Comparison of the Accuracy of Quadriceps Isometric Exercise between Using Quadriceps Education Device (QED) and Not Using QED for Osteoarthritic Knee Patients: A Randomized Controlled Trial

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Objective: *To compare the accuracy when osteoarthritic knee patients do quadriceps isometric exercise using quadriceps education device (QED) and not using QED after being instructed on the exercise program by doctors.*
Material and Method: *A randomized controlled study was conducted. Sixty patients were divided into 2 groups, QED group (patients using QED) and non-QED group (patients not using QED). We developed the Quadriceps Educational Device (QED). All patients were instructed on the quadriceps exercise method. Patients in the QED group were instructed to use the QED device and received the QED to take back and conducted the exercises at home. After 2 weeks, both groups of patients were tested by asking them to do the quadriceps exercise without using the QED. The accuracy of the quadriceps exercise was analyzed to determine the statistical difference. Chi-square test was used for statistical analysis.*
Results: *The number of patients in the QED group that conducted accurate quadriceps exercise totaled 23 patients (79.3%), while the number of non-QED was reduced to 8 patients (28.6%). The results were significantly different in statistic ($p < 0.01$). Patients in the QED group conducted the quadriceps exercise more accurately than the non-QED group.*
Conclusion: *The osteoarthritic knee patients, who used QED, can do the quadriceps isometric exercise more accurately than those who did not use the QED after being instructed on the exercise program by doctors.*

Keywords: *Osteoarthritis, Quadriceps isometric exercise, Quadriceps education device (QED)*

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Quadriceps exercise is recommended in patients who have osteoarthritis of the knee as it helps to increase the strength of knee and quadriceps muscle which will lessen the pain and knee instability[1-3]. There are 3 basic principles of quadriceps exercise: isotonic, isokinetic and isometric exercise. Isometric exercise is the most suitable way to suggest to patients. It is easy and safe, so the patients are able to carry out the exercise at home[4]. For the patients who do not do it accordingly, they did not have a full understanding and did not comprehend the necessity of knee exercise program. It is also found that despite the knowledge given, most patients, who were mainly the elderly, tend

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to forget how to exercise as advised. As a result, they exercised incorrectly when they had to do the exercise at home by themselves[5,6].

The Quadriceps Educational Device (QED) is invented to help patients do the accurate exercise with the right amount and with the correct timeframe. It helps to increase strength of the quadriceps muscle and reduce pain in the knee joints. The purpose of this device is to help patients conduct the quadriceps exercise accurately. If patients are able to exercise with the device correctly, they will be able to do the exercise correctly and effectively without the device as well.

The purpose of this study is to compare the accuracy of quadriceps isometric exercise between osteoarthritic knee patients using the QED and the patients not using QED after both have been given the instructions.

Material and Method

We developed the Quadriceps Educational Device (QED) (Fig. 1). The QED consists of 2 aluminum axles, the 25-centrimetres-axle attached to the thigh and the 20-centrimetres-axle attached to the calf. Both axles are connected with 2 elastic pads. The black elastic pad is attached around the patient's thigh while the brown pad is attached around the calf. QED has the degree indicator which is the movable adjusting tool. The adjustable measuring knot is used to adjust the bending joint to fit with each patient (as some of them have problems of not being able to stretch their knees up to the maximum or bending their knees up to the length). There is a sensor at the aluminum axle on the calf near the movable adjusting tool which receives the signal via the 110 centimeters cable to microelectronic box when the patient exercises correctly. The signal will be sent to the microelectronic box controlled by microprocessor. The microelectronic box has 2 light indicators (yellow and red) along with the on-off switch on the bottom of the box.

The adjustable measuring knot has a magnet attached at the rim. When it stops at the sensor, the sensor will send the signal to microprocessor control located in the electronic box, and then the microprocessor will start computing.

A sensor is used to examine if the patient does the correct exercise at the right position. If the position is correct, the device will start timing the exercise until the set time (T1) and then cut down the amount of counter (C1) by 1. When cycle 1 complete, the device starts timing the pausing time (T2), which is the time patient uses for resting until the next exercise cycle (C2). When T2 is completed, the device will load the value of C1 in order to let the patient continue until the end of circle C2. The device has 3 indicators: the LCD, 2 light indicators and sound indicator in each step of operation.

