Adding Muscle Power Exercises To A Strength Training Program For People With Patellofemoral Pain: Protocol Of A Randomized Controlled Trial

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Abstract

Background: Strong evidence supports the proximal combined with quadriceps strengthening for patellofemoral pain (PFP) rehabilitation. However, most reported rehabilitation programs do not follow specific exercise prescription recommendations or do not provide adequate details for replication in clinical practice. Furthermore, people with PFP have power deficits in hip and knee muscles and remains unknown whether the addition of power exercises would result in superior or more consistent outcomes. Therefore, this study is designed to verify whether the benefits of a rehabilitation program addressing proximal and knee muscles composed by power and strength exercises are greater than those of a program composed by strength exercises only.

Method: This study will be a randomized controlled trial, that will be conducted at university facilities. A minimum of 74 people with PFP between the ages of 18 and 45 years will be included. The experimental group will engage in a 12-week resistance training program focusing on proximal and knee muscles using power and strength exercises. The control group will engage in a 12-week resistance training program focusing on proximal and knee muscles using strength exercises only. Primary outcomes will be pain intensity and physical function; and secondary outcomes will be kinesiophobia, self-reported improvement, quality of life, peak hip and knee torque, and hip and knee rate of force development. The primary outcomes will be evaluated at baseline, and after six weeks, twelve weeks, three months, six months and one year. The secondary outcomes will be evaluated at baseline and immediately after the interventions. Therapists and participants will not be blinded to group allocation.

Discussion: This randomized clinical trial will investigate if adding power exercises to a progressive resistance training may lead to more consistent outcomes for PFP rehabilitation. The study will provide additional knowledge to support rehabilitation programs for people with PFP.

Trial registration: ClinicalTrials.gov NCT 03985254. Registered on 26 August 2019.

Introduction

Patellofemoral pain (PFP) is characterized by retropatellar and/or peripatellar pain that is aggravated during activities that increase the patellofemoral joint loading (e.g., squatting and ascending/descending stairs) [1], with an annual prevalence in the general population of around 22.7% [2]. Although PFP was previously considered as a self-limiting condition, recent studies suggest that alterations and symptoms may persist for several years [3–5]. Chronic pain associated with PFP has a negative impact on the level of physical activity and quality of life, interfering with work, activities of daily living and physical exercise [5–7].

Previous studies reported that people with PFP have decreased strength in hip [8, 9] and knee muscles [10, 11]. Additionally, other parameters of hip and knee muscle capacity seem to be altered in people with PFP, such as rate of force development (RFD) and power [12–15]. Therefore, exercise therapy addressing these deficits may be important for PFP rehabilitation. Some studies reported the effects of rehabilitation

programs for PFP patients focused on proximal muscles combined with quadriceps strengthening [16–23]. Two systematic review concluded that the combination of proximal and quadriceps rehabilitation results in greater benefits on pain intensity and physical function compared to isolated quadriceps rehabilitation [24, 25]. Nowadays, the combination of proximal and quadriceps rehabilitation presents the best evidence level for pain reduction and physical function improvement for PFP rehabilitation [26]. Although the improvement in pain and physical function, it is unclear the effects of resistance training on other characteristics seen in people with PFP such as kinesiophobia, quality of life and catastrophization [27–30].

According to the American College of Sports Medicine (ACSM), to achieve sustained improvements in muscle capacity, specific evidence-based guidelines must be followed, such as load progression, number of sets and repetitions, time to rest, weekly frequency and duration of this training [31, 32]. In the systematic review by Lack et al. [24], the included studies evaluated the effects of resistance training targeting proximal muscles of people with PFP. After further analysis using the ACSM criteria, the authors concluded that three out of 14 studies actually incorporated protocols which could evoke improvements in muscle strength [18, 21, 22]. However, none of the included studies completely accomplished the ACSM guidelines for structural strength gains (more than 8 weeks), as the protocols lasted four [18, 21] to eight weeks [22]. Additionally, according to Lack et al. [24], only one study included power exercises [33], even though the exercise protocol was not clearly described for replication in clinical practice or research. This is a common issue among PFP randomized controlled trials highlighted in the systematic review by Holden et al. [34]. The systematic review included 38 studies and the authors concluded that exercise prescriptions are poorly described which prevents the implementation in clinical practice.

