Designing of an expert system for the prediction of the Tennis Elbow injuries

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Abstract

The present study attempts to provide a technique for the prevention of the tennis elbow that develops over time due to repetitive overuse of the elbow. The tendon attachment at the elbow gets small tears causing excessive pain in the arm and elbow. An electronically controlled vibrating tool is developed that vibrates on the detection of incorrect arm movements. Various features of the developed simple electronic vibratory tool are discussed and compared with the existing techniques for the treatment of tennis elbow injury. The developed tool has the potential to effectively prevent tennis elbow injury in sportspersons and many industrial workers. The developed tool also helps to monitor and self-train the arm movements in such a way that the tennis elbow and its possible relapse can be avoided.

Keywords: Tennis Elbow, Epicondylitis Lateralis Humeri, Vibration, Accelerometer, and micro-controller.

1. Introduction

Epicondylitis lateralis humeri also known as tennis elbow causes pain at the lateral epicondyle of the humerus and on resisted dorsiflexion of the wrist [1]. Most of the tennis players and even other athletes who play golf, cricket, baseball, etc. report the condition of tennis elbow frequently. However, it is not limited to athletes since the sectors that has highest incidence rate of tennis elbow are construction, industrial manufacturing, and wholesale retail where repetitive motions of the wrist and arm are involved [2]. Dimberg reported that tennis elbow condition in 7.4 % of industrial workers and 40-50 % of regular tennis players in the United States of America [3]. Tennis elbow occurs as a result of repetitive microtrauma to the musculotendinous unit causing inflammatory and degenerative tissue damage [4]. In general practice 1-3 % of patients in a year are found to be with this condition according to a report [5]. Moreover, the persons with age above 40 years are more susceptible to the condition of tennis elbow [6]. If not treated, it can cause long-term disability in both men and women.

The first steps in managing lateral epicondylitis is a non-surgical treatment. A combination of technique modification, rest, applying ice, and Non-steroidal anti-inflammatory drugs (NSAID) are effective techniques for reducing inflammation and tendon strain that promotes cellular repair. However, when the injury is worse and the pain is chronic causing pale response to the initial treatment, physical therapy is initiated; the most common of which is ultrasound, electrical stimulation, manipulation, soft tissue mobilization, neural tension, friction massage, and stretching-strengthening exercise. Other new techniques include laser, acupuncture, and extracorporeal shock wave therapy. Surgery is persevered only to chronic and resistant cases [7]. Roughly 90% of patients achieve resolution of symptoms at 1 year without any treatment, and this occurs regardless of symptom duration before trial enrollment [8]. The prolonged duration for symptoms resolution leads to a higher societal and economic loss for the patients due to absenteeism and inability to work in working environment.

As mentioned earlier, tennis elbow is caused by repetitive overuse of the elbow that results in hypovascularity in the elbow area. The people who have the history of tennis elbow are advised to avoid bending of wrist, avoid frequent bending and straightening of arm, and avoid repetition of the same movement with same hand [9]. However, the athletes playing various sports (viz. tennis, cricket, baseball, golf, etc.) who may or may not have the history of tennis elbow injury finds it difficult to avoid such movements as it may affect their performance. Moreover, after recovering from the tennis elbow, there are comparatively higher chances of relapse. Therefore, prevention of tennis elbow is critical and the technological tools that can help prevent tennis elbow are the need of the hour. In the literature, there is not a single attempt of study made so far developing the prevention technique for tennis elbow injury.

The present study aims to offer a prevention technique using a vibratory tool that detects the undesired motion of the arm including wrong bending movements of the arms and wrist as well as motions of the arms that produces jerks. The vibration produced during such undesired motion helps the athletes or the patients to identify the movements that should be avoided help train them so that they can avoid the future relapse of tennis elbow. Moreover, the vibrations produced due to undesired movements of the arms also helps to relieve the muscle stresses.

