ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 4, Issue 2, March 2015

Patellar Tendinopathy Rehabilitation Device - Have fun with Serious Games

Konstantinos Katzis, Demetrios Stasinopoulos

Abstract: ***The term patellar tendinopathy refers to painful overuse tendon without implying pathology. Chronic patellar tendinopathy is a common clinical condition that is managed by physical therapists and is common among athletes and non-athletes alike. Eccentric training is a widely used physiotherapy treatment for patients with patellar tendinopathy. Eccentric training requires that patients are subjected to squats on a 25 degree decline board. This is considered an effective treatment approach when the patellar tendinopathy is at the inferior pole of the patella; To our knowledge, there have been no devices in eccentric training. In addition, to date, there have been no data comparing the effectiveness of eccentric training on a 25-degree decline board with other decline angles. In this paper, we describe how a patellar tendinopathy rehabilitation device has been designed and implemented to allow physical therapists to perform treatment at different inclination angles. Along with the patellar tendinopathy device, a simple serious game has also been developed using off-the-shelf components to allow patients to enjoy their treatment while optimizing their eccentric training. Furthermore, the methodology that employs the patellar tendinopathy rehabilitation device as well as the serious game developed for an eccentric treatment is proposed to assess the effectiveness of the eccentric training for various inclination angles. More specifically a controlled, monocentre trial is proposed to be conducted in a lab setting to assess the effectiveness of an eccentric training programme for a series of inclination angles (15, 25, 35, 45).***

Index Terms— **Eccentric Training, Patellar Tendinopathy, Unsupervised Training, Rehabilitation Device, Serious Games.**

I. INTRODUCTION

The term patellar tendinopathy refers to painful overuse tendon without implying pathology; it is ideal for clinical diagnosis [1]. Chronic patellar tendinopathy is a common clinical condition that is managed by physical therapists and is common amongst athletes and non-athletes alike. It is most commonly characterized by pain at the inferior pole of the patella, although pain can also be at the tibial attachment, in the attachment of the tendon to the superior pole of the patella as well as mid-substance pain has been reported [1]-[3]. Extrinsic factors such as inappropriate footwear, sport technique, training errors, and intrinsic factors such as muscle weakness and/or inflexibility, and misalignment are the main factors that lead to patellar tendinopathy [1]-[3]. Functional activities such as squat or hop can cause pain in this condition [2][3]. However, no ideal treatment has emerged for the management of patellar tendinopathy other than various techniques employed such as electrotherapeutic (ultrasound, ESWT, laser, iontophoresis) and non-electrotherapeutic modalities (exercise programs, soft tissue manipulation, and acupuncture) [4]. As with all sorts of injuries, traumas, and various medical conditions that involve personal mobility, humans have tried to improve the effectiveness of the rehabilitation process. Current approaches involve rehabilitation techniques, enhanced with electromechanical mechanisms and integrating entertainment by employing computer (serious) games. The combination of these three approaches has provided more structured, methodic, controlled and entertaining rehabilitation [5], [6]. Such multidisciplinary rehabilitation processes have evolved substantially over the past 15 years. Looking at computer games enhanced rehabilitation, also known as serious games, this effectively involves the engaging games coupled with functionally-targeted training devices aiming to increase patient's motivation as well as increase accessibility and duration of therapy sessions. Simple search on the web for related articles indicates that most common uses of serious games one can find involves recovery from incidents of stroke, traumatic brain injury, and other neuromuscular impairments. This study is different from the rehabilitation treatments proposed for the aforementioned incidents as it targets people with injuries as well as healthy people to improve their physical condition through unsupervised home training as well as challenges the current treatment of the patellar tendinopathy.

As illustrated in Fig. 1, the latest trends in treatment and training of people with difficulties in mobility not only involves the basic treatment and training that the patient has been asked to undergo but it requires the use of electromechanical aids as well as the integration of the treatment / training in a virtual environment designed to optimize the system.

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 4, Issue 2, March 2015

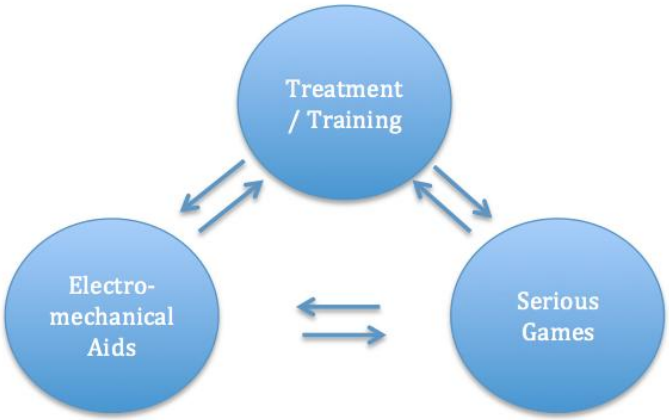

Fig. 1 Rehabilitation using electromechanical aids and Serious Games.

The aim of this paper is twofold. First, it aims to present a device specifically designed to examine the effectiveness of the treatment for various inclination angles that the patient is subjected to and secondly it aims to enhance the motivational characteristics of this device when used for unsupervised treatment. To be able to carry out these experiments, an apparatus was designed and implemented featuring an electromechanical mechanism with varying inclination angle capabilities while a feedback mechanism was used to translate patient's exercise motions into action in an old favorite video game (Super Mario original game running on a PC emulator [7]). Based on this apparatus, a treatment procedure has been designed where the patient must repeat a specific number of sets at different inclination angles, while playing the game.