Although the hip and knee strength exercises present the best evidence level for pain reduction and physical function improvement in people with PFP [24–26], little is known in relation to their long-term effects. To date, only the study by Fukuda et al. [21] investigated the exercise long-term effects (12 months) and the study reported that hip and knee strength exercises result in greater benefits on pain intensity and physical function compared to quadriceps strengthen alone. However, rehabilitation programs with exercises that correct other muscle capacity deficits, such as muscle power, can result in superior or more persistent benefits than those with only strengthening exercises. More recently, Barton et al. [30] demonstrated that a 12-week progressive resistance training program (hip and knee strength and power exercises) is feasible and is associated with improvements in pain, physical function and muscle capacity (strength and power) in people with PFP. Nonetheless, it is unknown whether the benefits of a proximal combined with quadriceps rehabilitation composed by power and strength exercises are greater than those of a proximal combined with quadriceps rehabilitation composed by strength exercises only.

To improve the knowledge regarding the effects of muscle power exercises on PFP rehabilitation, the primary study aim will be to verify if the addiction of power exercises to a strength training program addressing proximal and knee muscles provides better outcomes (pain relief and physical function improvement) for rehabilitation of people with PFP compared to a strength training program only, in the short, medium and long term. The secondary aim will be to compared both programs regarding

kinesiophobia, self-reported improvement, quality of life and muscle capacity (peak hip abduction and extension torque, and peak knee extension torque; hip abduction and extension RFD, and knee extension RFD). The hypothesis of the study is that people with PFP undergoing the proximal combined with quadriceps rehabilitation composed by power and strength exercises will provide a superior improvement to the evaluated outcomes when compared to people undergoing the proximal combined with quadriceps rehabilitation composed by strength exercises only.

Methods

Trial Design

This is a randomized controlled trial. The study will be developed in six stages, according to the Fig. 1. The baseline assessment will consist of evaluating anthropometric and demographic data, in addition to pain intensity, physical function, kinesiophobia, quality of life and muscle capacity. After one week, the intervention phase will be initiated, which will consist of two different intervention protocols for 12 weeks, according to the group allocation. Six weeks after starting the intervention, the intensity of pain and physical function will be assessed. At the end of the intervention protocols, the participants will be evaluated for pain intensity, physical function, kinesiophobia, quality of life, muscle capacity and self-reported improvement. After three months, six months and one year, participants will be re-evaluated for pain intensity and physical function through online questionnaires. The lower limb of the affected side will be assessed. In cases of bilateral symptoms, the more painful lower limb will be assessed [12].

The study will be conducted at Laboratory of Evaluation and Intervention in Orthopedics and Traumatology (LAIOT) of the Federal University of São Carlos (UFSCar), São Carlos, São Paulo, Brazil; and will follow the CONSORT guideline [35] and the TIDieR checklist to describe the interventions [36]. The present protocol was reported according to SPIRIT guideline [37].

Ethics

The research was approved by the Ethics and Research Committee of University (CAAE: 12417019.8.0000.5504). Each participant will receive explanations regarding research objectives, anonymity of their data, and freedom to participate. Participants will sign Informed Consent Term (ICT). This study will respect the ethical precepts of Resolution CNS 510/2016 and be performed according to the Declaration of Helsinki. It was registered in ClinicalTrials.gov, on 26 August 2019, under number ID: NCT 03985254.

Participants and setting

Potential participants will be recruited from the community, gyms or social media; and a minimum of 74 participants will be included in the study. A researcher will perform a preliminary screening of the eligibility criteria and will explain the study procedures during a telephone call. If the potential participants likely fulfill the inclusion criteria and declare their agreement to participate, the diagnosis of PFP will be confirmed by a physiotherapist through a physical examination [38]. This physiotherapist (BCL) will

explain the study procedures and will obtain written consent from patients willing to participate in the trial.

