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Strengthening exercises for old cruciate ligament tears

Fifty-three consecutive patients with troublesome old cruciate ligament lesions underwent a 3-month thigh and calf muscle training program. Before training, the diagnosis was established by arthroscopy and clinical examination under anesthesia. Significant improvement in strength, performance, knee score, and activity level took place; the majority were improved and declined surgery. A period of strength training is recommended before the decision to undertake surgery for cruciate ligament injury.

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Strength training has long been considered indispensable in the rehabilitation of patients with cruciate ligament injuries (DeLorme 1945, Noyes et al. 1983, Smillie 1978). Recently, we found that the improvement after a 3-month strength training program persists for at least a 2-year period (Tegner et al. 1984a). McDaniel and Dameron (1983) showed that the outcome of untreated anterior cruciate ligament injury was better if normal thigh circumference was regained.

We have studied a 3-month thigh and calf muscle-strength training program for patients with old cruciate ligament injuries.

Patients and methods

Fifty-three consecutive patients – 41 men and 12 women aged 27 (8) years – with an anterior (ACL) and/or posterior (PCL) cruciate ligament injury were included. Eighteen patients had previously undergone a ligament operation, but the knee remained unstable. The full extent of the injury was established by clinical examination and arthroscopy under anesthesia. Forty-one patients (31 men and 10 women) had ACL injury and 26 of them also had a medial collateral tear. Fifteen patients had been treated earlier with a meniscectomy and another 14 meniscus tears were treated with an arthroscopic operation. All the patients showed an anterior drawer sign and a positive Lachman test, and all but one, a positive pivot shift.

Twelve patients (9 men and 3 women) had an injury of the PCL. Two patients had isolated PCL tears, and all the others had combined injuries. Five patients had also an injury of the ACL. All the patients with a PCL injury had a posterior drawer sign and five had also a posterolateral drawer sign.

One month after the arthroscopy, all the patients started the training program, which 52 of them completed; one patient with a significant giving-way episode and hemarthrosis during the training period dropped out.

Strength training was done by heavy-resistance technique (DeLorme 1945) and included isometric and dynamic exercises for the quadriceps, hamstrings, and calf muscles. The patients were told to train at least three times a week and were instructed to increase the load at least once weekly. The following examinations were done before and after the 3-month training period.

Strength measurements. A Cybex-II dynamometer (Lumex Inc., Bay Shore, New York) was used monthly to determine thigh-muscle torque, isokinetically at 30° and 180° per sec and isometrically at 60° of knee flexion. The peak torque values were used (Moffroid et al. 1969). The relative strength of the injured leg was expressed as the quotient between the strengths of the injured and uninjured legs.

Performance test (Tegner et al. 1986).

a) Running in figure 8 pattern around two cones placed 10 m apart. The patients run two laps, a total distance of 40 m.

b) A one-leg long hop, three times with each leg. The quotient between the best distances for the injured an uninjured legs was used.

c) Running up and down a 25-step spiral staircase, taking one step at a time.

d) Running up and down a 55 m indoor slope with

a 180° turn at its midpoint. The inclination was 2.7°. All times were taken manually.

Knee-function score (Lysholm & Gillquist 1982, Tegner & Lysholm 1985b). The score used included eight different items, the most important being instability and pain. A score below 65, of a maximum of 100, was considered poor, 65–83 fair, and above 84 good/excellent.

Activity grading scale (Tegner et al. 1985). Activities of daily life and sports were graded on an 11-point scale, where 10 represents an elite soccerplayer, 6 an elite jogger, 3 a worker in light industry, and 0 a patient on sick leave or receiving a disability pension because of a knee problem.

Clinical examination of instability. The findings were graded as set out by the American Medical Association (1968).

Statistics. When analyzing differences in score, strength and performance, we used the student's t-test. The χ^2-test was used to analyze differences between groups and Wilcoxon's matched-pairs signed-ranked test for differences in the activity scale.

Results

No difference in results were found between patients with regard to different diagnoses. Therefore, the results are given for the entire group of patients without separation into different groups.