The rest of the paper is organized as follow: Section 2 highlights the problem of patellar tendinopathy. Section 3 presents the first part of the apparatus, the Patellar tendinopathy rehabilitation device, which was designed to perform the treatment. Section 4 presents the second part of the apparatus, the serious game, which was developed to motivate the patient as well as improve the unsupervised home training. This includes both hardware and software components employed. Section 5 presents the proposed methodology that we plan using to evaluate the effectiveness of the device as well as identify the optimum inclination angle. Finally, Section 5 provides the conclusions of this study and discusses future directions of research mainly focusing on the implementation of the methodology.

II. RELATED WORK

Many clinicians advocate a conservative approach and physiotherapy. Many physiotherapy techniques have been recommended for the treatment/rehabilitation of patellar tendinopathy such as electrotherapeutic (ultrasound, ESWT, laser, iontophoresis) and non-electrotherapeutic modalities (exercise programs, soft tissue manipulation, and acupuncture) [6]. All the above-mentioned treatments intend to improve symptoms (pain and function) of patellar tendinopathy but have totally different mechanisms of action. However, a treatment is effective when it reverses the pathology of the tendinopathy and does not only improve the symptoms. Nowadays, eccentric training is the most common physiotherapy treatment for patients with patellar tendinopathy [1]-[3]. Eccentric training consisting of squats on a 25-degree decline board is an effective treatment approach when the patellar tendinopathy is at the inferior pole of the patella. To our knowledge, there have been no devices in eccentric training. In addition, to date, there have been no data comparing the effectiveness of eccentric training on a 25-degree decline board with other decline angles.

Previous trials have found that a home exercise programme reduced the pain in patellar [5]-[11], lateral elbow [12] and Achilles [13]-[17] tendinopathy. However, they were performed for about three months in all previous studies. In contrast, in the recent controlled clinical trial and the studies of Stasinopoulos and colleagues, [18]-[20] a supervised exercise programme was administered for one month. Thus it seems that the supervised exercise programme may give good long-term clinical results in a shorter period of time than a home exercise programme. The most likely explanation for this difference is that a supervised exercise programme achieves a higher degree of

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 4, Issue 2, March 2015

patient compliance. Studies to compare the effects of these two types of exercise programmes are required to confirm the findings of the present controlled clinical trial.

Works on serious games such as in [21] showed that actively participating in rehabilitation programmes, increases the benefits and the effectiveness of the therapy by motivating and supervising the patient. For the field of rehabilitation, serious games and related virtual technology, can provide significant motivation to patients suffering from muscular, neuromuscular, and orthopedic impairments. Many examples of applications of virtual technology in rehabilitation can be found in post-stroke patients [21]-[25].

This study, proposes a multidisciplinary mechanism to examine the effectiveness of a home, unsupervised exercise programme, using a varying inclination angle mechanism and employing serious games to motivate and supervise the patient for compliance. Results of this work can be particularly useful when compared to unsupervised home exercise programme without any means of feedback.

III. APPARATUS – PATELLAR TENDON REHABILITATION DEVICE

The system proposed for the treatment of patellar tendinopathy is consisted of electromechanical components that change the elevation angle of the platform that the patient is using to carry out a series of squats as part of his/her eccentric training. The device proposed, illustrated in Fig. 2, uses a hydraulic mechanism to lift the upper part of the device and vary the inclination angle. This has a direct effect on the peroneus brevis of the patient. The following fig. illustrates the general system diagram of the patellar tendon rehabilitation device.

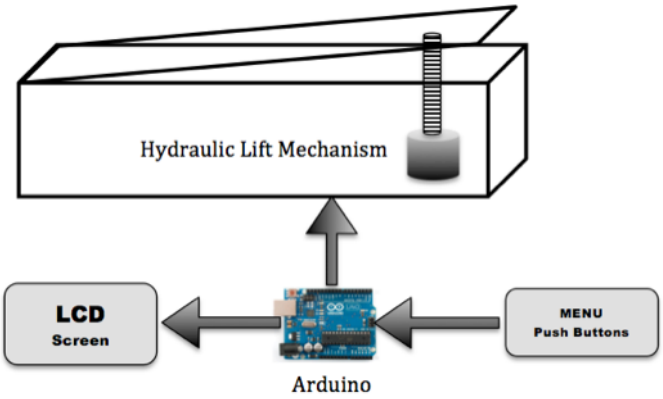

Fig. 2 System Design - Patellar Tendon Rehabilitation Device

The physical therapists can increase or decrease the angle in which the patient is subjected to, through a menu that appears on an LCD screen attached to the device. As illustrated in Fig. 3, angle θ is defined as the elevation angle and varies from 0 degrees up to 50 degrees. The system can increase / decrease angle θ by 1 degree thus allowing the physical therapist to set a precise elevation angle, if needed, for the patient.

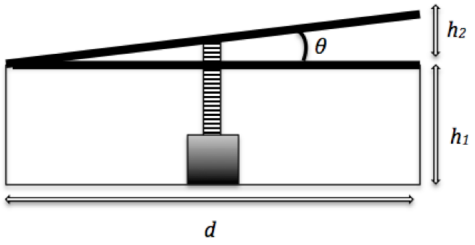

Fig. 3 Elevation Angle

When the patient is standing on the platform, different joints of the body are subjected to different angle variations as this is illustrated in Fig. 4. These angles are varying while the patient performs the exercise assigned. During the exercise, angular motion occurs at different body segments such as the ankles, knees and hips. These particular

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 4, Issue 2, March 2015

segments rotate about their joint centres that form the axis of rotation. During the movement, the segments generally undergo both rotation and translation.

