The Efficacy of a Muscle Exercise Program to Improve Functional Performance of the Knee in Patients with Osteoarthritis

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Abstract

Osteoarthritis (OA) is a common chronic and progressive degenerative joint condition. A major consequence of knee OA is physical disability ; especially difficulty with activities requiring ambulation and transfer, which are necessary to maintain independence and a good quality of life. The purposes of this study were to determine the efficacy of a muscle exercise program along with education about knee care, and investigate the clinical factors which influence its therapeutic efficacy. A prospective study was carried out among elderly Thai people aged 60 years and over, living in an urban community of the Bangkok metropolitan area around Siriraj Hospital, between October 1997 and September 1999. The number of elderly people with osteoarthritis of the knee was 392 (male : female=86:306) with a mean age of 67.7±6 years. They were interviewed for demographic data and information about their symptoms. The range of the knee movement, quadriceps strength and the six-minute walking distance and a knee X-ray were evaluated. Group exercise was arranged twice a week for 8 weeks for the intervention group only. The results of the study revealed that the quadriceps strength in the intervention group had a tendency to increase and the walking distance was significantly improved especially in the first two months but there was a tendency to decline by the sixth and twelfth month after enrollment. On the other hand, there was no statistically significant difference of both important outcomes for the control group when assessed in the second month. The findings at the sixth and twelfth month after enrollment were that the quadriceps strength was slightly increased but the walking distance was decreased when compared with the initial assessment. An exercise frequency of 12 sessions in two months was sufficient to improve muscle strength and walking distance. Group exercise produces a significant improvement in strength and walking ability, especially in the first two months. Deterioration over time could be due to multiple factors, such as lack of regular exercise, lack of motivation, lack of family support or poor economic status, so we should encourage the elderly to exercise regularly.

Key word : Osteoarthritis, Knee, Efficacy of Exercise, Functional Performance

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Osteoarthritis (OA) of the knee is the most common chronic joint disease found in elderly people[1]. The prevalence of knee OA in the U.S. is 35 per cent[2]. The major symptoms of OA are pain and stiffness. In addition to pain or discomtort, the major clinical consequence is physical disability ; specifically, difficulty with activities such as walking, climbing stairs, rising from a chair, getting in and out of a car, lifting and carrying. These activities are essential for independent living and to maintain a reasonable quality of life[3,4].

The clinical and functional status of knee OA patients appears to worsen gradually over time[5]. Because of its high prevalence and consequences, knee OA is a significant public health problem among the elderly[3,6]. Methods to prevent or reduce disability from this disease are therefore very important.

At the present time, no treatment can stop the osteoarthritic process[7]. Therefore, therapeutic aims focus on relieving pain, reducing stiffness and improving muscle strength and functional ability. Conservative treatment is used as the initial intervention[8], which includes medication, orthotics and physical therapy. The use of nonsteroidal anti-inflammatory drugs (NSAIDs) is associated with an increased risk of peptic ulceration[9]. In addition, these drugs rarely relieve symptoms completely. Surgical intervention relieves symptoms in some patients but is expensive and also associated with surgical risk. Education and counseling may help patients with osteoarthritis[10].

In this study, the authors investigated the efficacy of a muscle exercise program together with education about knee care on improvement in the functional performance of knee OA patients. This was investigated in relation to clinical factors, such as age, sex, use of medication, pain score graded, severity and body mass, all of which can influence the efficacy of any therapeutic measure applied.

METHOD AND SUBJECTS

Three hundred and ninety-two elderly people were recruited as volunteers from the urban community of the Bangkok Metropolitan area around Siriraj Hospital, between October 1997 and September 1999. More than ninety per cent of subjects had grade 2 or 3 OA, as judged by the criteria of Kellgren and Lawrence[11], based on weight-bearing radiographs. All subjects were interviewed to obtain demographic data, knee pain, the severity of OA knee[12] (score ranged from 10-30), pain and satisfaction score, health status (AIMS arthritis impact subscale)[13], use and frequency of medication, quality of life, height and weight (for calculation of body mass index, BMI)[14], and functional incapacity score (Modified Bandi's criteria of functional incapacity scale score[15], score ranged from 0-20).

Baseline measurements were conducted before and after two months of rehabilitation, (group exercise for the intervention group only) and six and twelve months after the initial assessment of the program.