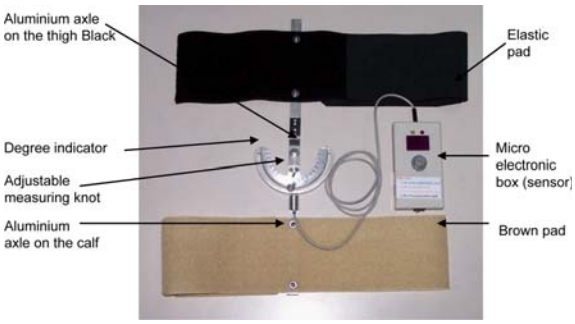

Fig. 1 QED component

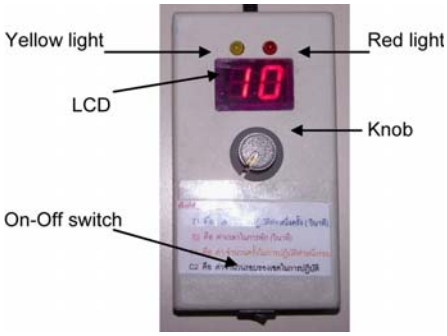

Fig. 2 Contents of microelectronic box

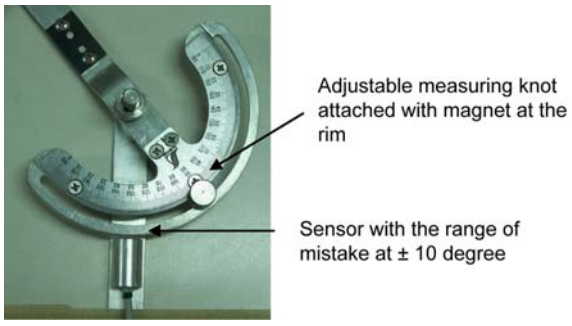

Fig. 3 Adjustable measuring knot

Between January 2007 and March 2007, 60 patients were divided into 2 groups, the QED and the non-QED group, 30 patients for each. Patient selection criteria included patients who were diagnosed with knee osteoarthritis and ages over 50 years. The

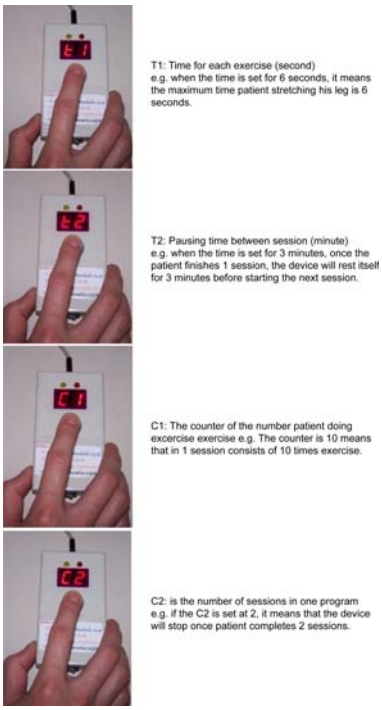

Fig. 4 Operating functions (T1-T2 and C1-C2)

Fig. 5 Quadriceps exercise was done with QED

patients who have never been instructed quadriceps exercise or have been instructed but still cannot do it correctly were included. Every patient is able to walk without a supporting device. Exclusion criteria were experiencing knee operation, having the history of neuromuscular disorder, flexion contracture more than 10 degree, and unable to talk or communicate.

All patients were instructed on the quadriceps exercise method, starting with sitting on a chair and bending his knee and hip joints for 90 degree. Next, stretch that leg up to the maximum extent and hold it at that position for at least 6 seconds then put the knee back to the initial 90 degree position. This is counted as one time. After finishing, pause for 20 seconds. Repeat the same exercise 10 times to strengthen up the muscle. All these are counted as one session. Change the leg and repeat all steps. The patient should do this exercise for 3 sessions daily by spreading the program into morning, afternoon, and evening session.

Patients in the QED group were instructed to use the QED device and received QED to take back and conducted exercise at home. After 2 weeks, both groups of patients were tested by asking them to do quadriceps exercise without using the QED. The researcher asked the patients from both groups to demonstrate the exercise10 times. The accuracy of quadriceps exercise was analyzed to determine the statistical difference.