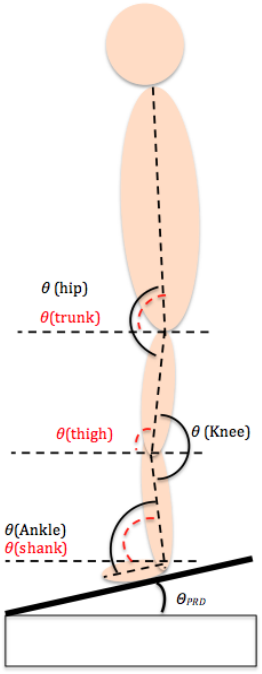

Fig. 4 Absolute and Relative Angles w.r.t. elevation angle θ

According to [26], the angle between the longitudinal axes of two adjacent segments is defined as the relative angle (θ_{ankle}, θ_{knee}, θ_{hip}) whereas the absolute angles refer to the angle of inclination of a particular body segment (θ_{foot}, θ_{shank}, θ_{thigh}, θ_{trunk}). These angles are depicted in Fig. 4 and their relation can be expressed as follows:

$$q_{ankle} = q_{shank} + q_{PRD} \quad (1)$$

and according to [26],

$$q_{ankle} = q_{shank} + (180° - q_{foot}) \quad (2)$$

Based on (1) and (2), it can be deduced that:

$$q_{PRD} = 180° - q_{foot} \quad (3)$$

When our device is set at θ_{PRD}=0° elevation angle, the foot is considered to be flat with respect to the ground (i.e. θ_{foot} =180°).

Furthremore, the θ_{knee} is defined as:

$$q_{knee} = q_{shank} + (180° - q_{thigh}) \quad (4)$$

and θ_{hip} is defined as:

$$q_{hip} = q_{trunk} + (180° - q_{thigh}) \quad (5)$$

Equations (4) and (5) can be used to provide some useful information about the posture of the patient during the exercise. Nevertheless, these angles are constantly varying during the exercise and this makes them difficult to calculate using coordinates of individual body landmarks. The only angles that can be considered fixed throughout

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 4, Issue 2, March 2015

this exercise are θ_{PRD} and θ_{foot} (see equation (3)). For the purpose of this research, only θ_{knee} is considered as vital for evaluating our methodology of rehabilitation. To calculate θ_{knee}, we considered the following two options that helped verify our readings.

First option was to measure:

1. The distance (d_{AH}) when the patient is standing, where distance d_{AH} is the distance between the ankle and the hip while the patient is in the standing or squat position.
2. The distance (d_{AK}) when the patient is standing, where distance d_{AK} is the distance between the ankle and the knee while the patient is in the standing or squat position.
3. The distance (d_{KH}) when the patient is standing, where distance d_{KH} is the distance between the knee and the hip while the patient is in the standing or squat position.

The three joints (ankle, knee and hip) form a triangle that can be used to calculate θ_{knee} for two positions (standing and squatting) using (6):

$$\theta_{knee} = a\cos\left(\frac{d_{AK}^2 + d_{KH}^2 - d_{AH}^2}{2 \times d_{AK} \times d_{KH}}\right) \quad (6)$$

Second option was to use a specially designed mechanism (presented in section IV) that was measuring the angle of the knee at any time using an electronic device connected to a PC. For our methodology, the second option is preferred in order to reduce the time required for the patients during orientation time and since it could keep track of all angles the knee was exposed during the exercise.

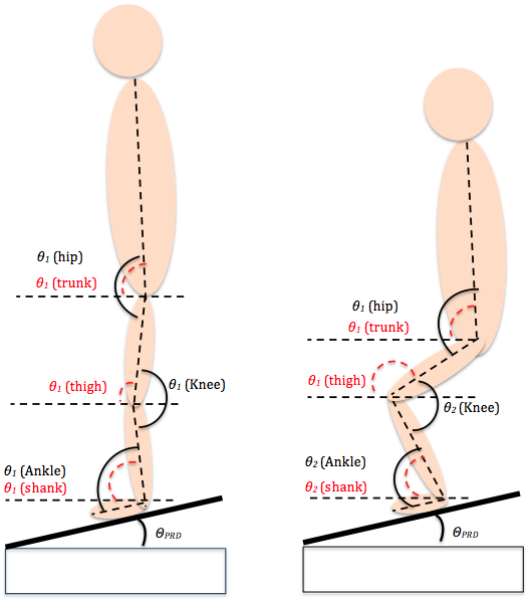

Fig. 5 Standing (Left) and immerse (Right) positions when PRD is set at angle θ

Fig. 5 illustrates how angles are changing when our patient is performing the exercise. From this fig. it can be observed that the greater the θ_{PRD} is, the greater the θ_{ankle} is. In addition, when the subject is sitting, θ_{ankle}, θ_{knee} and θ_{hip} decrease.

IV. APPARATUS - SUPER PHYSIO-MARIO SERIOUS GAME

Recent studies indicate that patients lack of motivation when requested to repeat a series of physiotherapy related exercises in order to get better [21]-[25] and [27]-[30]. Therefore, when a certain physiotherapy exercise is painful

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 4, Issue 2, March 2015

or boring the patients will consequently lose their interest when doing it. However with the use of a challenging / entertaining and sometimes addictive game, the patent's motivation is triggered as the exercise stops being just a repeated exercise but an amusing game. This is what is known as serious games. Serious games are defined as the (digital) games used for purposes other than mere entertainment applied to a broad spectrum of application areas, e.g. military, government, educational, corporate, healthcare [27]. These games have the advantage to allow learners to experience situations that are impossible in the real world for various reasons such as safety, cost, time, etc. [30]. Employing serious games can have a positive impact on the players' development and in our case the enhancement of the physical condition of the patient (player) in question.