To be included, the participants should meet the following inclusion criteria: (i) men and women affected by PFP (unilateral or bilateral) aged between 18 and 45 years; (ii) insidious onset of symptoms unrelated to a traumatic event; (iii) presenting retropatellar or peripatellar pain (3/10 points according to the visual analog scale - VAS) in at least two of the following functional activities: stair negotiation, running, kneeling, squatting, sitting for long periods, or jumping; and (iv) presence of pain for at least two months [17]. The exclusion criteria will be history of surgery to the knees; history of injury or pain in the hip; patellar instability; pain on palpation of the patellar tendon, iliotibial band, Hoffa fat, pes anserinus tendons or knee joint line; signs or symptoms of meniscal or ligamentous knee injuries; presence of Osgood-Schlatter or Sinding-Larsen-Johansson syndrome; and any vestibular, neurological or musculoskeletal alterations that interfere with or contraindicate the measurement procedures of this study [22, 39].

Sample size

The sample size of this study was calculated considering a statistical power of 80%, alpha of 5% and an estimated 15% of sample losses. In order to detect a 2-point difference in pain NRS [40] with a standard deviation of 2.8 points [41], a sample size calculation indicated 37 participants in each group.

Randomization and allocation

Participants will be randomized to the Strength Training Group (STG) or to the Power and Strength Training Group (PSTG). Randomization will be performed using consecutively numbered, sealed and opaque envelopes previously prepared and randomly assigned by a random number generator program (www.randomization.com).

A researcher not involved in the assessment process will perform the randomization and participant allocation to the groups by opening the envelopes after the baseline evaluation.

Interventions

Participants from both groups will perform the supervised training program three times per week for 12 weeks, with at least 24 hours interval between intervention sessions. No instruction for home exercise will be given. Participants will be instructed to maintain their physical and sports activities.

The duration of each session for the STG will be around 60 minutes and for the SPTG around 75 minutes. All sessions will be supervised by an experienced physiotherapist (> 5 years). The description of the exercises has been made simple and clear, so physiotherapists will need minimal training to apply the exercises (Appendix A – supplementary material).

The STG and SPTG programs will be based on the training principles recommended by the American College of Sport Medicine (ACSM) [32]. The exercises were chosen based on a study that successfully applied the protocol to people with PFP [30] and other strength training studies [22, 42–45].

To perform the exercises, ankle weights, free weights and/or dumbbells, and elastic bands will be used. The load to be used in the exercises of both groups will be determined based on the 10RM (repetition maximum) test to estimate the 1RM - the 10RM load indicates approximately 75% of the 1RM load [46]. As the participants have PFP, the 1RM test could exacerbate the symptoms. For exercises using an elastic band, the 1RM test will be performed. The 1RM will be considered the highest elastic band (considering the color of the elastic) which the participant can perform a single repetition [22].

Regarding pain management during exercise, a level equal to or lower than three points in VAS will be accepted; and if any participant presents pain above this level, the exercise will be modified according to the variations that are also in the exercise protocol (Appendix A). In addition to pain management, the presence of muscle failure will also be monitored. Exercise will be interrupted if muscle failure occurs, which will be considered as the participant's inability to move a specific load beyond a critical joint angle [47] or as the inability to complete a repetition in the stipulated range of motion due to fatigue [48].

As an adherence strategy to keep participants attending to training sessions, both groups will receive face-to-face education sessions about possible causes and consequences of PFP, pain management, importance of physical activity for the treatment and other questions that may arise during the intervention period. In addition, telephone contacts will be made to remind participants about the sessions. The intention is that the participants feel part of the treatment, understand how the intervention can help them and, thus, attend the intervention sessions [49].

Strength Training Group (STG)

The strength training program will consist of applying resistance and progressive exercises for strength gain. Initially, the goal will be the development of neuromotor control and endurance (load < 50% 1RM), and in subsequent weeks the goal will be to develop muscle strength (load > 70% 1RM) (Fig. 2). The protocol will initially focus on hip and trunk muscles and after four weeks of training, knee muscles exercises (weight-bearing or non-weightbearing) will be included.

At each training session, at least five exercises (out of a total of 15 exercises) will be chosen and applied by the therapist. From these five exercises, one will be for hip extensors, one for hip abductors, one for knee extensors, and two for the trunk. Appendix A provides a complete description of all exercises that may be applied to participants. According to the evolution of the participants, regarding pain and ease of execution, the therapist will perform the progression of the loads and even the substitution of one exercise for a more complex one as long as it is one of the program exercises.

