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The Effectiveness of Polarized Polychromatic Noncoherent Light (Bioptron light) and a Supervised Exercise Program on Pain and Disability in Chronic Patellar Tendinopathy: A Case Report

Stasinopoulos Dimitrios*

Department of Physiotherapy, University of West Attica, Greece

Abstract

Eccentric exercises are not effective for all patients with chronic patellar tendinopathy (CPT). The present case report aims to present the effect of the Bioptron light combined with an exercise programme on pain and disability in a patient experiencing CPT. A patient with unilateral CPT for 8 months was included in the present report. The patient followed a supervised exercise program five times per week for 6 weeks consisting of eccentric-concentric training, isometric contraction, simple lumbo-pelvic control exercises and static stretching exercises of hamstrings and quadriceps. The programme was individualized based on the patient's description of pain experienced during the procedure. Bioptron light was applied twice, once before and once after the exercise programme for 10 minutes each time. The patient was evaluated using the VISA-P questionnaire, the pain pressure threshold (PPT) and the strength of knee extensor at baseline, at the end of treatment (week 6), and 1 month (week 10) after the end of treatment. At the end of the treatment and at the follow-up there was a decline in pain and a rise in function. The results of the present trial suggest that the bioptron light combined with an exercise programme consisting of eccentric-concentric training, isometric contraction, simple lumbo-pelvic control exercises and static stretching exercises of hamstrings and quadriceps can produce significant improvements in terms of pain and disability in CPT.

Keywords: Patellar tendinopathy; Exercise; Stretching; Jumper's knee

Introduction

Chronic Patellar Tendinopathy (CPT) commonly referred to as Jumper's knee is the most common tendinopathy in the knee area. It is a degenerative condition and not an inflammatory one. Pain and decreased function are the main symptoms of CPT. Diagnosis is simple and the symptoms are reproduced by [1] lower limb activities such as squat or hop; [2] palpation on the site of pain (mainly at the inferior pole of the patella) and [3] clinical tests such as decline test [1].

No ideal treatment has emerged for the management of CPT. Many clinicians advocate a conservative approach [1] and physiotherapy is usually recommended [2]. A wide array of physiotherapy treatments has been recommended for the management of CPT such as electrotherapeutic/physical modalities, exercise programmes, soft tissue manipulation, and manual techniques [3]. These treatments have different theoretical mechanisms of action, but all have the same aim, to reduce pain and improve function. Such a variety of treatment options suggests that the optimal treatment strategy is not known, and more research is needed to discover the most effective treatment in patients with CPT.

One of the most common physiotherapy treatments for CPT is exercise. Eccentric exercise has shown good clinical results in CPT [4] as well as in conditions similar to CPT in clinical behaviour and histopathological appearance, such as lateral elbow [5], rotator cuff [6] and Achilles tendinopathy [4]. Eccentric training is not enough for all patients with CPT [7]. Malliaras and his colleagues [8] concluded that clinicians should consider eccentric-concentric loading alongside or instead of eccentric loading in lower limb tendinopathy. Moreover, poor lumbopelvic control has the potential to alter load distribution on the lower limb kinetic chain and increase the risk of lower limb tendinopathy [1]. The combination of eccentric-concentric training with isometric contractions, simple lumbo-pelvic control exercises and static stretching exercises of hamstrings and quadriceps (an aetiological factor of CPT) can produce significant improvements in terms of pain and disability in CPT [9].

Although an exercise program is an effective treatment approach, a supplement to the exercise program should be found to reduce the treatment period. One such modality is the polarized polychromatic noncoherent light (Bioptron light), a new modality of light therapy for the management of tendinopathies such as CPT. Manufacturers of polarized polychromatic non-coherent light devices (Bioptron light; Bioptron, Wollerau, Switzerland) claim that the waves of this light move in parallel planes (i.e., are polarized), cover a wide range of wavelengths (480–3400nm) including visible light and part of the infrared range (polychromy), and are not synchronized (incoherent). To our knowledge, there have been no studies to investigate the effectiveness of Bioptron light as a supplement to an exercise program in the management of CPT. Therefore, the present case report aims to present the effect of Bioptron light combined with an exercise programme consisting of eccentric-concentric training, isometric contraction, simple lumbo-pelvic control exercises and static stretching exercises on pain and disability in a patient experiencing CPT.

