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Research

New exercise-integrated technology can monitor the dosage and quality of exercise performed against an elastic resistance band by adolescents with patellofemoral pain: an observational study

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KEY WORDS

Patellofemoral pain
Exercise therapy
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ABSTRACT

Question: Is the exercise-integrated Bandcizer™ system feasible for recording exercise dosage (time under tension (TUT) and repetitions) and pain scores among adolescents with patellofemoral pain? Do adolescents practise the exercises as prescribed (TUT and repetitions)? Do adolescents accurately report the exercises they do in an exercise diary? **Design:** Observational feasibility study. **Participants:** Twenty adolescents between 15 and 19 years of age with patellofemoral pain. **Intervention:** Participants were prescribed three exercise sessions per week (one with and two without supervision) for 6 weeks. The exercises included three hip and one knee exercise with an elastic resistance band. Participants were instructed to perform three sets with a predefined TUT (3 seconds concentric; 2 seconds isometric; 3 seconds eccentric; 2 seconds pause), equating to 80 seconds for 10 repetitions (one set). **Outcome measures:** The exercise-integrated system consisted of a sensor attached to the elastic resistance band that was connected to the Bandtrainer app on an electronic tablet device. Pain intensity was reported on a visual analogue scale on the app. Participants also completed a self-report exercise diary. **Results:** No major problems were reported with the system. Participants performed 2541 exercise sets during the 6 weeks; 5% were performed with the predefined TUT (ie, within 10 seconds of the 80-second target) and 90% were performed below the target TUT. On average, the participants received 15% of the instructed exercise dosage based on TUT. The exercise dosage reported in the exercise diaries was 2.3 times higher than the TUT data from the electronic system. Pain intensity was successfully collected in 100% of the exercise sets. **Conclusion:** The system was feasible for adolescents with patellofemoral pain. The system made it possible to capture detailed data about the TUT, repetitions and sets during home-based exercises together with pain intensity before and after each exercise. **[Rathleff MS, Bandholm T, McGirr KA, Harring SI, Sørensen AS, Thorborg K (2016) New exercise-integrated technology can monitor the dosage and quality of exercise performed against an elastic resistance band by adolescents with patellofemoral pain: an observational study. *Journal of Physiotherapy* 62: 159–163]**

Introduction

Knee pain is common during adolescence, with a reported prevalence of up to 25%.[1,2] Patellofemoral pain has a prevalence of 6 to 7%, making it the most common knee condition amongst adolescents.[3] Pain is typically long-standing and results in severe reductions in function and health-related quality of life.[4] Symptoms of patellofemoral pain include diffuse anterior knee pain provoked by squatting, sitting for extended periods of time, and descending and ascending stairs.[5]

The latest Cochrane systematic review concluded that lower-extremity exercise therapy is effective in reducing knee pain in patients with patellofemoral pain.[6] Exercise dosage may be an important aspect of the intervention because a higher self-reported exercise dosage is associated with improved odds of recovery.[3,7] Adherence to prescribed exercises is likely to be important because low adherence would be expected to reduce the magnitude of their effect.[3,7] This is a challenge because adherence to exercise protocols is approximately 50% for clinic-based programs, and reportedly lower for home-based exercise.[8]

Adherence involves a number of factors, including how often the patient performs the exercises, whether the quantity of the exercise performed is sufficient to provide a therapeutic benefit, and how long the patient continues to perform the exercises.[9] Pain

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during exercises may help to explain non-adherence to exercise programs, which is why continuous pain monitoring may be an important factor in explaining adherence.[10]

The latest systematic review on self-reported adherence to home-based intervention rehabilitation programs concluded: 'The results expose a gap in the literature for well-developed measures that capture self-reported adherence to prescribed but unsupervised home-based rehabilitation exercises'.[9] A lack of objective measurements limits the ability of clinicians and researchers to evaluate the outcome of exercise interventions. This makes it virtually impossible to ascertain if a lack of improvement is due to the incorrect exercise, dosage, or due to poor adherence. In a recent series of studies,[11–13] technology that measures these factors has been developed and validated; the Bandcizer™ is an in-built sensor attached to an elastic resistance band and connected to an iPad, hereafter referred to as the exercise monitoring system. In lab-based studies, the exercise monitoring system has shown that it can validly quantify exercise data, such as the number of repetitions and sets, as well as the time under tension.[11] The feasibility of using the exercise monitoring system connected to an iPad (hereafter referred to as the tablet device) during week-long home-based interventions in clinical populations is currently unknown and, thus, it is too premature to use the system in clinical trials or clinical practice. It is therefore pertinent to test the feasibility of the system and record any issues associated with using it during home-based unsupervised interventions.

The general research question for this study related to whether it is feasible to use the exercise monitoring system connected to a tablet device to measure exercise adherence and dosage among adolescents with patellofemoral pain.