The rehabilitation protocol

All subjects were divided by cluster random sampling into 2 groups; 193 in the control group and 199 in the intervention group. Only the intervention group attended the exercise class, which emphasized quadriceps muscle strengthening. The protocol required subjects to join two exercise sessions per week, each lasting one hour. The program lasted for 8 weeks, during which the subjects continued their usual medical treatments. They were supervised by one physical therapist.

Outcome measurement

Measurements of quadriceps muscle strength were conducted for either the right or left affected leg by using a leg dynamometer. Maximal isometric force for knee extension was determined. Two trials were performed at each examination. The highest value was recorded.

The range of motion for flexion and extension of the knee was evaluated by using a goniometer on two occasions. The highest value was recorded.

The total walking distance in six minutes was assessed. All subjects were encouraged to walk as fast as they could with or without any gait aids. They could stop and take a rest if they couldn't walk further due to their physical fitness or other medical conditions. The total distance walked within six minutes was recorded.

Data analysis

ANOVA, Friedman and Cochran's Q test were applied to compare measured values before, after intervention, and at the end of the follow-up within the same group. A *t*-test, Mann-Whitney U test and Chi-square test were used to compare measured values between the two groups with 95 per cent

confidence interval to measure the efficacy. A *p*-value less than 0.05 was considered statistically significant.

RESULTS

The demographic characteristics of the 392 patients at entry to the study are summarized in Table 1. The age of the patients ranged from 60 to 88 years. Both the intervention and control groups included more women than men, but gender distribution was similar between the two groups ($p = 0.598$). The two groups did not differ regarding income, educational level, medication use, BMI and severity grading of knee OA. The mean duration since diagnosis of osteoarthritis was 46 ± 42 months for the control group and 44 ± 38 months for the intervention group ($p = 0.62$).

Compliance

One hundred and seventy-three patients (86.93%) in the intervention group completed the 8 week exercise program and were retested; 193 patients in the control group were also retested at the conclusion of the study. The average number of program sessions attended by patients in the intervention group was 10.5 ± 5.4 sessions (range 1 to 16 sessions).

Outcomes

The subjective and objective outcomes of the intervention and control groups at the initial program are shown in Table 2. All variables are not different except range of motion : degree of lack of extension and 6-minute walking distance. Comparison of the percentage of the elderly who could walk more than 439 meters in 6 minutes which was the average distance for normal elderly persons in the pilot study is shown in Table 3. Baseline and post-intervention measurements and outcomes for the control and intervention groups are summarized in Table 4 and 5 respectively. There are statistically significant differences in health score, pain score and satisfaction score between both groups but these are all subjective evaluations. The functional incapacity score shows a trend to a decreasing score especially in the intervention group, which means functional improvement.

After intervention, the walking distance in the intervention group increased an average of 30 meters from the baseline of 389 ± 85 meters, which

Table 1. The demographic characteristic data of all the subjects : control and intervention groups.

Variables		Control group N	Control group %	Intervention group N	Intervention group %	p value
Sex :	Male	45	23.3	41	20.6	0.598
	Female	148	76.7	158	79.4	
Age (year)		67.6 ± 6.1		67.9 ± 5.7		0.601
Duration of knee pain (month)		46.4 ± 42.1		44.3 ± 38.3		0.618
Income :	Yes	185	95.9	187	94.0	0.39
	No	8	4.1	12	6.0	
Education :	Yes	157	81.3	165	82.9	0.784
	No	36	18.7	34	17.1	
Medication use (regularity)		67	34.7	66	33.2	0.798
Body mass index :	Normal	80	51.0	65	48.5	0.892
	Overt	59	37.6	54	40.3	
	Obese	18	11.5	15	11.2	
Severity of knee OA :	Mild	108	56.0	111	55.8	0.854
	Moderate	84	43.5	85	42.7	
	Severe	1	0.5	3	1.5	

Table 2. The subjective and objective outcomes of the control and intervention groups at entry.

Variables	Control group Mean ± SD	Intervention group Mean ± SD	p value
Health score+	6.05 ± 1.80	6.22 ± 1.65	0.345
Pain score++	5.62 ± 2.18	5.32 ± 2.20	0.164
Satisfaction score+	6.85 ± 2.33	6.83 ± 2.00	0.940
Functional incapacity score++	7.19 ± 3.83	6.87 ± 3.47	0.288
ROM of knee : Flexion (degree)	121.41 ± 7.33	121.97 ± 10.85	0.557
Extension (degree lack)	10.50 ± 6.05	13.17 ± 7.42	<0.001*
Quad. strength (kilogram)	13.07 ± 6.14	12.8 ± 4.8	0.612
Walking distance in 6 min. (meter)	344.66 ± 10.09	382.24 ± 9.37	<0.001*

\+ The higher the score, the better the outcome
++ The higher the score, the worse the outcome
* Statistically significant

Table 3. Comparison of the percentage of the elderly who could walk more than 439 meters in 6 minutes in the pilot study.