Case Presentation

History

The subject was a 19-year-old male basketball player with an

***Corresponding author:** Stasinopoulos Dimitrios, Department of Physiotherapy, University of West Attica, Greece, E-mail: dstasinopoulos@uniwa.gr

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eight-month history of anterior knee pain, in his right (dominant) knee. He was diagnosed by a specialist (orthopaedic) as having CPT. He has played basketball for about 10 years. The site of pain was over the inferior pole of the patella (the most common site of patellar tendinopathy) without spreading down. He complained of pain during his training and walking downstairs. The pain subsided within two hours after his training. He did not complain of pain after prolonged sitting. He did not have any problems with the other joints. He did not complain of other symptoms such as stiffness, swelling, locking, crepitus or giving away. He took no drugs at the time of assessment; he had no history of trauma in the knee before, only two ankle sprains in the same leg. He had followed a physiotherapy rehabilitation program for the ankle sprains. He had no prior physiotherapy treatment for the problem in his knee. He did not have a history of diabetes, epilepsy or cancer and none in his family did. He did not have any operation or illness in the past.

Examination findings

Although the condition was diagnosed by a specialist, the physiotherapist D. S. assessed his knee to rule out other conditions and confirm the diagnosis.

No pain was mentioned during gait and posture. Body deformity, colour changes, muscle wasting or swelling were not noted. In palpation, signs of inflammatory activity like heat, swelling and synovial thickening were not found.

On physical examination, the movements of the low back, hip and ankle were pain free, with full range of motion and full power. All ligamentous stress tests were normal, meniscal stress tests were normal, muscle strength tests were normal and no capsular pattern was found. Isotonic resisted knee extension was pain-free. The subject mentioned pain (7 out of ten) at the inferior pole of the patella when conducting the decline squat test. The Royal London Hospital test was also positive. Knee extension by gliding the patella medially was negative, without reproducing the pain; furthermore the position of the patella was normal [10]. These two latter procedures ruled out the patellofemoral joint dysfunction. Tenderness with palpation over the inferior pole of the patella was found, confirming the diagnosis.

Procedure

The subject followed a supervised exercise programme consisting of, isometric quadriceps exercise, slow progressive eccentric-concentric training of quadriceps and simple lumbo-pelvic control exercises. Firstly, the subject performed the Spanish squat as an isometric quadriceps exercise. The Spanish squat is a double leg squat to be performed at an angle of approximately 70-90° of knee flexion with the assistance of a rigid strap fixating the lower legs. The subject performed 3 sets of five repetitions of Spanish squat with 1-min rest interval between each set. Each repetition was painless and last 45 seconds. Later, the subject will carry out the eccentric-concentric training. As eccentric-concentric training, the subject carried out three sets of 15 repetitions of unilateral squat on a 25o decline board with 1-min rest interval between each set. The squat was performed at a slow speed at every treatment session. The subject counted to 6 during the squat. As the subject moved from the standing to the squat position, the quadriceps muscle and patellar tendon by inference was loaded eccentrically; followed by concentric loading, as the injured leg was used to get back to the start position. At the beginning the load consisted of the body weight and the participant was standing with all his body weight on the injured leg. The subject was told to go ahead with the exercise even if he experienced mild pain. However, he was told to stop the exercise if the pain became disabling. When the squat was pain-free the load was increased by holding hand weights. Finally, the subject performed two simple lumbo-pelvic control exercises such as single leg bridging in supine and four-point prone bridging exercises. The patient performed 3 sets of five repetitions of each of the above lumbo-pelvic control exercises with 1-min rest interval between each set. Each repetition was painless and last 45 seconds. Static stretching exercises of quadriceps and hamstrings were performed as described by Stasinopoulos and his colleagues [11] before and after the supervised exercise programme. Each stretch lasted 30 seconds and there was a one-minute rest between each stretch. A supervised exercise program was given five times a week for 6 weeks and was individualized based on the patient's description of pain experienced during the procedure.