To make the process of physical recovery / exercise more exciting, a simple yet addictive game has been developed to motivate our subjects.

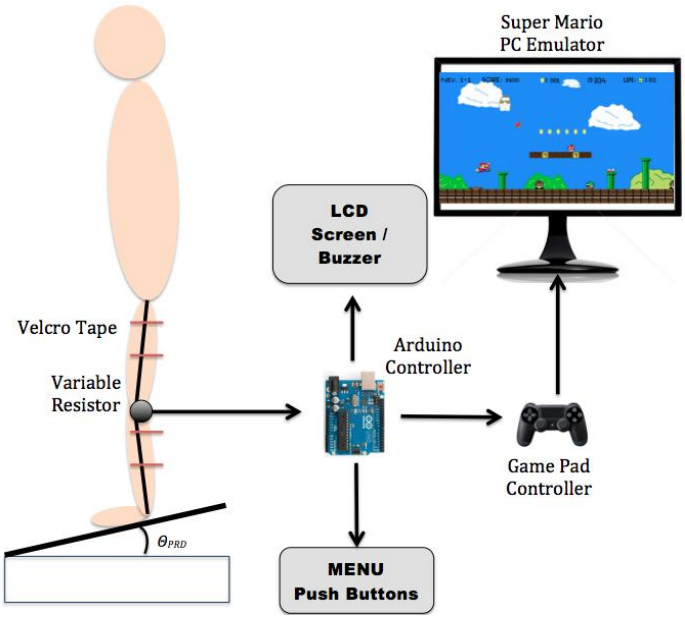

Fig. 6 Super Physio-Mario Serious Game

The serious game system proposed here (illustrated in Fig. 6) complements the apparatus presented in the previous section. The patients here have to perform an exercise of lowering their posture while standing straight. The device is consisted of an off-the-shelf usb-gamepad, an Arduino platform and a sensing mechanism (two plastic tubes connected together using a variable resistor). The variable resistor is connected to a 5-volt supply voltage and depending on its position; there is a voltage drop across it. The Arduino has been programmed to monitor the sensing mechanism (voltage drop) while it is connected on the gamepad, overriding one of its existing buttons. The mechanism works as follow: the sensing mechanism is attached on the left or right leg of the patient. While the patient moves up and down, the angle between the two plastic tubes varies. These variations are reflected on the voltage read at the analog input of the arduino controller. Based on these variations, the "jump" button on the gamepad controller is triggered.

Initially, the device requires calibration. The calibration mode of the software developed for the arduino platform is used to select the maximum angle of triggering a certain action in the game (best suited angle selected by the physiotherapist). The angle is measured using the voltage of the variable resistor, which is read using one of the analogue inputs of the Arduino. The conversion from volts to degrees is performed based on a series of measurements obtained to ensure linear relation between the two values.

Fig. 7 compares the readings from the Arduino controller when varying the angle between the two sticks (θ_{knee}) with the voltages calculated based on the ranges of 0-180 degrees and 0-5 volts (5V supply voltage provided from the Arduino controller). Results indicate that the mechanism is behaving in a linear manner like a variable resistor

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 4, Issue 2, March 2015

should and it is close to the theoretical values. θ_{knee} is not expected to cover the full range of 0-180 degrees but a small range (between 90-180 degrees).

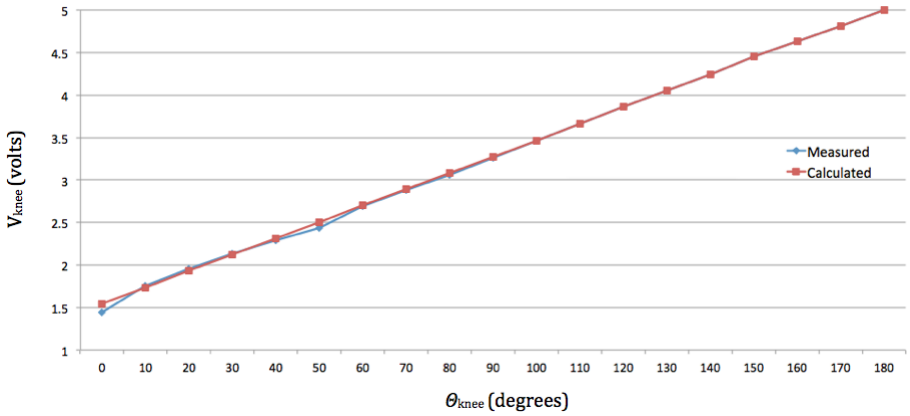

Fig. 7 Variable Resistor Readings

The system developed is based on off-the-shelf components and it is fairly easy to build. Nevertheless it permits the use of any game that is currently running on the PC emulator, thus making it flexible and easily adjustable to any game available. For this work, the classic "Super Mario" was chosen due to its simplicity and the type of movement required to play the game (jump). The Super Mario game was set to operate on an online emulator running on Windows 8.1 [7]. With the use of the standard off-the-shelf usb-controller and the arduino mechanism, the patient can move Mario left or right using the gamepad and when the patient lowers his/her posture - at the selected angle of trigger and then returns back to the standing position - Mario then jumps. This challenges the patient in overcoming the pain or boredom by doing his/her best in the game. The serious game system developed counts the number of squats and informs the patient that the maximum number of iterations (set to 15) per set has been reached. This is achieved since the arduino keeps track of the number and uses a LCD screen and a buzzer to stop the patient from doing more repetitions than necessary. It also prevents the user from exceeding the maximum knee angle (θ_{knee}) that the physiotherapist specified and risking any further injuries by sounding a warning through the buzzer. The serious game developed also ensures that the unsupervised home exercise is performed correctly just like as if it was supervised, as the user must perform the right movement to trigger for Mario to jump.

