Isometric Exercise to Reduce Pain in Patellar Tendinopathy In-Season; Is It Effective "on the Road?"

Ebonie Rio, PhD,*† Craig Purdam, M Sports Phys,*‡ Michael Girdwood, M Physio Prac,*† and Jill Cook, PhD*†

Abstract

Objective: To investigate the effectiveness of an isometric squat exercise using a portable belt, on patellar tendon pain and function, in athletes during their competitive season. **Design:** Case series with no requirements to change any aspect of games or training. The object of this pragmatic study was to investigate this intervention in addition to "usual management." A control or sham intervention was considered unacceptable to teams. **Setting:** In-season. **Participants:** A total of 25 male and female elite and subelite athletes from 5 sports. **Intervention:** 5 × 30-second isometric quadriceps squat exercise using a rigid belt completed over a 4-week period. **Main Outcome Measures:** (1) single-leg decline squat (SLDS)—a pain provocation test for the patellar tendon (numerical rating score of pain between 0 and 10), (2) VISA-P questionnaire assessing patellar tendon pain and function, and (3) self-reported adherence with completing the exercise over a 4-week period. **Results:** Baseline SLDS pain was high for these in-season athletes, median 7.5/10 (range 3.5-9) and was significantly reduced over the 4-week intervention ($P < 0.001$, ES r = 0.580, median change 3.5). VISA-P scores improved after intervention ($P < 0.001$, ES r = 0.568, mean change 12.2 ± 8.9, percentage mean change 18.8%, where minimum clinical important difference of relative change for VISA-P is 15.4%-27%). Adherence was high; athletes reported completing the exercise 5 times per week. **Conclusions:** This pragmatic study suggests that a portable isometric squat reduced pain in-season for athletes with PT. This form of treatment may be effective, but clinical trials with a control group are needed to confirm the results.

Key Words: patellar tendinopathy, in-season, pain, tendon, isometric

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INTRODUCTION

Patellar tendinopathy is prevalent in athletes who jump, land, and change direction[1] and most commonly presents as localized pain at the inferior pole of the patella.[2] There are currently few successful in-season loading protocols, as eccentric exercise that has been shown to be beneficial in several rehabilitation studies can be provocative when added to the already high loads during the competition season.[3,4] Few studies have investigated alternate modes of strength training. Heavy slow resistance (isotonic) and isometric exercise have been shown to reduce pain and allow continued sports participation with high adherence.[5,6] Isometric exercise has been shown to reduce patellar tendon pain immediately as well as immediately improve muscle performance, probably by reducing cortical inhibition.[7] The study by Rio et al[6] was a small controlled laboratory-based study that demonstrated efficacy but not effectiveness. From a practical perspective, reduction in inhibitory drive (and functionally an improvement in quadriceps maximal voluntary contraction) means that isometric exercise may have the potential to be used immediately before games and training sessions without causing deficits in muscle performance.

However, one of the challenges during the competitive season is access to strength training equipment when playing "away" or travelling because facilities may not be available. Rio et al[6] and van Ark et al[7] have previously investigated isometric quadriceps exercise using a weighted leg extension machine. Similarly, previous heavy slow resistance programs for patellar tendinopathy have used gym-based equipment.[5] Therefore, while strength training, and in particular isometric exercise has been shown to be beneficial in-season for patellar tendinopathy, it may not be feasible to complete regularly if equipment is not available.

The "Spanish squat or Catalan squat" is a bilateral quadriceps exercise completed with a portable wide rigid belt fastened around an immoveable object and the patient's lower legs.[8] This belted squat position has been previously investigated using the protocol of a 3-second eccentric contraction and a 3-second concentric contraction, with a 3-second isometric phase at the turn around phase in a study of 6 track and field athletes (triple and high jump).[8] The protocol used by Basas et al[8] also included electrical stimulation and was completed in the preseason, and data were reported every 6 months for 2 years.