Power and Strength Training Group (PSTG)

Participants assigned to this group will perform the same exercise program as the STG and power training exercises (fourth column of Appendix A). Initially, the focus will be on neuromotor control and resistance development (load < 50% 1RM). After, the goal will be to develop strength (load > 70% 1RM) and muscle power (load between 40–60% 1RM) (Fig. 3).

Outcome Measures

Primary outcomes will be pain intensity and physical function; and secondary outcomes will be kinesiophobia, self-reported improvement, quality of life, peak hip and knee torque, and hip and knee rate of force development. The primary outcomes will be evaluated at baseline, and after six weeks, twelve weeks, three months, six months and one year. The secondary outcomes will be evaluated at baseline and immediately after the interventions.

Pain intensity

Pain intensity will be measured using the Numeric Rating Scale (NRS-11), where 0 represents “no pain” and 10 represents “the worst pain possible”. Participants will indicate their usual pain and worst pain during the past week [40].

Physical function

The Anterior Knee Pain Scale (AKPS), translated and validated into Portuguese [50] will be used to assess subjective symptoms such as anterior knee pain and functional limitations related to PFP. The items evaluated in the questionnaire are patellar subluxation, limp, pain, walking, climbing stairs and sitting for a long time with bent knees. It has a score from 0 to 100 points, where 100 means no pain and/or functional limitations and 0 means constant pain and various functional limitations [51]. The AKPS is a reliable and valid instrument for assessing function in individuals with PFP [40].

Kinesiophobia

The evaluation of kinesiophobia will be performed by the translated and validated Portuguese version of the Tampa Scale for Kinesiophobia questionnaire [52], which consists of 17 items that assess fear of movement, injury or recurrence of injury [53]. This questionnaire is a four-point Likert scale, where the sum of the answers can vary from 17 to 68, and scores higher than 37 indicate the presence of kinesiophobia [54].

Quality of Life

Participants will be assessed using the specific subscale for quality of life assessment of Knee Injury and Osteoarthritis Outcome Score (KOOS). This subscale comprises four questions and each one will be scored from 0 to 4, where 0 represents extreme knee problems and 4 that there are no knee problems. The sum of these questions will be used for further analysis [55, 56].

Muscle Capacity

Isometric torque and RFD of knee extensors, hip extensors and abductors will be evaluated using an isokinetic dynamometer (Biodex Multi Joint System 3, Biodex Medical Systems Inc., New York, USA), with a sampling frequency of 100 Hz.

- Knee extensors: the participants will be placed in a sitting position with hips at 85 degrees of flexion and neutral position for transversal and frontal planes, and the knee of the assessed limb at 60 degrees of flexion [13]. The resistance pad will be fixed with a velcro strip just above the lateral malleolus and the rotation axis of the dynamometer will be aligned with the lateral femoral epicondyle.

- Hip extensors: the participants will be in prone position on the testing table of the dynamometer, with their legs out of the table. The assessed lower limb will be placed with the hip at 30 degrees of flexion and the participants should keep the knee at 90 degrees of flexion and avoid hip rotations during the test. The resistance pad will be fixed with a velcro strip just above the popliteal fossa and the rotation axis of the dynamometer will be aligned with the center of the hip joint in the sagittal plane near the greater trochanter of the femur [12, 57].

- Hip abductors: the participants will be placed in side-lying position with the top leg being the assessed side. The assessed hip will be in neutral position for all three planes, the knee will also be in neutral position, and the participants will be instructed to keep their toes pointed forward and not to bend the knee during the test [58]. The resistance pad will be fixed with a velcro strip 5 cm above the upper edge of the patella and the rotation axis of the dynamometer will be aligned to a point representing the intersection of two lines: one line directed inferiorly from the posterior superior iliac spine towards the knee, and the other line oriented medially and posteriorly to the greater trochanter of the femur toward the midline of the body.