V. PROPOSED METHODOLOGY

A controlled, monocentre trial is proposed at this point as part of utilizing the apparatus and the serious game described in the previous sections. More specifically, the monocentre trial will be conducted in a lab setting to assess the effectiveness of an eccentric training programme for a series of inclination angles (15, 25, 35, 45). A parallel group design will be used because crossover designs are limited in situations where patients are cured by the intervention and do not have the opportunity to receive the other treatments after crossover [31]. Two investigators will be involved in the study. The first one, Demetrios Stassinopoulos (DS) is the primary investigator who will administer and evaluate the patients to confirm the patellar tendinopathy diagnosis; and the second investigator is Konstantinos Katzis (KK), will perform all baseline and follow-up assessments, and gain informed consent. Investigators involved in the assessment, will be blind to the patients' therapy group. The second investigator will interview each patient to ascertain baseline demographic and clinical characteristics, including patient name, sex, age, duration of symptoms, previous treatment, occupation, affected leg and dominant leg.

Patients between 18 and 30 years old who will be experiencing anterior knee pain will be examined and evaluated in our research centre located in European University of Cyprus, Nicosia, Cyprus, between May 2015 and September 2016. All patients will live in Cyprus and will be either self-referred or referred by their physician or physiotherapist.

The selection criteria for the study will be [32]-[34]:

- Tenderness with palpation over the inferior pole of the patella;

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 4, Issue 2, March 2015

- No history of trauma to the knee;
- Minimum duration of symptoms three months;
- Unsuccessful conservative treatment before entering the study, but not in the preceding one month;
- No other current knee or lower extremity problems including anterior knee pain, muscle
- Strains and hip or ankle injuries;
- Positive decline squat test ([20], [32], [33]) This is a clinical diagnostic test.

All patients will receive a written explanation of the trial before entry into the study and then they will give signed consent to participate. They will be divided into four groups based on the angle set on apparatus (15, 25, 35 and 45 degrees). The allocation will be sequential and alternate, so the first patient will be assigned to the eccentric training (15 degrees) the second to the eccentric training group (25 degrees), the third one to the eccentric group (35 degrees) and the fourth one to the eccentric group (45 degrees). All patients will be instructed to use their knee during the course of the study but to avoid activities that irritated the joint such as jumping, hopping and running. They will be also told to refrain from taking anti-inflammatory drugs throughout the course of study. Patient compliance with this request will be monitored using a treatment diary.

During the exercise sessions, communication and interaction (verbal and non-verbal) between the therapist and patient will be kept to a minimum, and behaviors sometimes used by therapists to facilitate positive treatment outcomes will be purposefully avoided thus establishing an unsupervised exercise. For example, patients will be given no indication of the potentially beneficial effects of the treatments or any feedback on their performance in the pre-application and post-application measurements [35]. Treatments will be repeated on a regular basis as instructed and they will be completely unsupervised. The only indication of the users performance is their performance at the Super Physio-Mario Serious Game.

The eccentric training will be the same for all groups. As eccentric exercises, participants will carry out three sets of 15 repetitions of unilateral squat on the decline board. The squat will be performed at a slow speed and different time instances at every treatment session since the patients will be playing the very first stages of the Super Mario game which are particularly slow. The patients will be informed by the Super Physio-Mario Serious Game that all 15 repetitions have been completed. As they will move from the standing to the squat position, the quadriceps muscle and patellar tendon by inference will be loaded eccentrically; no following concentric loading will be done, as the non-injured leg will be used to get back to the start position. At the beginning, the load will consist of the body weight and participants will be standing with all their body weight on the injured leg. Subjects will be told to go ahead with the exercise even if they experience mild pain. However, they will be told to stop the exercise if the pain becomes disabling. When the squat is pain-free, the load will be increased for the patients by giving them weights to hold in their hands. Between each set there will be a two-minute rest. Each training session will be completed once daily, five times per week, for four weeks and will be individualized on the basis of the patient's description of pain will experience during the procedure [20]. Pain, function, dropout rate will be measured in the present study. Each patient will be evaluated at baseline (week 0), at the end of treatment (week 4) and at six months (week 24) after the end of treatment.

The VISA-P questionnaire will be used to monitor the pain and function of patients. The instrument is a simple questionnaire, consisted 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 [35]. A dropout rate will be also used as an indicator of treatment outcome. Reasons for patient dropout will be categorized as follows: (1) withdrawal without reason, (2) not returned for follow-up, and (3) request for an alternative treatment.

The change from baseline will be calculated for each follow-up. Differences in this change will be calculated between the groups and will be determined using a one-way analysis of variance (one-way ANOVA). Bonferroni post-hoc comparisons will be conducted when the results from the one-way ANOVA will be significant to determine how the groups will differ. A 5% level of probability will be adopted as the level of statistical significance.