For the current study, the squat from the study by Basas et al[8] was modified to be completed isometrically, that is a static squat hold, to align with research in PT demonstrating pain reduction following isometrics with particular

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*From the *The Australian Collaboration for Research in Injury and Its Prevention (ACRISP), La Trobe University, Bundoora VIC, Australia; †La Trobe Sport and Exercise Medicine Centre (LASEM), School of Allied Health, College of Science, Health and Engineering, La Trobe University, Bundoora, VIC, Australia; and ‡The Australian Institute of Sport, Physical Therapies Department, Bruce ACT, Australia.*

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Corresponding Author: Ebonie Rio, PhD, La Trobe Sport and Exercise Medicine Centre (LASEM), School of Allied Health, College of Science, Health and Engineering, La Trobe University, Bundoora, VIC, Australia 3086 (e.rio@latrobe.edu.au).

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application for in-season. It was also investigated because of its portability, as feedback from physiotherapists and patients reported that access to gym equipment was challenging, especially for sports that travelled interstate and internationally. Athletes have varied workloads, analgesic regimes, recovery habits, and gym programs; therefore, this study was designed to assess whether the addition of the isometric squat exercise had any benefit in a normal game and training environment, where nothing else was altered to examine true effectiveness. The aim of collecting adherence data was that it may infer whether the intervention was effective because it would be reasonable that a beneficial exercise would be more likely to be completed. Therefore, the aim of this study was to investigate the effect of an isometric squat exercise during the competitive season in elite and subelite athletes with PT over a 4-week in-season period. The clinically based outcome measures chosen to investigate the effect on patellar tendon pain, function, and record adherence were (1) patellar tendon pain [recorded as a numeral rating score 0-10 of pain during the single-leg decline squat (SLDS)], (2) patellar tendon pain and function (recorded as the score on the VISA-P tool, a questionnaire of patellar tendon pain and function), and (3) adherence (the number of times per week athletes reported completing the exercise).

METHODS

Participants

Men and women older than 18 years participating in elite or subelite sport were eligible to participate in this study. The inclusion criteria was a clinical diagnosis of PT (imaging not required) made by a physiotherapist, where (1) pain was reported to be localized to the inferior pole of the patella (does not move or spread) and (2) aggravated by patellar tendon energy storage and release activities such as jumping or fast change of direction[1] and (3) minimum of 2/10 pain on the SLDS test, a pain provocation test, where athletes report pain during the test based on an 11-point numerical rating scale (0-10). There were no restrictions regarding the minimum length of time of symptoms. Exclusion criteria included traumatic and nontraumatic knee pain other than PT.

Recruitment

Physiotherapists who work in sports where this condition has a greater prevalence—where fast change of direction and/or jumping is common including tennis, Australian football, basketball, and badminton—were approached. Physiotherapists received a pack outlining the inclusion and exclusion criteria, exercise protocol as well as a phone contact with the primary researcher. Basic anthropometric data were requested [height (cm), weight (kg), sex]. Data were returned directly to researchers.

Outcome Measures and Timeline

At baseline and each week for 4 weeks, the SLDS and VISA-P were completed. These outcome measures were chosen because they are quick, reliable, and valid[9,10] to reduce burden on both participant and physiotherapist. The VISA-P has a minimum clinical important difference (MCID) of relative change of 15.4% to 27% from the baseline score.[11]

Participants were encouraged to complete the rehabilitation exercise daily but were asked to record how often they completed it each week. They were also invited to provide additional comments. Athletes with patellar tendinopathy who did not wish to complete the squat were invited to provide SLDS and VISA-P data at the same time points as the intervention group to act as a control group.

Intervention

Athletes were advised to complete 5 repetitions of a 30-second double-leg squat using the rigid belt (Figure 1). No sham condition was offered because these athletes were in-season, had pain, and were looking for symptom relief. Furthermore, 2 sports advised that they would not provide assent for their athletes to be approached or support the study if there was a sham treatment offered. These restrictions limited the study to a case series design for feasibility of completion of the study (with the design allowing for opportunity of a control group providing data at the same time points but without the isometric squat intervention).

Figure 1. The double-leg isometric squat utilized in the current study.