For all the assessment, the participants should perform the contraction as powerfully and as quickly as possible and maintain the contraction for five seconds. For each assessed muscle group, three maximal contraction will be collected with a 1-minute interval between them. The participants will be verbally encouraged to achieve maximum power during all contractions. Previously the data collection, the participants will familiarize with the tests by performing two submaximal contractions and one maximal contraction. A three-minute interval will be adopted between familiarization and data collection. Isometric torque measures will be normalized by body mass (Nm/kg × 100) and the highest value of the three repetitions will be used for statistical analysis for each muscle group [12].

A test-retest reliability study will be conducted to verify intra-examiner reliability of measurements by evaluating 10 participants in two moments, with an interval of 3 to 7 days.

To calculate the RFD, the highest value of the three repetitions for each muscle group will be used [12]. The normalized torque data will be exported and processed in the Matlab Software (Mathworks, Natick, Massachusetts, USA, version 2008b). RFD will be calculated using the slope of the torque/time curve. The slope will be obtained by dividing the variation of the normalized torque (Nm/Kg X 100, represented as %) by the time variation (ms) from the start of the contraction until 30% and 90% of the maximal isometric

torque [59, 60]. The beginning of the contraction will be defined as the moment when the isometric torque exceeds 2% of the peak torque [61]. Thus, higher RFD values indicate an increased ability to generate force rapidly [62].

Self-Reported Improvement

The self-reported improvement with reference to the start of the study will be quantified using the Global Rating of Change (GROC). This tool is a 15-point Likert-type scale that measures a patient's perception of a change in knee pain following a specific treatment [63]. The scale ranges from − 7 (a very great deal worse) to + 7 (a very great deal better), with 0 (zero) indicating no change. Changes of 4 points or more on this scale have been previously considered as clinically important in patients with knee pain [64].

Blinding

The researcher in charge for the evaluations and the data processing will be blinded to the group allocation. Participants and the therapist will not be blinded to the group allocation due to the differences between of our interventions which are easily detectable.

Minimizing missing data

In order to avoid and minimize missing data, as an adherence strategy to keep participants attending to training sessions, both groups will receive face-to-face education sessions about possible causes and consequences of PFP, pain management, importance of physical activity for the treatment and other questions that may arise during the intervention period. In addition, telephone contacts will be made to remind participants about the sessions and the evaluations. Regarding the 3 month-, six month- and one-year follow-ups, the researcher will contact the participant by telephone and send online questionnaire.

Data management

Data are being collected at Laboratory of Evaluation and Intervention in Orthopedics and Traumatology (LAIOT) of the Federal University of São Carlos (UFSCar). Data will be stored in the Physical Therapy Department at UFSCar with a password-protected computer file, to which only researchers will have access. The main researcher will have a backup copy of all the information.

The study results will be released in conferences, such as scientific conferences, internationally and nationally, and through articles published in peer-reviewed journals. This research is a part of a PhD thesis, and the publishing rights are owned by the authors. The results will be frequently presented to the supervising professor (FVS).

Data monitoring

Researchers will monitor participants throughout the study development. Adverse events during the study procedures, either during evaluations, interventions or follow-up, will be registered and reported. Adverse events will be considered any symptom or disease that is related or not to the evaluations and the intervention.

The University Post Graduate Program will supervise for the integrity of the data, and the responsible Internal Data Monitoring Committee will have access to the patient allocation, while the whole analysis will be confidential.

Harms

Participant data will be carefully accessed and all harms and complications of the treatment will be reported together with the other results of this trial, if any.

Auditing

The University Post-Graduate Program will supervise the integrity of the data.

Statistical analysis

The intention-to-treat approach will be applied for all analyses [65]. The differences from baseline will be used in the analysis. For pain and function outcomes, analysis of variance with a linear model will be used to compare the groups in six different time points (baseline, six weeks, twelve weeks, and three months, six months and one-year post-interventions). For quality of live, kinesiophobia, and muscle capacity (hip and knee torque; hip and knee RFD) outcomes, independent t tests will be applied to compare the groups. For GROC outcome, the reference criterion of treatment success will be a score of + 6 (much improved) or higher and these data will be presented as a percentage. Mean difference and 95% CI will be also calculated for each comparison. In cases of missing data, multiple imputation method will be applied to impute missing values [66], and per-protocol analysis will be also performed. The significance level will be 0.05. All the statistical analysis will be performed using a Statistical Package for the Social Sciences software program (version 20.0, SPSS, Inc., Chicago, IL, USA) and the researcher who will perform the analysis will be blinded to the group allocation.