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 4, Issue 2, March 2015

VI. DISCUSSION AND FUTURE WORK

The proposed mechanism described in this paper can be used for the effective treatment of patellar tendinopathy. The mechanism consists the patellar-tendon rehabilitation device and a serious game developed from off-the-shelf components. The patellar-tendon rehabilitation device varies the inclination angle that the patient will be required to stand on it as illustrated in Fig. 4. The Super Physio-Mario Serious Game is then used to motivate the patient to perform the exercise. The whole mechanism aims to provide unsupervised home training to patients. Along with the mechanism developed, we also propose a clinical trial in order to compare the existing techniques employed in physiotherapy. The proposed controlled clinical trial is novel; to date, there have been no similar approaches nor data comparing the effectiveness of eccentric training on the proposed degrees (15, 25, 35, 45) for the reduction of pain and improvement of function in patellar tendinopathy in non-athletes between 18 and 30 years old. The load of eccentric exercises will be increased according to the patients' symptoms because the opposite has shown poor results [36]. Eccentric exercises will be performed at a low speed in every treatment session because this allows tissue healing [13],[37]. The avoidance of painful activities is crucial for tendon healing, because training during the treatment period increases patients' symptoms and delays tendon healing [38].

Eccentric training appears to reduce the pain and improve function, reversing the pathology of tendinopathy [39]-[42] as supported by experimental studies on animals [43]. The way that eccentric training achieves the goals remains uncertain as there is a lack of good quality evidence to confirm that physiological effects translate into clinically meaningful outcomes and vice versa. Standard eccentric exercises offer adequate rehabilitation for tendon disorders, but many patients with tendinopathies do not respond to this prescription alone [44]. Eccentric and static stretching exercises seems to be an effective treatment for tendinopathies [18]-[20]. Eccentric training with or without static stretching exercises is called an exercise programme. Such an exercise programme is used as the first treatment option for patients with tendinopathy [45]. There are two types of exercise programme: home exercise programmes and exercise programmes carried out in a clinical setting. The former is commonly advocated for patients with tendinopathies, such as patellar tendinopathy, because it can be performed any time during the day without requiring supervision by a physiotherapist. Our clinical experience, however, has shown that patients fail to comply with this regimen [45]. This problem can be solved by exercise programmes performed in a clinical setting under the supervision of a physiotherapist.

For the purposes of this study, 'supervised exercise programme' will be challenged using a serious game that will effectively supervise the patient without the physiotherapist interfering with the exercise (just like an unsupervised exercise). Further to this, we anticipate that the trials will have some shortcomings such as: first, although this study will not be a randomized controlled trial because a genuine randomization procedure will not be followed, the use of sequential allocation to allocate patients to treatment groups allow a true cause and effect relation to be demonstrated. Second, no placebo (sham) or no treatment group will be included in the present trial. The placebo (sham)/no treatment group is important when the absolute effectiveness of a treatment is determined. However, the absolute effectiveness of technique-based interventions is difficult to investigate because a good and trustworthy placebo (sham)/no treatment control for exercise programmes appears to be difficult or impossible to devise, due in part to difficulties in defining the active element of these treatments. Absolute effectiveness also does not provide the therapists with information as to which is the most appropriate treatment for the management of a condition, in this case patellar tendinopathy. Finally, the blinding of patients and therapists would be problematic in that case, if not impossible, because patients know if they are receiving the exercise programme treatment and therapists need to be aware of the treatment to administer it appropriately.

VII. CONCLUSIONS

Simple mechanisms can be developed using off-the-shelf devices to solve complex everyday problems. Such a mechanism is our patellar-tendon rehabilitation device along with the Super Physio-Mario Serious Game. Both parts have been tested and showed that they can perform the proposed clinical trial. This work encapsulates the essence of a multi-disciplinary project that aims at improving the current patellar-tendon rehabilitation techniques.

REFERENCES

[1] D. Stasinopoulos, P. Manias, and K. Stasinopoulou, "Comparing the effects of eccentric training with eccentric training and static stretching exercises in the treatment of patellar tendinopathy. A controlled clinical trial," Clin Rehabil. 2012;26(5):423–30.

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 4, Issue 2, March 2015

[2] P. Jonsson, and H. Alfredson, "Superior results with eccentric compared to concentric quadriceps training in patients with jumper's knee: a prospective randomized study," Br J Sports Med. 2005; 39(11):847–50.

[3] M.A. Young, J. L. Cook, C. R. Purdam, Z. S. Kiss, and H. Alfredson, "Eccentric decline squat protocol offers superior results at 12 months compared with traditional eccentric protocol for patellar tendinopathy in volleyball players," Br J Sports Med. 2005;39(2):102–5.

[4] E. M. Roos, M. Engstrom, A. Lagerquist, and B. Söderberg., "Clinical improvement after 6 weeks of eccentric exercises in patients with mid-portion Achilles tendinopathy: A randomized trial with 1-year follow-up," Scand J Med Sci Sports 2004; 14: 286–295.

[5] P. Rego, P. M. Moreira, and L. P. Reis, "Serious games for rehabilitation: A survey and a classification towards a taxonomy," Information Systems and Technologies (CISTI), 2010 5th Iberian Conference on , vol., no., pp.1,6, 16-19 June 2010

[6] T. M. Connolly, E. A. Boyle, E. MacArthur, T. Hainey, and J. M. Boyle, A systematic literature review of empirical evidence on computer games and serious games, Computers & Education, Volume 59, Issue 2, September 2012, Pages 661–686

[7] Play Super Mario World Online, http://www.letsplaysnes.com/play-super-mario-world-online/?play=true#content, Accessed: 12/1/2015

[8] D. Stasinopoulos, "Patellar Tendinopathy May not be The Proper Term for Patients With Clinical Diagnosis of Patellar Tendon Disorder," Trauma Mon. 2014 April; 19(2): e15301.