The subject received Bioptron light therapy, via the BIOPTRON Pro optical device (BIOPTRON AG, Wollerau, Switzerland) for 10min twice, once before the exercise program and once after the exercise programme, daily for 6 weeks, a total of 60 treatments. The equipment used was noninvasive. The physical parameters of the light output from this optical medical device were as follows: wavelength 480–3400nm, light spot size 254cm^2, and specific power density 40mW/cm^2. During active light exposure, the energy output of the device (energy density) was 2.4 J/cm^2 /min (that is, 24 J/cm^2 /10min session). During each light exposure the subject was seated and fitted with darkened eye wear, the treatment area (patellar tendon) was exposed, carefully cleaned (by wiping with a sterile gauze soaked in clean water), and dried, then the optical medical device was powered up and used to 'paint' the exposed area with Bioptron light for 10min. During light exposure, the optical medical device was positioned via a support floor stand to be approximately at right angles to the skin surface, and at a distance of approximately 10cm from the treatment area. A ''beep'' signified the end of the 10min treatment.

The patient was instructed to use his knee during the course of the study but to avoid activities that irritated pain such as jumping, hopping and running [7,9,11,12]. He was also told to refrain from taking anti-inflammatory drugs throughout the course of the study. Patient compliance was monitored using a treatment diary.

Communication and interaction (verbal and non-verbal) between the therapist and patient were kept to a minimum, and behaviors sometimes used by therapists to facilitate positive treatment outcomes were purposefully avoided. For example, the patient did not indicate the potentially beneficial effects of the treatments or any feedback on his performance in the pre-application and post-application measurements [13].

Pain and function were measured in the present study. The patient was evaluated at the baseline (week 0), at the end of treatment (week 6), and at 1 month (week 10) after the end of treatment. The VISA-P questionnaire was used to monitor the pain and function of patients. The instrument is a simple questionnaire, consisting of eight questions that take less than five minutes to complete and once patients are familiar with it they will be able to complete most of it themselves. It is a valid and reliable outcome measure for patients with patellar tendinopathy [14].

Secondary outcomes were the pain pressure threshold (PPT) [15] and the strength of knee extensor using the handheld dynamometer [16].

The PPTs of the subject patellar tendon were measured using an adjusted MicroFET2 hand-held dynamometer. Because the device had to be applied to a tendon, a specially developed rubber disc shaped like

a fingertip with a surface of 1 cm^2 was used. The pressure algometer is a device with a predefined force calibrated in Newtons that can be administered to the tendon through a rubber disc at the end of the algometer. The measurement of the PPT was performed with the subject in a standardized position, with slightly flexed knees supported by a cushion under the popliteal fossa. The researcher palpated the identified area to locate the exact painful spot; then, the algometer was placed on this position. In order to facilitate palpation of the tendon directly distally of the patellar apex, the patella was slightly tilted within the sagittal plane by pressing the proximal pole of the patella. To standardize the procedure, the force was gradually increased in a standardized time frame to a maximum of 50N in 5 seconds. This maximum is set to avoid any harm to the knee. If the subject experienced any sense of pain, he had to say "stop" and immediately the algometer was removed. The peak force of the measurement was displayed on the algometer. The mean of two measurements was taken for analysis. The second measurement was taken immediately after the first one, with a minimum of 30 seconds between each other, and on the same spot.

Knee extensor torque was measured with the athlete in supine lying with 30o of knee flexion. This test position was chosen because it more closely resembles the knee flexion angle the athletes have to generate force in during jumps. The dynamometer was positioned immediately proximal to the midpoint between the lateral and medial malleoli. The athlete was asked to cross the arms in front of the thorax and to 'push trying to extend the knee'. This measurement was found to have excellent reliability.

Result

At week 0 VISA-P score was 45, the PPTs was 22 Newton and the knee extensor torque was 80 kilograms. At week 10 (1 month after the end of the treatment) the VISA-P was 83, the PPTs was 33 kilograms and the knee extensor torque was 119 kilograms (Table 1).

Discussion

The present study examined the effect of Bioptron light combined with an exercise programme consisting of eccentric-concentric training, isometric contraction, simple lumbo-pelvic control exercises and static stretching exercises in a patient with CPT. Its findings have demonstrated significant improvements in terms of pain and disability. The results obtained from this case report are novel; as to date, similar studies have not been conducted.