Interim analyses will not be performed. No additional analyses will be performed in the trial.

Discussion

Knee pain is the second most prevalent condition, in which PFP is considered one of the most common forms of knee pain [67]. People with PFP have decreased hip [8, 9] and knee muscles strength [10, 11] and, as a result, many studies focused on improving these deficits [16–23]. According to the latest PFP consensus [26], the proximal combined with quadriceps strengthening is the physiotherapeutic procedure that has the best evidence for pain reduction and function improvement in PFP patients.

Moreover, people with PFP present other proximal and knee muscle capacity deficits, such as rate of force development (RFD) and power [12–15]. Nunes et al. [12, 13] reported lower hip abductor and extensor, and knee extensor rate of force development (RFD) during maximal isometric contraction in women with PFP compared to women without PFP. Similarly, according to the study by Ferreira et al. [15], women with PFP have lower hip abductor and knee extensor RFD during isometric, concentric and eccentric

contractions compared to women without PFP. Finally, using a linear position transducer, it was found that people with PFP had deficits of 31% and 29% in hip abductor and extensor power, respectively [14].

Although these recent studies have shown that patients with PFP have hip and knee muscle power deficits [12–15], little is known in relation to power training effects in these people. Until the moment, only two studies included power exercises for the treatment of these patients [30, 33]. Nevertheless, Tyler et al. [33] did not adequately describe which power exercises were applied and Barton et al. [30] did not have a comparator group (isolated muscle strength protocol) to clarify whether adding power exercises to a strength training protocol results in greater benefits than muscle strength training alone.

In addition to these problems, other are identified in previously published studies with interventions for PFP. For example, the vast majority of them did not follow ACSM recommendations aiming to gain muscle strength (load progression, number of sets and repetitions, time to rest, weekly frequency and duration of this training) [24]. Another problem, presented in the systematic review by Holden et al. [34], is that they were not clearly described (exercise prescriptions), making it difficult to apply them in clinical practice. And these problems can interfere with long-term results.

Therefore, this study will be the first clinical trial to compare the effects of adding power exercises to strength training with an isolated strength training program. And also, if these effects will be more lasting than those of isolated strength training. The protocols will follow ACSM recommendations and will be described in detail to facilitate applications in clinical practice, and that could be favor long-term benefits.

In relation to benefits, hip and knee strength training alone is able to improve pain and physical function in people with PFP [24–26], but only one study has evaluated long-term effects [21]. Adding power exercises to a strength training can promote more consistent results in people with PFP. And, it is possible that these results will be more lasting than those of strength training alone (12 months).

Trial Status

This trial is currently recruiting patients, the first patient was included in 12 August 2019 and is on original version. To date, we have enrolled 37 study participants who have completed treatment, assessments, and follow-ups. We predict that recruitment will be completed in December 2021. Although existing data are being entered, no analysis has yet been performed.

Declarations

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Contributions

GSV, GSN and FVS conceived of the study. BCL and RFM performed the assessment. GSV, GKP and MECBS were responsible for the interventions. GSV, GSN and FVS were responsible for paper writing. CJB critically reviewed the paper. All authors have read and approved the final manuscript and agreed to be accountable for all aspects of the work.

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Ethics declarations

Ethics approval and consent to participate

The study was approved by Ethics and Research Committee of University (CAAE: 12417019.8.0000.5504). Each participant will receive explanations regarding the study development. Participants will sign two copies of the Informed Consent Term (ICT), one copy will be with volunteer and another with researcher. All collected data will be held confidential.

Any modification in study objectives, study design, study procedures, participant population, sample size, or significant administrative aspects will lead to a change in the study protocol. It will be under the supervision of the supervisor professor (FVS) and approved by the Ethics Committee of University prior to implementation.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Availability of data and materials

The dataset(s) supporting the conclusions of this article are available upon request from authors.