Duration	Control group (%)	Intervention group (%)	p value
Initial	20.2	26.8	0.159
2 months	11.2	41.0	< 0.001*
6 months	10.3	37.7	<0.001*
12 months	7.9	26.1	<0.001*

* Statistically significant

Table 4. The baseline and post-intervention measurement and outcomes of the control group.

Variables	Start	2 months	6 months	12 months	p value
Health score	6.28 ± 1.89	6.09 ± 1.68	6.47 ± 1.68	6.86 ± 1.97	0.01*
Pain score	5.71 ± 2.0	5.15 ± 2.26	5.07 ± 2.53	4.57 ± 2.69	0.047*
Satisfaction score	7.18 ± 2.11	6.92 ± 1.87	7.55 ± 1.74	7.79 ± 2.07	0.004*
Functional incapacity score	6.90 ± 3.75	6.38 ± 3.58	6.09 ± 3.44	6.32 ± 3.63	0.037*
ROM : Flexion	121.50 ± 8.04	119.27 ± 6.19	118.96 ± 5.61	118.02 ± 6.07	0.009*
Lack extension	10.12 ± 5.77	7.24 ± 4.41	5.87 ± 8.16	4.47 ± 3.49	0.041*
Quad. strength	13.01 ± 6.16	13.21 ± 6.24	13.79 ± 6.28	13.46 ± 6.11	0.025*
Walking distance	354.49 ± 93.24	354.73 ± 80.94	341.49 ± 73.83	341.51 ± 72.95	0.044*

* Statistically significant

represents an 7.7 per cent increase in the distance walked. In contrast, the mean distance walked in 6 minutes by the control group decreased an average of 13 meters from a baseline of 354 ± 93 meters.

The strength of the quadriceps in the intervention group increased by an average of 2.5 kilograms from the baseline of 12.7 ± 4.6 kilograms (20% increase in strength) but the strength in the control group increased slightly by an average of 500 grams from the baseline of 13 ± 6 kilograms or about a 4 per cent increase in strength.

The frequency of group exercise sessions in the intervention group related to the six minute walking distance is shown in Table 6. The elderly who attended the 12-session-group exercise had better average walking distances than the elderly

Table 5. The baseline and post-intervention measurement and outcomes of the intervention group.

Variables	Start	2 months	6 months	12 months	p value
Health score	6.05 ± 1.56	6.66 ± 1.86	6.51 ± 1.61	6.86 ± 1.79	0.011*
Pain score	5.35 ± 2.01	4.14 ± 2.28	4.06 ± 2.53	4.25 ± 2.70	0.000*
Satisfaction score	7.04 ± 1.80	7.20 ± 1.97	7.58 ± 1.94	7.59 ± 2.01	0.012*
Functional incapacity score	6.74 ± 3.15	6.08 ± 3.14	5.39 ± 3.61	5.28 ± 3.46	<0.001*
ROM : Flexion	122.25 ± 13.25	121.01 ± 4.50	118.42 ± 5.55	118.53 ± 6.21	0.001*
Lack extension	12.94 ± 7.7	10.16 ± 6.08	5.79 ± 2.38	4.11 ± 2.99	<0.001*
Quad. strength	12.74 ± 4.66	13.89 ± 5.61	15.30 ± 6.78	15.12 ± 6.52	0.024*
Walking distance	388.82 ± 84.83	417.06 ± 84.39	402.94 ± 92.57	382.91 ± 96.40	0.006*

* Statistically significant

Table 6. The frequency of exercise and the six minute walking distance in the intervention group.

Exer. freq. (number)	Walking distance (meter)	Exer. freq. (number)	Walking distance (meter)	p value
16	415.9 ± 68.3	≤ 15	410.9 ± 92.0	0.757
15	417.0 ± 79.1	≤ 14	409.4 ± 90.0	0.603
14	419.9 ± 80.0	≤ 13	404.6 ± 91.2	0.288
13	422.4 ± 80.8	≤ 12	399.4 ± 90.7	0.111
12	423.2 ± 80.1	≤ 11	391.9 ± 92.9	0.037*
11	416.6 ± 84.9	≤ 10	400.6 ± 88.0	0.352

* Statistically significant

who exercised less frequently. The difference was obviously statistically significant.

