanism may be the most important [9]. However, limited and conflicting evidence is available for neuromuscular factors underlying exercise-induced effects in patients with knee OA. To the authors' knowledge, five studies [10–14] have investigated the existence of a direct association between change in muscle strength following exercise therapy and treatment outcome; three of these studies showed an association [10–12], and two studies found no association [13,14]. Only one study [12] focused on change in proprioception, showing a relationship with treatment outcome for a home exercise programme. With the exception of one study [14], these studies reported correlation coefficients without adjusting for confounders. Therefore, high-quality studies are needed to understand the underlying neuromuscular mechanisms of exercise-induced effects [9].

Recently, the authors compared two exercise programmes in a randomised controlled trial of 159 patients with knee OA suffering from instability of the knee joint [15]. Both the experimental and control programmes focused on muscle strengthening and performance of daily activities, but additional knee joint stabilisation training was only provided in the experimental programme. Large effects were found in both exercise groups [within-group effect sizes of 0.9 for numeric rating scale (NRS) pain and 0.7 to 0.8 for Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) physical function], but no significant differences were found between the groups. In addition, both groups showed similarly large improvements in upper leg muscle strength and knee joint proprioception.

The aim of this study was to evaluate whether improvements in neuromuscular factors (i.e. upper leg muscle strength and knee joint proprioception) underlie the beneficial effects of exercise therapy in patients with knee OA.

Methods

Design

This study was a secondary analysis of data from a single-blinded, randomised controlled trial (STABILITY trial) [15] on the effectiveness of two exercise programmes. Data from both groups were combined, as similar improvements were found, with adjustment for group allocation. Participants were measured at baseline, 6 weeks (mid-treatment), 12 weeks (directly after treatment) and 38 weeks (6 months after treatment) by a single assessor who was blinded to group assignment.

Setting and participants

The study was conducted at an outpatient rehabilitation centre (Reade, Centre for Rehabilitation and Rheumatology, Amsterdam, The Netherlands) and approved by the Medical Ethical Review Board at Reade/Slotervaart Hospital. Participants were recruited from February 2009 to March 2011 through advertisements in local and regional newspapers, and from regular referral from rheumatologists or rehabilitation physicians from the rehabilitation centre. All participants provided written informed consent.

Inclusion criteria were: diagnosis of knee OA according to the clinical criteria of the American College of Rheumatology [16]; age between 40 and 75 years; and presence of self-reported knee instability (i.e. at least one self-reported episode of the knee buckling, shifting or giving in past 3 months [17]) and/or biomechanically assessed knee instability (i.e. upper leg muscle weakness in combination with proprioceptive inaccuracy and/or high varus–valgus laxity of the knee joint, according to cut-off points based on previous data [15,18,19].

Exclusion criteria were: forms of arthritis other than OA (e.g. crystal arthropathy, septic arthritis, spondylarthropathy) identified by radiography and/or blood and urine samples; presence of comorbidity resulting in severe activity limitations; total knee arthroplasty (TKA) or TKA anticipated in near future; severe knee pain (i.e. NRS score >8); insufficient comprehension of Dutch language; inability to be scheduled for therapy; and unwillingness to give informed consent [15].

Experimental and control programmes

The experimental and control programmes comprised a supervised exercise programme of 12 weeks, with two 60-minute sessions per week, in groups of approximately eight participants, and a home exercise programme for 5 days per week (performed on non-treatment days only). Each group was supervised by two physical therapists (out of a pool of 17) who were specifically trained to supervise one of the groups. Training intensity, which increased gradually during the programme, and amount of attention from physical therapists were similar in both groups [15]. The reader is referred to Knoop *et al.* [15] for a detailed description of the exercise protocol.

In summary, the experimental programme consisted of three phases: the first phase (Week 1 to Week 4) targeted knee joint stabilisation, the second phase (Week 5 to Week 8) targeted muscle endurance in addition to knee joint stabilisation, and the third phase (Week 9 to Week 12) targeted performance of daily activities, in addition to knee joint stabilisation and muscle power. Knee joint stabilisation training consisted of instructions and feedback from physical therapists on knee position and motion, plus specific exercises

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