Alfredson H, et al. [17] first proposed the eccentric training of the injured tendon. It is the most commonly used conservative approach in the treatment of tendinopathy. Unilateral squat eccentric training of the patellar tendon was the most commonly used conservative approach in the treatment of CPT [18] when the problem is at the inferior pole of the patella; however, no studies have investigated the effectiveness of training on other sites of patellar tendinopathy. Studies determining the effectiveness of exercises at other sites of patellar tendinopathy are needed. Later, it was found that the unilateral squat eccentric training on a 25o decline board applied more load on the tendon [9]. However, squat eccentric training of the patellar tendon alone, on decline board or not, was not effective for many patients with CPT. Malliaras and his colleagues [4] concluded that clinicians should consider eccentric-concentric loading alongside or instead of eccentric loading in Achilles and patellar tendinopathy. A Heavy Slow Resistance (HSR) program is recommended in the management of lower limb tendinopathy [19,20]. The HSR program was produced equivalent pain and function improvement (VISA) than the Alfredson eccentric program, but significantly better patient satisfaction at six month follow–up. In the Achilles tendon, eccentric and HSR have recently been shown to yield similar clinical outcomes (VISA and patient satisfaction) at 1 year follow up. Based on the above findings, the HSR program can be recommended as an alternative to the Alfredson eccentric program lower limb tendinopathy rehabilitation for young active people.

Table 1: VISA-P score, PPTs and knee extensor torque before each evaluation.

	Visa -P	PPTs	Knee Extensor Torque
Week-0	45	22	80
Week-6	78	31	112
Week-10	83	33	119

Recently, isometric exercises have been recommended to reduce and manage tendon pain increasing the strength at the angle of contraction without producing inflammatory signs [8,21]. Five repetitions of 45-second isometric mid-range quadriceps exercise at 70% of maximal voluntary contraction have been shown to reduce patellar tendon pain for 45 minutes post exercise and this was also associated with a reduction in motor cortex inhibition of the quadriceps that was associated with patellar tendinopathy [21]. The dosage of isometric contractions is based on clinical experience [8,21] and their effect on pain in patients with CPT requires further study. The 'Spanish squat is- used as isometric contraction and is useful when there is limited or no access to gym equipment [8]. However, conflicting results have been reported in terms of immediate and short-term pain relief [22]. Definitive conclusions about the effectiveness of isometric exercise in tendinopathy are yet to be made [22].

A component lacking from evidence-based programs is adequate potential to alter load distribution on the lower limb kinetic chain and increase the risk of lower limb tendinopathy [1,23]. It is our belief that the improvement of lumbo-pelvic control can be achieved by performing simple exercises such as single leg bridging in supine and four - point prone bridging exercises. Future research is needed to confirm this suggestion.

In addition, hip extensors weakness has been associated with patellar tendinopathy [24]. Exercises to strengthen these muscle groups should be considered in exercise protocols and patellar tendinopathy. However, hip extensors were not strengthened in the present case trial because the strength of hip muscles in the assessment was normal. Functional activities such as jumping, cutting and sprinting should also be included in lower limb tendinopoathy rehabilitation programs among athletes, but have so far not been included in popular programs in the literature [24]. These activities were included in the present study. The athlete carried out these activities in the court under the supervision of the gymnast.

The load of exercises was increased according to the patients' symptoms otherwise the results are poor [25]. Furthermore, eccentric exercises were performed at a low speed in every treatment session because this allows tissue healing [26]. Ice was not recommended at the end of the treatment because research has shown that ice as a supplement to an eccentric exercise programme offers no benefit to patients with tendinopathy [27]. Finally, the avoidance of painful activities is crucial for tendon healing, because training during the treatment period increases patients' symptoms and delays tendon healing [28].

Eccentric exercises appear to reduce pain and improve function. The mechanism by which eccentric training achieves these outcomes remains uncertain, as there is a lack of good-quality evidence relating

to physiological effects. The clinical improvement of the HSR group was accompanied by increased collagen turnover. It is unknown if the isometric contractions can reverse the pathology of the tendinopathy and in this case the pathology of CPT.