The instructions were to position the belt around a sturdy pillar. The belt was long, so any size pillar/pole could be used. Athletes were told to wrap the belt as many times around pillar as needed so that when they stepped 1 leg inside each loop; the belt was around upper calf (not popliteal fossa) and toes against pillar as shown. Participants were instructed to place their legs inside each loop, with toes positioned against a pillar to stop any sliding. They were asked to make sure that the loops were even. Athletes were instructed to squat back as deep as possible, keeping their spine upright, and not to lean forward. It should be noted that the belt used was a continuous loop because a seatbelt with buckle was considered to be a safety risk. Two pictures are provided, demonstrating different depths but a straight spine with green ticks to indicate acceptable positions. An additional picture demonstrating the athlete leaning forward (thus unloading their quadriceps) is provided with a red cross indicating ineffective position.

Statistical Analysis

Where athletes reported bilateral symptoms, a coin toss was used to select the side that was included for analysis. De-identified data were entered in Microsoft Excel, and participant data order randomized so that SLDS and VISA-P data were independently analyzed, blinded to the other outcome measure. Data were presented as median and range inter-quartile range (IQR). Single-leg decline squat and VISA-P scores were analyzed using repeated-samples Wilcoxon Signed-Rank tests, with the alpha level set at 0.05, and effect sizes calculated post hoc. All participant data were included, and missing 4-week data were analyzed using the baseline score of SLDS or VISA-P carried forward. Reasons for drop outs were also explored.

RESULTS

A total of 25 participants (mean height 1.82 ± 0.11 m and body mass index 23.04, 6 women) returned signed consent forms during the recruitment period from 2014 to 2017 from 5 sports (national Australian football, national level squash, dance and volleyball, and world ranked tennis). Athletes reported completing the exercise median 5 times per week in those that returned adherence data (n = 23, range 4-7).

For SLDS data, 2 athletes did not provide baseline or 4-week follow-up; thus, 23 athletes were included in analysis for SLDS. Missing 4-week SLDS (n = 3) where baseline SLDS data were provided were given a change score of zero (these athletes had baseline SLDS pain of 6, 7, and 8/10). All participants provided baseline VISA-P, and 4 athletes did not return 4-week VISA-P data, thus were given a change score of zero for VISA-P (baseline VISA-P were 63, 64, 66, and 48). All athletes except 2, returned either SLDS or VISA-P data, or both, at 4-week follow-up, thus only 2 athletes were lost to follow up. Both participants who dropped out of the study (defined as no 4-week data at all) were women.

Single-Leg Decline Squat

Tendon pain measured on the SLDS was significantly reduced during the 4-week intervention ($P < 0.001$, effect size [ES] r = 0.580, median change 3.5, Figure 2). This represents an average reduction in pain of 49% of their baseline pain and a clinically important change.

VISA-P Questionnaire

VISA-P scores improved at the end of the intervention [$P < 0.001$, ES r = 0.568, mean change 12.2 ± 8.9, percentage mean change 18.8% (MCID of relative change for VISA-P is 15.4%-27% from baseline score)].

DISCUSSION

This study demonstrates that a simple, double-leg isometric squat exercise using a portable rigid belt reduced patellar tendon pain in a real world sporting environment across different sports. These results have immediate clinical applicability for athletes' in-season, where there is a dearth of loading protocols to reduce patellar tendinopathy [PT] pain and enable continued sports performance.

Nineteen of the 25 participants recruited were men supporting previous literature that PT is predominantly

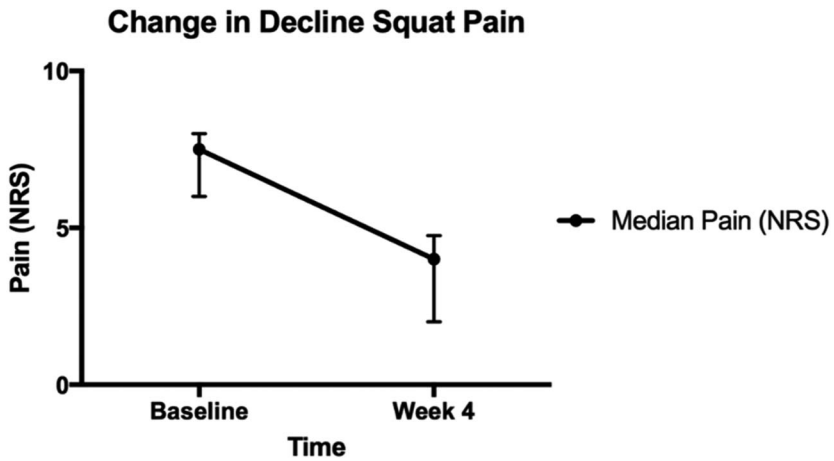

Figure 2. Median change in single-leg decline squat pain over 4-week intervention (median and IQR).

