



Effect of exercise therapy on neuromuscular activity and knee strength in female adolescents with patellofemoral pain—An ancillary analysis of a cluster randomized trial



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ABSTRACT

Background: Female adolescents with patellofemoral pain are characterized by altered neuromuscular knee control and reduced maximal quadriceps torque. The purpose of this study is to investigate whether exercise therapy and patient education are associated with larger improvements in neuromuscular knee control and maximal quadriceps torque compared with patient education alone.

Methods: This is an ancillary analysis of a cluster randomized controlled trial investigating the effect of patient education and exercise therapy on self-reported recovery in 121 adolescents with patellofemoral pain. A random subsample of 57 female adolescents was included and tested at baseline and after 3 months. Neuromuscular control of the knee was quantified as the complexity of surface electromyography of the vastus lateralis and vastus medialis during stair descent. Secondary outcomes were complexity of knee flexion/extension kinematics and maximal quadriceps torque.

Findings: There was an 8–15% greater decrease in the complexity of surface electromyography suggesting an improvement in neuromuscular knee control among those randomized to exercise therapy ($0.08 < p < 0.30$). Adolescents randomized to exercise therapy had a 0.28-Nm/kg (95% CI: 0.05–0.52; $p = 0.02$) larger increase in maximal quadriceps torque.

Interpretation: Female adolescents randomized to patient education and exercise therapy had a significantly larger increase in maximal quadriceps torque and greater improvement in neuromuscular knee control during stair descent than those receiving patient education alone. This suggests that exercise therapy has an effect not only on self-reported outcome measures but also on objective measures of thigh muscle function in female adolescents with patellofemoral pain.

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1. Introduction

Self-reported knee pain is highly prevalent among adolescents (Fairbank et al., 1984; Rathleff et al., 2013b; Stovitz et al., 2008). Cross-sectional studies show that 19–31% of adolescents report knee pain (Fairbank et al., 1984; Rathleff et al., 2013e; Vahasarja, 1995). One of the most common knee conditions among adolescents is patellofemoral pain (PFP), which has a population prevalence of 6–7% (Molgaard et al., 2011; Rathleff et al., 2013c). The most frequent self-

reported symptoms are diffuse peri-patellar and retro-patellar localized pain (Haim et al., 2006). Pain is typically provoked by activities of daily living that require loading on a flexed knee such as stair descent or squatting (Haim et al., 2006).

Recently, we observed a higher complexity (i.e., higher sample entropy) of the muscle activity of the vastus lateralis (VL) and the knee kinematics during stair descent in female adolescents with PFP (Rathleff et al., 2013d). Higher sample entropy values express a higher complexity of the signal which is thought to be suggestive of altered neuromuscular control (Hausdorff et al., 1995; Lamothe et al., 2004). Self-reported pain intensity was positively associated ($r^2 = 0.11$, $p = 0.01$) with the complexity of surface electromyography (sEMG) of VL. This indicates that adolescents with PFP with the highest amount of pain displayed greater signal irregularity or unpredictability of sEMG compared to