DISCUSSION

Osteoarthritis of the knee is the most common degenerative joint disease in elderly Thai people[16]. It affects activity and quality of life[3,4]. The goal of therapy is to improve the functional ability of the patients. The authors hypothesise that the measurement of functional variables such as quadriceps strength and walking distance are the best means to judge the outcome of therapy.

The demographic data and the subjective and objective outcomes at the initial examination in both the control and intervention groups were not different except for the ROM (extension) and walking distance (Table 1, 2). A few degrees difference of lack of extension between the two groups had no clinical significance, but the walking distance of the intervention group was longer than the control group (average 38 meters). From the pilot study of 40 elderly people; 20 with knee OA and 20 without, the average walking distance in 6 minutes of 20 elderly people without knee OA was 439 meters. Comparing the percentage at the initial evaluation of the elderly between the two groups who could walk more than 439 meters, there was no statistically significant difference (p value 0.159, Table 3). The percentage of the control group who could still walk 439 meters had a tendency to decrease when followed over a 2, 6 and 12 month period. In contrast, in the intervention group, the percentage of the subjects who could walk 439 meters increased especially at 2 and 6 months. This is definite evidence of the effectiveness of rehabilitation in the intervention group which received group exercise during the first two months. However, the percentage who could walk 439 meters at 12 months decreased slightly when compared to the initial evaluation. This difference was statistically significant at 2 and 6 months ($P < 0.001$) ($P = 0.003$) but not at 12 months ($P = 0.419$). This means that the effect of exercise did not last long, so the elderly who have knee OA should be encouraged to have regular exercise to maintain their walking ability.

The health score, pain score, satisfaction score and functional incapacity score at the 2, 6 and 12 months follow-up period of the two groups (Table

4, 5) showed a statistically significant difference. At 2 months, the elderly in both groups evaluated themselves as having better health and satisfaction.

Pain score and functional incapacity score decreased in the intervention group more than in the control group. All of these were subjective outcomes which could show a difference due to individual differences or a combination of factors such as family status, psychological condition and socio-economic status.

Pain is probably another important factor limiting walking capacity and muscle strength, but during our test there was no evidence that pain inhibited the walking ability or quadricep strength.

The quadricep strength of the intervention group showed a tendency to increase (which was statistically significant). This was also shown in the increased walking distance (Table 5). Although muscle strengths evaluated at the twelve month interval were lower than those assessed at the six month interval, they were still higher than the prerehabilitation level. It was noticeable that the quadriceps strength did not increase in parallel with walking ability at 6 months. In fact an increase in muscle strength is a means to achieve better functional performance and seems to be reflected in improved walking ability[17]. But the present results do not support this hypothesis. The authors postulate that the 6-minute walking distance is the most direct and therefore most valid procedure to judge the outcome of therapy. Otherwise it affects the lifestyle of the elderly, indicates reliably their functional exercise capacity and demonstrates a moderate to strong correlation with exercise stress test using a treadmill or bicycle ergometer[18]. However, the 6-minute walking distance among the intervention group had a tendency to increase, especially in the first two months, which should be the effect of the group exercise.

Kovar et al[19] set an 8-week program of supervised fitness walking and patient education and evaluated 6 minute walking distance. The intervention participants had a 70-meter increase (18%) in 6 minute walking distance compared with a 17-meter decrease in controls. The study of Fisher et al[20] also showed evidence that a muscle rehabilitation program significantly improved muscle function and functional performance such as degree of difficulty and pain during walking, standing, arising from a chair, and climbing stairs. These improvements were sustained for four to eight months after rehabilitation. The other study[21] to report similar data suggested that aerobic benefits of an aerobic program lasted for nine months after formal exercise. The walking ability in the present study seemed to last for six months, so the elderly should be encouraged to exercise regularly. The authors also analysed the frequency of exercise that could improve the walking distance (Table 6). The lowest frequency of group exercise session was 12 in 2 months. It can be concluded that if the elderly can maintain regular exercise for at least 12 sessions within 2 continuous months or a 6 week period (twice per week), they will gain muscle strength and improve their walking ability.