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Figures

	STUDY PERIOD							
	Enrolment	Allocation	Post allocation (12-week intervention)					Close-out
TIMEPOINT	*Prior randomization*	*0*	*Baseline*	*6 weeks*	*Post intervention*	*3-month follow-up*	*6-month follow-up*	*12-month follow-up*
ENROLMENT:								
Eligibility screen	X							
Informed consent	X							
Allocation		X						
INTERVENTIONS:								
Strength Training			←	—	→			
Strength and Power Training			←	—	→			
ASSESSMENTS:								
Pain Intensity			X	X	X	X	X	X
Physical Function			X	X	X	X	X	X
Kinesiophobia			X		X			
Quality of Life			X		X			
Isometric Peak Torque			X		X			
Rate of Force Development			X		X			
Self-Improved Perception					X			

Figure 1

Participant timeline: schedule of enrolment, interventions and assessments.

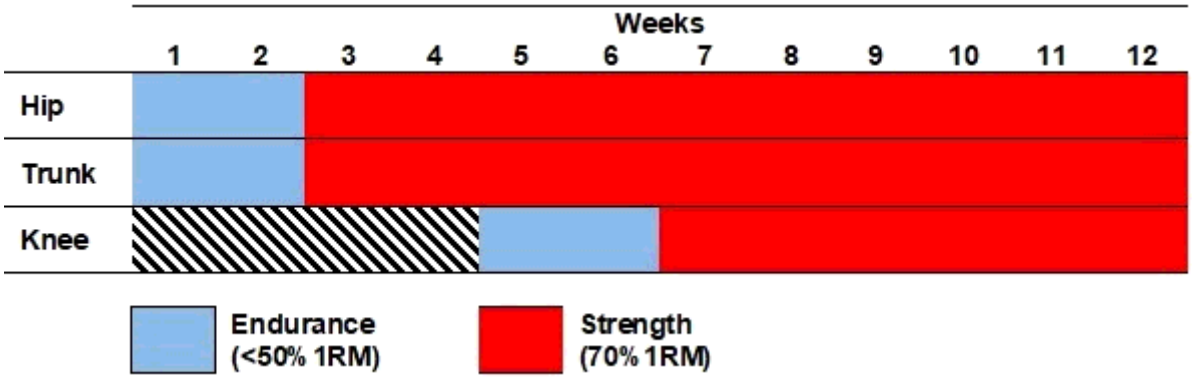

Figure 2

Strength Training Group (STG) schedule.

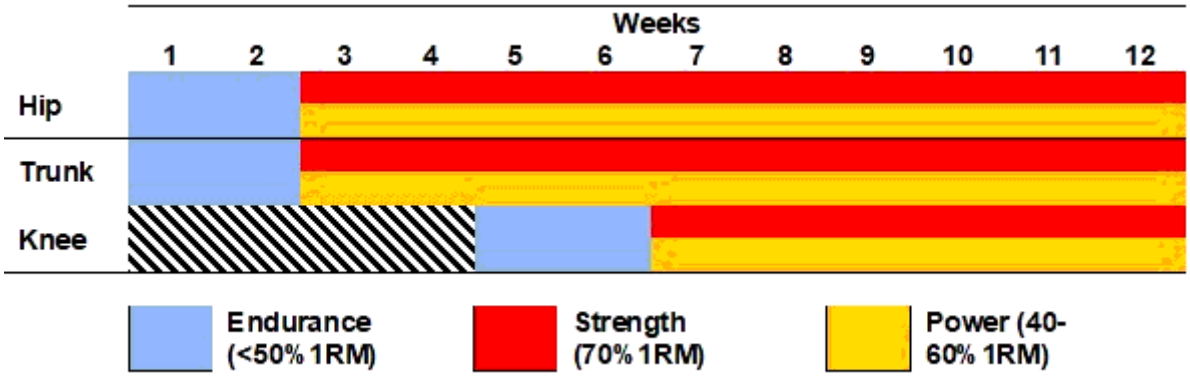

Figure 3

Power and Strength Training Group (PSTG) schedule.

Supplementary Files

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- AppendixA.pdf
- SpiritChecklist.doc