Quadriceps exercise is accurate when patient can fully stretch his leg and hold it tensely at least 6 seconds but not more than 15seconds before bending it back to the initial position. This is counted as a one time exercise. The exercise must be repeated at least 8 times it is then recognized as a correct exercise (the acceptable mistake of this study is 2 out of 10 which is 20 percent).

Statistical analysis

Demographic data and accuracy of quadriceps exercise was presented in percentage. Chi-square test was used for statistical analysis.

Results

The research population of 60 patients was divided into 2 groups, the QED and the non-QED group with 30 patients for each. However, one patient in each group lost follow-up. The number of male and female patients for each group were the same, 2 male patients (6.9%) and 27 female patients (93.1%). The average age of patients in the non-QED group was 60.69 $\pm$ 8.260 and 61.86 $\pm$ 8.717 in the QED group.

The educational level of the non-QED patients were 2 uneducated (6.9%), 12 primary school educated level (41.4%), 11 secondary/high school educated level (37.9%), 11 undergraduate level (37.9%) and 0 post-graduate level.

The educational level of the QED patients were 2 uneducated (6.9%), 15 primary school educated level (51.7%), 5 secondary/high school educated level (17.2%), 6 undergraduate levels (20.7%), and 1 post-graduate level (3.4%).

The proportion of patients who have bilateral and unilateral knee symptom in each group is the same, 26 bilateral knee patients (89.7%) and 3 unilateral knee patients (10.3%). Most of the patients have never been instructed about how to do quadriceps exercise,

20 patients in non-QED group (69%) and 23 patients in QED group (79.3%) (Table 1).

In the QED group, the number of patients who demonstrated the correct quadriceps exercise was 23 (79.3%) compare to 8 in non-QED group (28.6%). We conducted statistical analysis by using Chi-Square test and the result showed a significant difference ($p < 0.01$) (Table 2).

Discussion

Knee osteoarthritis is often found in the elderly. The most common symptom is pain at the knee joint. Some patients experience severe pain that interferes with their daily lives. Physiotherapy can help reduce the pain, decrease joint toughness, and increase knee function efficiency. However, there were some problems that occurred among the patients[6-11]. Although most patients had been instructed by the doctor about how to do the appropriate exercise as the treatment, the result was not impressive as most patients were not aware of the positive outcome that the exercise could bring and neglected it. In addition, the elderly patients tended to forget the correct exercise method when they did it at home, so they did if wrongly[5,6].

The study showed that most patients were female and experienced bilateral knee pain. There were new and recurrent patients who still could not do the exercise correctly. The study showed that 74.13% of patients in both groups (QED and non-QED) have never been instructed on the quadriceps exercise method, even though some of them were recurrent patients. All these showed that patients have not been properly instructed and made known of the conservative exercise. The 25.87% of the patients, who had been instructed, still could not do the exercise correctly. This meant that even the doctor's instruction alone could not bring an effective result.

Table 1. General information of QED and non-QED group

Variable	Non QED group (n = 29) Number (%)	QED group (n = 29) Number (%)
Age		
Average age (year)	60.69	61.86
Standard deviation (SD)	8.260	8.717
Gender		
Male	2 (6.9%)	2 (6.9%)
Female	27 (93.1%)	27 (93.1%)
Educational level		
Uneducated	2 (6.9%)	2 (6.9%)
Primary educated	12 (41.4%)	15 (51.7%)
Secondary/High school educated	11 (37.9%)	5 (17.2%)
Undergraduate	4 (13.8%)	6 (20.7%)
Post graduate and above	0	1 (3.4%)
Number of affected knee		
Unilateral	3 (10.3%)	3 (10.3%)
Bilateral	26 (89.7%)	26 (89.7%)
Previous experience on Quadriceps exercise		
Yes	9 (31%)	6 (20.7%)
No	20 (69%)	23 (79.3%)

Table 2. Excercise accuracy in QED and non-QED group

Exercise Accuracy	Non QED group Number (%)	QED group Number (%)	p-value
Number of patients with accurate exercise	8 (28.6%)	23 (79.3%)	<0.01
Number of patients with inaccurate exercise	21 (72.4%)	6 (20.7%)	

The QED was invented to solve these problems. However, there are slight problems found when using the QED such as the device assembling on the patients' thighs before an exercise and the misallocation of the sensor resulting to the wrong exercising. Despite that weakness, most of the patients experiencing the device have been satisfied with it and using the device correctly. Hence, QED is a useful device to help patients have a better understanding of quadriceps exercise that results in an accurate exercise.