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โรคข้อเข่าเสื่อมเป็นโรคที่พบได้บ่อยในผู้สูงอายุ เป็นโรคเรื้อรังที่รักษาไม่หายขาด ทำให้ปวดข้อ เข่าบวม ข้อยึดติด ผิดรูป เป็นอุปสรรคต่อการดำเนินชีวิตของผู้สูงอายุ ทำให้สูญเสียความสามารถในการใช้เข่าในชีวิตประจำวัน เช่น การยืน การเดิน การขึ้นลงบันได เป็นต้น อันเป็นสาเหตุให้คุณภาพชีวิตด้อยลง วัตถุประสงค์การศึกษา คือ ศึกษาประสิทธิผลของการให้การรักษาโดยวิธีสอนการออกกำลังกายและการใช้ข้อเข่าอย่างถูกต้องโดยการจัดกลุ่มการออกกำลังเปรียบเทียบกับกลุ่มควบคุม โดยทำการศึกษาในผู้สูงอายุโรคข้อเข่าเสื่อมที่อาศัยอยู่ในชุมชนรอบโรงพยาบาลศิริราช 12 ชุมชน จำนวน 392 ราย เป็นชาย 86 ราย หญิง 306 ราย อายุเฉลี่ย 67.7 $\pm$ 6 ปี แบ่งเป็นกลุ่มศึกษาและกลุ่มควบคุมโดยการสุ่ม ผู้เข้าร่วมโครงการทั้งสองกลุ่มได้รับการซักประวัติข้อมูลพื้นฐาน และข้อมูลทั่วไปเกี่ยวกับการปวดข้อ การใช้ข้อเข่า วัดพิสัยข้อ กำลังกล้ามเนื้อขา และระยะทางที่สามารถเดินได้ในเวลา 6 นาที รวมทั้งถ่ายภาพรังสีข้อเข่าทุกราย เฉพาะกลุ่มศึกษาจะจัดกลุ่มการออกกำลังสัปดาห์ละ 2 ครั้ง นาน 8 สัปดาห์ ติดตามผลหลังการศึกษา 2, 6 และ 12 เดือน เปรียบเทียบกับกลุ่มควบคุม ผลการศึกษาพบว่าในกลุ่มศึกษามีกำลังกล้ามเนื้อควอดไดรเซพส์เพิ่มขึ้นอย่างชัดเจน รวมทั้งระยะทางที่ผู้สูงอายุสามารถเดินได้ในเวลา 6 นาทีก็เพิ่มขึ้นเช่นกัน โดยเฉพาะช่วงติดตามผล 2 เดือนแรก แต่เมื่อเวลาผ่านไป 12 เดือน ระยะทางกลับลดลงมามีค่าน้อยกว่าเมื่อเริ่มต้นเล็กน้อย ส่วนในกลุ่มควบคุมผลการศึกษาช่วง 2 เดือน พบว่าไม่มีความแตกต่างของกำลังขารวมทั้งระยะทางที่เดินได้ใน 6 นาที และเมื่อติดตามผลในระยะเวลา 6 และ 12 เดือน พบว่ากำลังกล้ามเนื้อจะเพิ่มขึ้นเล็กน้อย แต่ความสามารถในการเดินกลับลดลงกว่าเมื่อเริ่มต้นอย่างมีนัยสำคัญ ($p = 0.044$) นอกจากนี้ยังพบว่าถ้าผู้สูงอายุออกกำลังกายเพียง 12 ครั้ง หรือโดยประมาณ 6 สัปดาห์อย่างต่อเนื่องในช่วงแรก เพียงพอที่จะช่วยเพิ่มกำลังกล้ามเนื้อ และส่งผลให้ความสามารถในการเดินดีขึ้นได้ อาจสรุปได้ว่า การทำกลุ่มออกกำลังกายมีผลเพิ่มกำลังกล้ามเนื้อขารวมทั้งความสามารถในการเดินอย่างชัดเจน โดยเฉพาะในช่วง 2 เดือนแรก แต่เมื่อเวลาผ่านไปความสามารถนี้ลดลงบ้างจากหลายปัจจัย อันได้แก่ การออกกำลังไม่สม่ำเสมอ, ขาดแรงจูงใจ, ขาดการสนับสนุนของครอบครัว รวมทั้งปัญหาเศรษฐานะ อย่างไรก็ตามควรแนะนำให้ผู้สูงอายุเหล่านี้ มีการออกกำลังกายกล้ามเนื้ออย่างสม่ำเสมอ

คำสำคัญ : ข้อเข่าเสื่อม, ประสิทธิผลการออกกำลังกาย, ความสามารถทางกาย

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