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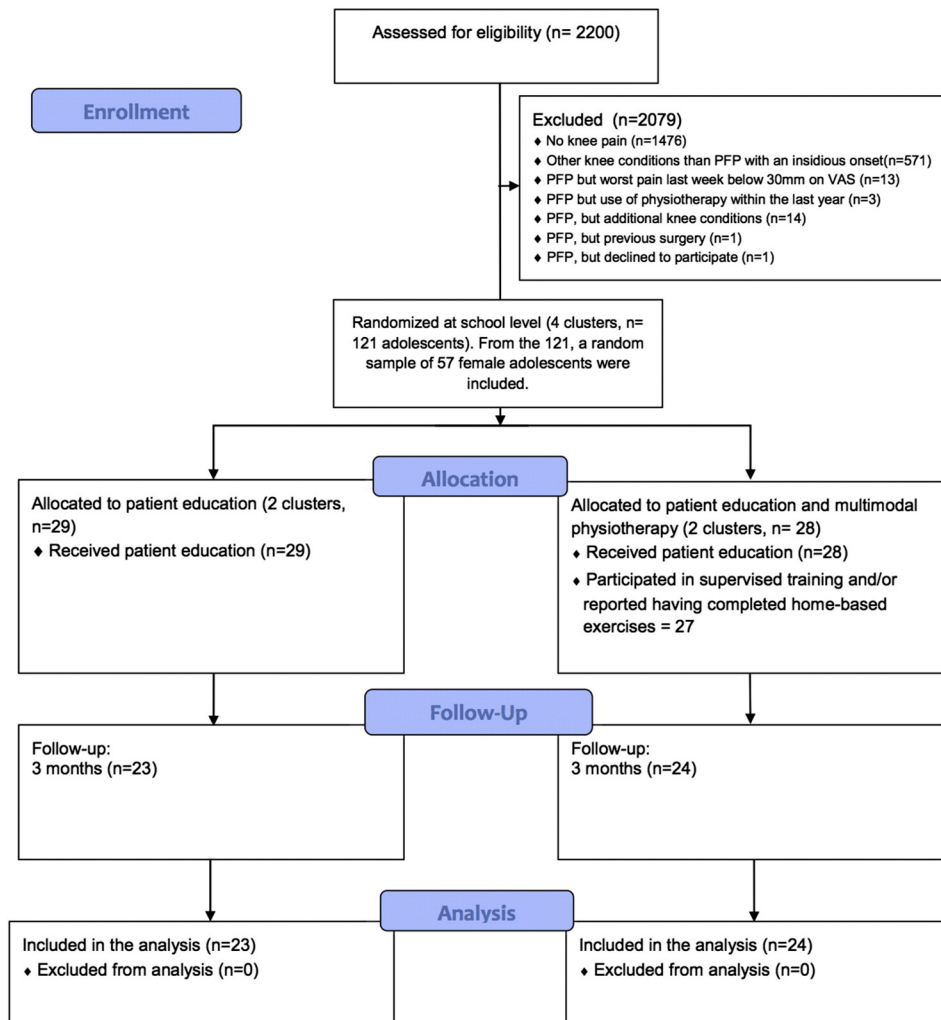


Fig. 1. Flow chart.

pain-free controls. These results suggest that rehabilitation is needed and should focus on both restoring neuromuscular control and increasing muscle strength (Rathleff et al., 2013d).

Two of the core elements in exercise therapy are neuromuscular training, challenging the control of the lower extremity, and strength training. One of the aims in the treatment of PFP is to target strength and neuromuscular control deficits that may help reduce patellofemoral loading. However, it is not known whether exercise therapy can improve neuromuscular knee control and increase quadriceps strength among adolescents with PFP. Therefore, the purpose of this ancillary analysis was to investigate whether 3 months of exercise therapy and patient education were associated with larger positive changes in neuromuscular control compared to patient education alone. We hypothesized that adolescents randomized to additional exercise therapy would show larger improvements in neuromuscular knee control after 3 months treatment compared to adolescents randomized to patient education alone.

2. Methods

This is an ancillary analysis of a cluster randomized controlled trial investigating the effect of exercise therapy with or without the addition of patient education on self-reported recovery (see description of recovery in the section “Self-reported recovery” (Rathleff et al., 2015)). The main study showed that adolescents randomized to patient education

and exercise therapy were more likely to be recovered at 3 to 24 month follow-up (Rathleff et al., 2014b). The adolescents included in this ancillary report were a randomly selected subsample of female adolescents from the original cluster randomized study (Rathleff et al., 2015). All adolescents were recruited from a population-based cohort (Adolescent Pain in Aalborg 2011, the APA2011-cohort) (Rathleff et al., 2012). The study was approved by the local ethics committee of North Denmark Region and all adolescents provided informed consent.

2.1. Recruitment

In the original study, 2846 students aged 15–19 years from four schools were invited to answer an online questionnaire concerning musculoskeletal pain and physical activity (Fig. 1) (Rathleff et al., 2012). The students who reported knee pain were contacted by telephone and offered a clinical examination by an experienced rheumatologist if they fulfilled the following criteria: pain for more than 6 weeks; pain felt anteriorly around the patella or diffusely around the knee; no treatment within the previous 12 months; and no previous knee surgery and a history of insidious onset of knee pain.

During the subsequent clinical examination, the students were diagnosed with PFP if they met the following criteria, which are in accordance with a previous clinical trial (Cowan et al., 2002):

- Insidious onset of anterior knee or retro-patellar pain for more than 6 weeks and provoked by at least two of the following situations:

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