2. Methods and Materials

A digital accelerometer (ADXL345) (refer to Fig. 1) capable of measurement in three axis (X, Y, and Z) with sensitivity level up to 16g has been used for the detection of the accelerated movements. A vibration motor shown in Fig. 2 (1.5 mm displacement, 55 Hz frequency, 22 m/s^2 acceleration) is capable of vibrating in all three mutually perpendicular axes and controlled through the accelerometer. 8-bit AVR Microcontroller (32K Bytes in-system programmable flash) shown in Fig. 3 is used to program the control action of the vibration motor.

2.1 Features of the present prototype model

Fig. 4 shows the prototype model of the tennis elbow remediation tool (named ‘vibra-elbow’ for simplicity to readers) that helps controlling the arm movements of the person to prevent tennis elbow injury. Vibra-elbow can also be useful for the athletes to modify their techniques so that they may prevent the tennis elbow or its relapse.

Fig. 1 Accelerometer

Fig. 2 Vibration motor

2.2 Movement detection

The Vibra-elbow is capable of detecting the movements of the arm that are to be avoided for prevention of tennis elbow. It will send an indication in the form of vibration only if the arm movements exceeds the pre-determined value of acceleration, beyond which it cause jerks while working with the arms.

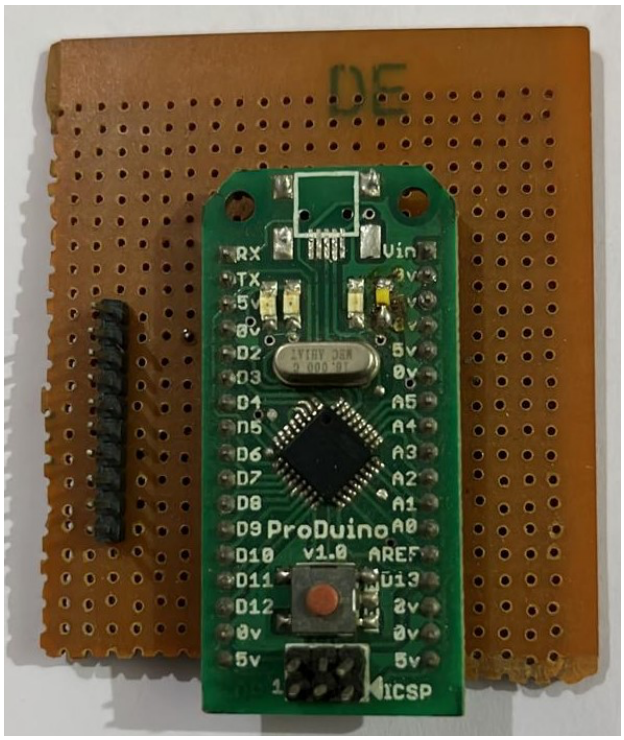

Fig. 3 Vibra-elbow prototype model

2.3 Stress relief through vibration

The utilization of the Vibra-elbow also reduces the pain of the person by relieving the muscle's stress caused due to undesired movements of the arms.

2.4 Self-training for guided movements

The Vibra-elbow can be effectively utilized for the self-training of the individuals for modifying their techniques in work including the sports involving repetitive arm and wrist movements and other industrial works like painting, canvasing, carpentry, plumbing etc.

2.5 Painless and simple to use

The Vibra-elbow is to be attached at the arm circumferentially making it painless, quick wearable, and simple to use.

2.6 USB charging

It uses a rechargeable battery that can be charged through USB cable on the go. The battery life is comparatively higher for uninterrupted functioning since the vibrator gets turned on only when incorrect movement of the arm is detected by the sensor unlike other vibratory tools.

3. Comparison with the existing treatments

Various treatments have been reported including acupuncture [10], autologous blood injection in the joint [11], local corticosteroid injections [12], shock-wave therapy [13], iontophoresis [14], laser [15], oral and

topical NSAID [16], electromagnetic pulse [17], surgery, and ultrasound [18]; however, none of these method talks about the prevention of this injury.

3.1 Acupuncture

A sterile needle is inserted 2 cm into the acupuncture point known as classical Chinese acupuncture point. The inserted needle is manipulated manually until the patient feels Deqi (varying sensation of tension, tingling, numbness, and tenderness). The patient is then asked to move the injured arm and perform general active flexion and extension mobilizing exercise for few minutes. This technique is effective to reduce pain in the injured arm. Treatment time is 2-3 weeks.