a condition of male athletes[1] and in fact more common in those with better jumping ability.[12] Furthermore, 2 female athletes were lost to follow up; 1 athlete retired but reported "pain in the whole front of the knee"; and 1 athlete cited "knee swelling." The patellar tendon is extra-articular; thus, one may question whether the patellofemoral joint was involved in these pain presentations rather than tendinopathy because tendinopathy is not associated with joint swelling or diffuse anterior knee pain. As imaging was not performed for clinical diagnosis, it is plausible that other knee pathologies were included especially in this instance where participants provided reasons for drop out. However, as imaging does not correlate with tendon pain,[13] imaging may not have been helpful. As there were only 2 drop outs, it is difficult to infer clinical implications; however, it is possible that the isometric squat exercise may provoke symptoms in those people with vague pain or knee swelling. Other conditions of the anterior knee, such as patellofemoral joint pain may be aggravated by the position, given the retro-patellar forces in closed kinetic chain squatting.[14] Furthermore, the SLDS will actually provoke different types of anterior knee pain, given the patellofemoral forces.[15] Future studies aiming to investigate responders and nonresponders should consider providing clinicians with a short video demonstration of assessment to ensure uniformity (and identify features of these subgroups).

There were limitations in this study. It was not possible to recruit a control group within the athlete population approached because all athletes chose to receive the intervention. However, the natural history of PT is that it does not seem to improve in-season even with cointerventions such as anti-inflammatory medication.[4] Given the complexities of performing research in an elite environment (eg, international tennis athletes with various support staff and their full-time occupation), the study design was very much dictated by the clinicians and staff managing these athletes and providing these data. There was substantial planning around study design with team executives, administrators, and physiotherapists, and a randomized trial was considered unacceptable to sports, as was a sham intervention. Future studies may consider intervening in a nonelite population that may have the potential for a control group design. Athletes were likely to have been receiving cointerventions; however, there are a lack of data supporting the effectiveness of other interventions in-season, thus a pragmatic decision was made to not alter any aspects of management—this was to promote support for the study within sports and athletes and maximize clinical applicability to the real world, where athletes are receiving cointerventions. No athlete had any injections during the study period. There were also sources of bias—athletes are more likely to return data if they have had a good result. However, this may also be inferred as a strength of the protocol because only 2 were lost to follow up. It is also possible that athletes and physiotherapists were likely to expect a positive result, given the instructions provided.[16] It is possible that positivity alone would provide sufficient placebo effect to drive the magnitude of improvements in patellar tendon pain and function; therefore, in combination, this study provides support for combining both an effective intervention with positive expectations.

The intervention consisted of 5 × 30-second isometric double-leg squat holds, and this protocol represents less time under tension than other published isometrics studies demonstrating an effect.[6,7] This is because the current study was commenced before the pilot testing by Rio et al.[6] It is possible that the results from this current study protocol could be improved by increasing the time under tension to 5 × 45 seconds or alternatively the shorter duration was more acceptable to athletes and demonstrated effectiveness. Further studies should aim to identify the optimal exercise protocol; however, it is likely to be highly individual, and based on clinical decision-making around the athletes capabilities including muscle strength. One advantage of the bilateral isometric squat exercise is the ability to modify depth based on individual capabilities.

Clinical Perspective

This study demonstrates that an isometric squat exercise offered in-season in athletes with localized inferior pole pain, has good adherence and reduced pain across different sports and schedules. Although it would not replace a comprehensive rehabilitation that includes progressive strength, energy storage, and release activities then sports-specific function (reserved for the off-season),[17] it does provide clinicians with a practical in-season option, given the challenges around time, pain, equipment, and the inability to complete thorough rehabilitation during the competitive season. Further given that the exercise is easy to perform and requires minimal equipment, it may be useful to clinicians and patients who do not have access to specialized equipment. This isometric squat exercise may be especially beneficial for sports in which travel schedules limit access to more conventional means of knee extensor resistance exercise.

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