Although a home exercise programme can be performed any time during the day without requiring supervision from a therapist, our clinical experience has shown that patients fail to comply with the regimen of home exercise programmes [27]. Although many ways can be recommended to improve the compliance of patients with the home exercise programme such as phone calls, exercise monitors and better self-management education, it is believed that this problem can be solved by the supervised exercise programmes performed in a clinical setting under the supervision of a therapist. It is believed because our experience has shown that many patients stopped the home exercise programme without giving an explanation, whereas patients completed the supervised programme. One possible reason why they continue the supervised exercise programme could be the cost. In the supervised exercise programme, the patients visit the therapist more times than the home exercise programme, and this is more expensive. A future study will combine the both types of exercise programmes in order to maximize the compliance of the patients.

Eventhough a supervised exercise program is an effective treatment approach, a supplement to the exercise program should be found to reduce the treatment period. One such modality is the Bioptron light which is a relatively new treatment approach, but it is reported to be used by clinicians worldwide. It is probable that BIOPTRON light accelerates the cellular mechanisms and improves the local blood supply, and exposure to both the visible and infrared parts of the electromagnetic spectrum of BIOPTRON light may explain its potential mechanism of action. Further research is needed to investigate exactly how this occurs [29].

Like laser therapy, Bioptron light is also a low-power light source, but differs in that it is polychromatic and incoherent rather than monochromatic and coherent.[1,8] Moreover, Bioptron light combines visible light at a wavelength of 480-700nm and infrared light at a wavelength of 700-3400nm.[9,29] In contrast, low power laser contains either visible or infrared light at one specific wavelength.[9,29] Several drawbacks have impaired the usefulness of low-power laser light in comparison to Bioptron light, such as high cost, high risk, required user skills, and the small diameter of the laser beam, which allows only a limited area to be treated [9,29].

The BIOPTRON light therapy Instructions for use state that incorrect application of Bioptron light is not hazardous to a patient's health,[9,30] but that the effects of the Bioptron light therapy are reduced if any of the following conditions apply:

- It is not applied to bare skin.
- It is held at an operating distance more than of 10cm. (The appropriate distance is 5-10cm).
- It is not held at a 900 angle from the skin. (For greater penetration depth, the device should be perpendicular to the treatment area).
- The light is not held steady relative to the skin.
- The irradiation time is 6 -10 minutes. (The appropriate irradiation time is 6min: irradiation times more than 10 minutes do not produce better results).
- The period of treatment is at least 3 times per week for at least 1month.

It is important to mention that no side effects were reported during or after the treatment period. There is no UV light in the BIOPTRON light spectrum, so there is no tanning or heating effect on the skin [9,29]. Furthermore, BIOPTRON light is not harmful to the eyes and poses no danger to pregnant women [9,29]. It is easy-to use and can be used in the clinical setting or if required in the patient's home [1,8]. Finally, BIOPTRON light is not associated with cancer: the unsafe range for cancer risk is UV light at 250nm, and the shortest wavelength in the Bioptron spectrum is 480nm [9,29].

Previous trials assessed the effectiveness of BIOPTRON medical light in chronic injuries, such as lateral epicondylitis [30-32] and carpal tunnel syndrome [33,34]. The most likely explanation for the lack of published research using BIOPTRON light for this application is that it has only recently become available for use in physiotherapy settings. Previously reported trials found that a course of BIOPTRON light treatment may improve patients' symptoms [30-34]. The findings of these published trials may also encourage the initiation of well-designed randomized controlled trials (RCTs) that might produce better evidence for the effectiveness of BIOPTRON light in acute and chronic injuries.

Even though the positive effects of such a physiotherapy approach in CPT have been reported in the present report, its study design limits the generalization of these findings. Future well-designed clinical trials are needed to confirm the positive results of this case study establishing the effectiveness of such an exercise program in the management of CPT. In addition, structural changes in the tendons related to the treatment interventions and the long-term effects (6 months or more after the end of treatment) of these treatments need to be investigated. Further research is needed to establish the possible mechanism of action of this treatment approach, and the cost effectiveness of such treatment, because reduced cost is an important issue for the recommendation of any given treatment.

Conclusion

The Bioptron light combined with an exercise programme consisting of eccentric-concentric training, isometric contraction, simple lumbo-pelvic control exercises and static stretching exercises reduced the pain and improved the function in a patient with CPT at the end of the treatment and one month follow-up. Further well-designed trials are needed to confirm the results of the present case report.

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