3.2 Autologous blood injection in the joint

Autologous plasma injection (rich in platelet) are given in the elbow joint with a single dose of approx. 1.5-2 ml. Patients are discharged with instruction of taking rest for 24 hrs. Paracetamol or the ice packs are prescribed for the pain relief. After 24 hrs. stretching protocol is to be followed for at least 3 weeks. After 6 weeks normal sporting activities are allowed as per the tolerance of the patient.

3.3 Corticosteroid injections

It is used for the faster pain relief with the recovery in tennis elbow; however, it may worsen the condition in the long run [19].

3.4 Shock-wave therapy

The shock waves (120 to 240 pulses per minute) are applied under local anesthesia with pulses of range up to 2000 within the interval of one week. It is important to mention some side effects of the shock-wave therapy including reddening of the skin, pain, haematomas, swelling, migraine attacks, etc. [20].

3.5 Iontophoresis

It is also known as the ionization in which a drug such as corticosteroid is introduced through the skin using an electrical charge. The treatment time may vary up to 4 months depending on the recovery rate. Mild adverse effects on the skin such as skin vesicles, blisters, atopic dermatitis, erythema, burning sensation, local skin reaction, hypersensitivity, and pruritus are reported while using iontophoresis for treating tennis-elbow [21].

3.6 Laser therapy

Low Level Laser Therapy (LLLT) utilizes near infrared or red wavelength light over injurious cells to stimulate repairing of the cells. LLLT has a pronounced anti-inflammatory and healing effect on the swollen tendons of the elbow and surrounding inflamed soft tissues.

3.7 Oral and topical NSAID

NSAIDs (e.g. ibuprofen, diclofenac, celecoxib) are preferably taken to reduce the pain. NSAIDs are available either in gel form as well as tablet form that can be either applied directly to the skin or can be consumed orally, respectively. Very rare cases of side effects on applying gels are reported [16].

3.8 Electromagnetic pulse

There are two methods of electromagnetic pulse to be used as the therapeutic agent. In the first method, the opposing electrodes are in direct contact with the skin surface surrounding the elbow tissues while in the second method no direct contact with the skin tissues is required. Moreover, the effectiveness of this method for tennis-elbow treatment is not appreciable and requires unexpectedly longer time [17].

3.9 Surgery

Surgery for tennis elbow removes the damaged tendon to ease pain and help you move your elbow more easily. The surgery can be done in one of two ways: by open surgery or arthroscopy. In an open surgery, the damaged piece of tendon is replaced by a healthy part. In arthroscopy, very small instruments and camera go through small hole and tiny parts of the damaged tendon are removed. The surgery has drawbacks of high cost, reduced strength and flexibility, and longer recovery time [22].

3.10 Ultrasound

Ultrasound are the sound waves which can be produced through either piezoelectric or magnetostriction method. Ultrasound vibration relieves the pain of the tennis elbow and therefore reduces the medications required for the pain relief. However, ultrasounds' effectiveness is found inferior to shock wave therapy [23].

All these techniques mentioned in the literature are the cure of the tennis elbow with varying effectiveness and efficiencies and does not guarantee the assured treatment. All the treatment has different effectiveness in various aspects of recovery including grip strength, flexibility, pain relief, etc. but none succeeds to take care of all [24]. Therefore, avoiding the muscle's movements are critical in order to avoid such injuries for the sportspersons as well as industrial workers. The prevention of the tennis elbow can be possible with the use of the present product that does simultaneous functions of training the individual to self-prevent the arm movements that leads to repetitive overload on tendon and cause tiny tears.

4. Conclusions

The treatment of the tennis elbow cannot be considered as the solution to the most common problem of athletes and industrial workers, instead the way of preventing the tearing of tennis elbow tendon has much more importance. The present study and the prototype developed puts the light on the idea of preventing the motions of the arms and self-train the individual by continuously guiding their motions. The developed prototype of the model and the product concept has the commercial potential due to its economic feasibility and since it attempts to solve the much-emphasized problem of tennis elbow that occurs to the most of the athletes and industrial workers in their service life.

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