[9] C. R. Purdam, P. Johnsson, H. Alfredson, R. Lorentzon, J. L. Cook and K. M. Khan, "A pilot study of the eccentric decline squat in the management of painful chronic patellar tendinopathy," Br J Sports Med 2004; 38: 395–397

[10] P. Jonsson and H. Alfredson, "Superior results with eccentric compared to concentric quadriceps training in patients with jumper's knee: A prospective randomized study," Br J Sports Med 2005; 39: 847–850.

[11] R. Bahr, B. Fossan, S. Loken, and L. Engebretsen "Surgical treatment compared with eccentric Training for patellar tendinopathy (jumper's knee)". A randomized, controlled trial. J Bone Joint Surg Am 2006; 88: 1689–1698.

[12] T. Pienimaki, T. Tarvainen, P. Siira, and H. Vanharanta, "Progressive strengthening and stretching exercises and ultrasound for chronic lateral epicondylitis," Physiotherapy 1996; 82: 522–530.

[13] H. Alfredson, T. Pietila, P. Johnson, and R. Lorentzon, "Heavy load eccentric calf muscle training for the treatment of chronic Achilles tendinosis," Am J Sports Med 1998; 26: 360–366.

[14] N. Mafi, R. Lorentzon, and H. Alfredson, "Superior short term results with eccentric calf muscle training compared to concentric training in a randomized prospective multicenter study on patients with chronic Achilles tendinosis," Knee Surg Sports Traumatol Arthrosc 2001; 9: 42–47.

[15] S. L. Niesen-Vertommen, J. E. Taunton, D. B. Clement, and R. E. Mosher, "The effect of eccentric versus concentric exercise in the management of Achilles tendonitis," Clin J Sports Med 1992; 2: 109–113.

[16] L. Ohberg, R. Lorentzon, and H. Alfredson, "Eccentric training in patients with Achilles tendinosis: Normalized tendon structure and decreased thickness at follow up," Br J Sports Med 2004; 38: 8–11.

[17] K. G. Silbernager, R. Thomee, P. Thomee, and J. Karlsson, "Eccentric overload training with chronic Achilles tendon pain: A randomized controlled study with reliability testing of the evaluation methods," Scand J Med Sci Sports 2001; 11: 197–206.

[18] D. Stasinopoulos, and I. Stasinopoulos, "Comparison of effects of exercise programme, pulsed ultrasound and transverse friction in the treatment of chronic patellar tendinopathy," Clin Rehabil 2004; 18: 347–352. Θα το βρεις στο άρθρο ή ως νούμερο 20 ή ως Stasinopoulos & stasinopoulos, 2004

[19] P. Manias, and D. Stasinopoulos, "A controlled clinical pilot trial to study the effectiveness of ice as a supplement to the exercise programme for the management of lateral elbow tendinopathy," Br J Sports Med 2006; 40: 81–85.

[20] D. Stasinopoulos, and I. Stasinopoulos, "Comparison of effects of Cyriax physiotherapy, a supervised exercise and polarized polychromatic non-coherent light (Bioptron light) for the treatment of lateral epicondylitis," Clin Rehab 2006; 20: 12–23.

[21] E. Flores, G. Tobon, E. Cavallaro, F. I. Cavallaro, J. C. Perry, and T. Keller, "Improving patient motivation in game development for motor deficit rehabilitation," Proc. of the 2008 International Conference on Advances in Computer Entertainment Technology (ACE '08). ACM, New York, NY, USA, 381-384.

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 4, Issue 2, March 2015

[22] R. Colombo, F. Pisano, A. Mazzone, C. Delconte, et al., "Design strategies to improve patient motivation during robot-aided rehabilitation," Journal of Neuro Engineering and Rehabilitation 2007, 4(3):33-39.

[23] R. C. V. Loureiro, C. F. Collin, and W. S. Harwin, "Robot aided therapy: challenges ahead for upper limb stroke rehabilitation." In Proc. of 5th Intl. Conf. of Disability, VR & Assoc. Tech. (Sep. 20-22 2004), 4(1):7-11

[24] J. H. Crosbie, S. Lennon, J. R. Basford, S. McDonough, "Virtual reality in stroke rehabilitation: Still more virtual than real," Disabil. Rehabil. 2007, 29(14):1139-1146.

[25] D. J. Reinkensmeyer, and S. J. Housman, "If I can´t do it once, why do it a hundred times?": Connecting volition to movement success in a virtual environment motivates people to exercise the arm after stroke. Virtual Rehabil., 2007, pp.44 – 48.

[26] J. L. McNitt-Gray, "Introduction to Biomechanics," Accessed: 15/12/2014 (http://www.usc.edu/dept/LAS/kinesiology/exsc408l/lab/408_Lab3_AngKin_F13.pdf)

[27] S. Tarja, M. Johannesson, and P. Backlund, "Serious Games - An overview, Technical report," HS-IKI-TR-07-001, 2007, University of Skövde.

[28] N. Hocine, and G. Abdelkader, "A Survey of Agent Programming and Adaptive Serious Games," Accessed: 10/11/2014 (http://hal-lirmm.ccsd.cnrs.fr/lirmm-00577722).

[29] P. Rego, P. M. Moreira, and L. P. Reis., "Serious games for rehabilitation: A survey and a classification towards a taxonomy," 5th Iberian Conference on Information Systems and Technologies (CISTI), 2010, pp. 1-6.

[30] K. Corti, K., "Games-based Learning; a serious business application," PIXEL earning Limited, 2006, Accessed: 10/11/2014 (https://www.cs.auckland.ac.nz/courses/compsci777s2c/lectures/Ian/serious%20games%20business%20applications.pdf)

[31] F. Johannsen, A. Gam, B. Hauschild, B. Mathiesen, and L. Jensen, "Rebox: An adjunct in physical medicine?", Arch Phys Med Rehabil 1993; 74: 438–440.