Therefore, the research questions for this feasibility study were:

1. Is the exercise monitoring system feasible for recording exercise dosage (time under tension and repetitions) and pain scores among adolescents with patellofemoral pain?
2. Do patients perform exercises as prescribed, with respect to time under tension and repetitions?
3. Do patients accurately report the exercises that they perform in an exercise diary?

Methods

Design

The study was designed as a feasibility study. The term feasibility study refers to studies that are carried out in preparation for future large-scale definitive studies such as randomised trials or observational studies, and to address key issues of uncertainty[14] – in this case, uncertainty related to the home-based use of the Bandcizer™ system. The study investigated whether the exercise monitoring system could be used to record exercise dosage and pain, to test whether adolescents with patellofemoral pain perform their exercises as prescribed, and to test whether they report their adherence accurately in their exercise diary. This was tested among 20 adolescents with patellofemoral pain that were prescribed 6 weeks of exercises.

Participants, therapists, centres

Participants were recruited from upper secondary schools using a similar process to that described by Rathleff et al.[3] In short, adolescents in these schools answered an online questionnaire on musculoskeletal pain and if they reported knee pain, they were contacted by telephone and offered a clinical examination by a physiotherapist to determine the specific knee condition. As the present study was a feasibility study, no formal sample-size calculation was conducted. Twenty adolescents between 15 and 19 years of age with patellofemoral pain were included. Two were males and 18 were females. Their average age was 17 years (range 15 to 19), height was 167 cm (SD 6), weight was 60 kg (SD 8) and pain duration was 3.5 years (SD 1.4).

Inclusion criteria were: the insidious onset of anterior knee or retropatellar pain lasting > 6 weeks and provoked by at least two of the following activities – prolonged sitting, prolonged kneeling, squatting, running, hopping or stair climbing; tenderness on palpation of the patella; pain when stepping down or double-leg squatting; and worst pain intensity during the previous week of > 30 mm on a 100-mm visual analogue scale. Exclusion criteria were: injury to other areas of the body; pain in the hip, lumbar spine or other areas of the knee (eg, participants with Osgood-Schlatter disease or other knee conditions not related to patellofemoral pain would be excluded); previous knee surgery; self-reported patellofemoral instability; knee joint effusion; physiotherapy treatment for knee pain within the previous year; and weekly or more frequent usage of anti-inflammatory drugs.[3]

Intervention

Exercises

The description of the exercise intervention follows the Template for Intervention Description and Replication (TIDieR) checklist.[15] The exercise intervention lasted 6 weeks and covered three weekly exercise sessions (one group-based session at the local hospital and two sessions at home without supervision). The exercises were prescribed by two physiotherapy students under the supervision of a senior physiotherapist with 7 years of clinical experience in musculoskeletal physiotherapy. Before they prescribed the exercises to the participants, the physiotherapy students attended 2 hours of training on prescribing the exercises. The exercise program included three hip and one knee exercise with an elastic band. Participants were instructed to perform the exercises with a predefined time under tension (3 seconds concentric; 2 seconds isometric; 3 seconds eccentric; 2 seconds pause), equating to 80 seconds for 10 repetitions in a set, with a total of three sets prescribed. They were instructed to perform the exercises at 10 repetition-maximum and used exercises previously used for treating patellofemoral pain.[16] The exercises were: knee extension (loading from 90 deg flexion to full extension), hip external rotation (loading starting from 0 deg external rotation to full external rotation), hip abduction (loading starting from 0 deg hip abduction progressing to full hip abduction) and hip extension (loading starting from 20 deg hip flexion to full hip extension) (see Figure 1). During the supervised exercise sessions, the participants were repeatedly told that adherence was important and would improve their likelihood of recovery. During the supervised group sessions, the participants received instructions to ensure proper exercise form.

Equipment

The exercise monitoring system consisted of a Bandcizer™ attached to the elastic exercise band used to resist the exercises, connected via Bluetooth to the Bandtrainer app installed on an iPad tablet device (Figure 1). The University of Southern Denmark and the National Danish Partnership UNIK developed the Bandcizer™ and the Bandtrainer app. The Bandcizer™ consists of two connected parts that are mounted on either side of an elastic band, held together by internal magnets. The two parts form a sensor that measures deformation and, thereby, stretch of the elastic band. The measured data are transmitted via Bluetooth-4 low energy, directly to the tablet device.[11] The Bandtrainer app has an inbuilt visual analogue scale where users record their current knee pain intensity before and after each exercise set. The exercises are shown on the tablet and the participant selects which exercise they wish to perform by tapping on a picture of the relevant exercise (see screenshot in Figure 1). Both the Bandcizer™ and the tablet device need charging at least once every week.