Conclusion

The study confirms that the patients, who use the QED, can do the exercise more accurately than being instructed by the doctor alone. This means that when patients do the quadriceps exercise correctly, their muscles will be strengthened. The result is less knee pain as well as a more effectively functioning knee.

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เปรียบเทียบความถูกต้องของการบริหารกล้ามเนื้อต้นขา (Quadriceps Muscle) แบบไอโซเมตริก (Isometric Exercise) ระหว่างการใช้เครื่องมือ Quadriceps Education Device (QED) กับการบริหารกล้ามเนื้อต้นขาโดยไม่ใช้เครื่องมือ QED ในผู้ป่วยข้อเข่าเสื่อม โดยการทดลองแบบสุ่ม

สาธิต เที่ยงวิทยาพร, ภูมิบาล เวศย์พิริยะกุล, ยุพดี ฟู่สกุล, ทวีป งามสม, ปราโมทย์ วัฒนวิทย์, เจษฎาพงษ์ ปิ่นทองทันธ์

วัตถุประสงค์: *เพื่อเปรียบเทียบความถูกต้องของการบริหารกล้ามเนื้อต้นขาแบบไอโซเมตริก (Quadriceps isometric exercise) โดยใช้เครื่องมือ Quadriceps Education Device (QED) และการบริหารกล้ามเนื้อต้นขาแบบไอโซเมตริกโดยไม่ใช้เครื่องมือ QED ในผู้ป่วยข้อเข่าเสื่อม หลังจากได้ทำการสอนผู้ป่วยในการบริหารกล้ามเนื้อต้นขาโดยแพทย์*

วัสดุและวิธีการ: *เครื่องมือ QED เป็นนวัตกรรมที่คิดขึ้นใหม่โดยคณะผู้นิพนธ์ โดยมีแนวคิดที่จะช่วยในการบริหารกล้ามเนื้อต้นขาได้อย่างถูกต้องมากขึ้นกว่าการสอนผู้ป่วยแบบปกติ ศึกษาโดยแบ่งผู้ป่วยข้อเข่าเสื่อมโดยการสุ่มเป็น 2 กลุ่ม ได้แก่ กลุ่มที่ใช้เครื่อง QED และกลุ่มที่ไม่ใช้เครื่อง QED ทำการสอนผู้ป่วยในการบริหารกล้ามเนื้อต้นขา และกลุ่มที่ใช้เครื่อง QED จะได้รับการสอนการใช้งานเครื่องมือเพิ่มเติม ประเมินผลที่ 2 สัปดาห์ โดยให้ผู้ป่วยทำการบริหารกล้ามเนื้อต้นขาให้ผู้ประเมินดู โดยในกลุ่ม QED ให้ทำการบริหารโดยไม่ใช้เครื่องมือประเมินความถูกต้องตามเกณฑ์ และนำข้อมูลที่ได้มาวิเคราะห์ทางสถิติโดยใช้ Chi-square test*

ผลการศึกษา: *การใช้เครื่องมือ QED ทำให้การบริหารกล้ามเนื้อต้นขา ทำได้อย่างถูกต้องจำนวน 23 คน (79.3%) เมื่อเทียบกับการไม่ใช้เครื่อง QED ทำถูกต้องเพียง จำนวน 8 คน (28.6%) เมื่อนำมาวิเคราะห์ทางสถิติพบว่ามีความแตกต่างกันอย่างมีนัยสำคัญ ($p < 0.01$)*

สรุป: *การใช้เครื่องมือ QED ช่วยในการบริหารกล้ามเนื้อต้นขา ทำให้การบริหารกล้ามเนื้อต้นขาทำได้อย่างถูกต้องมากกว่าการสอนปกติ ซึ่งน่าจะทำให้เกิดความแข็งแรงของกล้ามเนื้อมากขึ้น ส่งผลให้อาการปวดลดลง และผู้ป่วยสามารถใช้งานของข้อเข่าได้ดีขึ้น*