[32] A. Kountouris, and J. Cook, "Rehabilitation of Achilles and patellar tendinopathies. Best practice and research clinical rheumatology," 2007; 21: 295–316.

[33] K. Khan, J. Cook, J. Taunton, and F. Bonar, "Overuse tendinosis, not tendonitis," The Physician Sportsmed. 2000; 28: 31–46.

[34] K. Khan, N. Maffulli, D. Coleman, and J. Cook, "Patellar tendinopathy: Some aspects of basic science and clinical management," Br J Sports Med 1998; 32: 346–355.

[35] P. J. Visentini, K. Khan, J. Cook, Z. S. Kiss, P. R. Harcourt, J. D. Wark, "The Visa score: An index of severity of symptoms in patients with jumper's knee (patellar tendinosis)," Victorian institute of sport tendon study group. J Sci Med Sport 1998; 1: 22–28.

[36] K. Jensen, and R. Di Fabio, "Evaluation of eccentric exercise in treatment of patellar tendinitis," Phys Ther 1989; 9: 211–216.

[37] B. Kraushaar and R. Nirschl, "Current concepts review: Tendinosis of the elbow (tennis elbow). Clinical features and findings of histological immunohistochemical and electron microscopy studies," J Bone Joint Surg 1999; 81: 259–285

[38] H. Visnes, J. Cook, and R. Bahr, "No effect of eccentric training on Jumper's knee in volleyball players during the competitive season. A randomized clinical trial," Clin J Sports Med 2005; 15: 227–234.

[39] E. Peers, and J. Lysens, "Patellar tendinopathy in athletes. Current diagnostic and therapeutic recommendations," Sports Medicine. 2005; 35: 71–87.

[40] R. Hawary, W. Stanish, and S. Curwin, "Rehabilitation of tendon injuries in sport," Sports Med 1997; 24: 347–358.

[41] K. M. Khan, J. L. Cook, P. Kannus, N. Maffulli, S. F. Bonar, "Time to abandon the 'tendonitis' myth," BMJ 2002; 324: 626–632.

[42] L. Ohberg, R. Lorentzon, and H. Alfredson, "Neovascularisation in Achilles tendons with painful tendinosis but not in normal tendons: An ultrasonographic investigation," Knee Surg Sports Traumatol Arthrosc 2001; 9: 233–938.

[43] R. Vilarta, and B. D. C. Vidal, "Anisotropic and biomechanical properties of tendons modified by exercise and denervation: Aggregation and macromolecular order in collagen bundles," Matrix 1989; 9: 55–61.

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 4, Issue 2, March 2015

[44] L. Cannell, J. Taunton, D. Clement, C. Smith, and K. M. Kahn, "A randomized clinical trial of the efficacy of drop squats or leg extension/ leg curls to treat clinically diagnosed jumper's knee in athletes: A pilot study," Br J Sports Med 2001; 35: 60–64.

[45] D. Stasinopoulos, and M. I. Johnson, "Treatment/management for tendinopathy," Rapid response to [41] article Time to abandon the 'tendinitis' myth. BMJ 2004.

AUTHOR BIOGRAPHY

Konstantinos Katzis received his BEng degree in Computer Systems Engineering and his MSc degree in Radio Systems Engineering from the University of Hull in 2000 and 2001 respectively. In 2001 he became a member of the Communications Research Group at the University of York (UK) were he remained there until the end of September 2006. In March 2002 Dr Katzis attended a professional short-course in parallel with his PhD studies on "Small Terminal Satellite Communications: VSAT Systems" which took place at the University of York. From 2001 to 2006, Dr Katzis has been working towards the development of highly efficient resource allocation techniques as well as handoff techniques optimized for the operation of High Altitude Stratospheric Platform communication systems (HAPs). He has also been looking at the different aspects of Radio resource management, including cognitive radio, fairness in Quality of Service, dynamic spectrum sharing and coexistence of terrestrial and aerial communication wireless networks. Since October 2006, Dr Katzis has been working as an Assistant Professor at the Department of the Computer Science and Engineering at European University Cyprus (EUC). During this time, Dr Katzis has been involved in numerous multi-disciplinary projects such as the improvement of rehabilitation techniques for eccentric patellar exercises.

Demetrios Stassinopoulos is an Assistant Professor of Physiotherapy, coordinator of the programme MSc in Sports Physiotherapy and co-coordinator of the programme BSc in Physiotherapy. His primarily teaching areas include electrotherapy, sports physiotherapy, physiotherapy in musculoskeletal injuries of upper and lower extremities and how to write a scientific essay. He worked as a part-time Lecturer, from 2007 to 2011, at T.E.I. Lamias School of Physiotherapy (modules electrotherapy I and physical therapy in musculoskeletal injuries of upper and lower extremities) and, from 2010 to 2012, at the European University of Cyprus, Nicosia, Cyprus (modules electrotherapy I and II). He completed his PhD studies in the Leeds Metropolitan University, UK where his research focused on the management of tendinopathy using electrotherapeutic and non-electrotherapeutic modalities. He has presented his research findings in many seminars, conferences and symposiums. He is a reviewer in 16 journals and member of the editorial board in 10 journals. His current research and clinical interests focus on tendinopathy management, electrotherapy, rehabilitation of musculoskeletal injuries of upper and lower extremities, epidemiology of sports and musculoskeletal injuries, validity and reliability of questionnaires in Greek and systematic reviews in the area of musculoskeletal injuries assessment, prevention, and rehabilitation