Strength

Increase in absolute and relative strength was noted for both quadriceps and hamstring muscles (Table 1). Twenty-four of 52 patients showed an increase of more than 25 per cent in relative quadriceps strength at 30° per sec (RQ30), 19 an increase of 10–24 per cent, and 9 an increase of less than 10 per cent. The increase was most pronounced during the first month of training. At the end of the training period a strength difference at 30° per sec persisted between the injured and uninjured leg for the quadriceps, but not for the hamstrings (Figure 1). Similar results were found for strength measured at 180° per sec and isometrically.

Table 1. Muscle strength expressed as the quotient between injured and uninjured leg (mean ± SD) before and after the 3-month training period

	Muscle strength			
	Before		After	
Quadriceps				
30°	0.79±0.16	***	0.90±0.11	
180°	0.84±0.14	***	0.93±0.11	
Isom	0.83±0.16	***	0.95±0.12	
Hamstrings				
30°	0.92±0.14	**	0.99±0.11	
180°	0.96±0.15	**	1.03±0.12	
Isom	0.90±0.16	**	0.98±0.16	

*** $p < 0.001$, ** $p < 0.01$.

Table 2. The results in the performance test (mean ± SD) before and after training. The times of running are given in seconds

	Performance			
	Before		After	
Running in a figure 8	12.2 ±1.7	***	11.7±1.3	
Hop quotient (injured/uninjured leg)	0.88±0.15	***	0.93±0.10	
Running up and down stairs	10.3 ±1.9	***	9.4 ±1.2	
Running up and down slope	21.0 ±3.1	***	20.0 ±2.7	

*** $p < 0.001$.

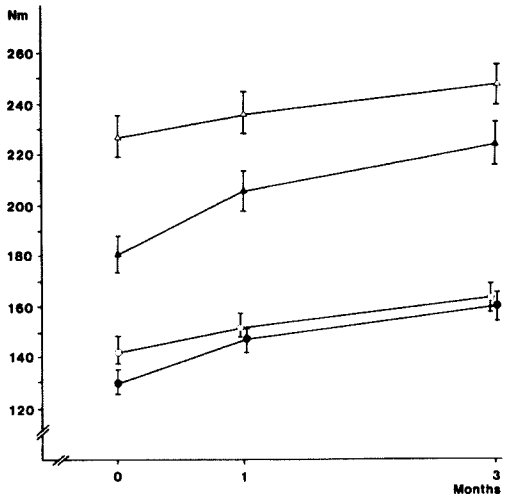

Figure 1. Increase in quadriceps and hamstring strength (mean ± 2 SEM) at 30° per sec. In the quadriceps, significant differences were found between the injured and the uninjured leg on all three occasions. In the hamstrings significant differences were noted only initially. Quadriceps strength in the uninjured leg △, in the injured leg ▲. Hamstrings strength in the uninjured leg ○, in the injured leg ●.

Performance test

All components were improved (Table 2). Before starting training, 20 patients had normal performance (Tegner et al. 1985a) in three or four components, and 32 patients in two or less. After the training period 30 patients had normal performance in three or four of the tests ($p < 0.05$).

Knee score

The mean score before training was 73 ± 15. After training, the score increased to 83 ± 14 ($p < 0.001$). In 41 patients the knee score was increased after the training period, and in eight it was decreased. Items improved by training were instability ($p < 0.01$), locking/catching ($p < 0.05$), stair climbing ($p < 0.001$), and squatting ($p < 0.01$).

More patients had a good/excellent and fewer a poor knee score after the training period than before ($p < 0.05$, Table 3). The most striking improvements in the functional scores were found among patients in whom the initial RQ30 was below 0.80 and the final RQ30 above 0.90 (Table 4); here the score increased from 65 ± 10 to 87 ± 10 ($p < 0.001$). The improvements in the performance test were also greatest in this group. More patients had an excellent/good score, normal (≥ 0.90) relative muscle strength, and hop quotients above 0.90 after training than before ($p < 0.005$), (Figure 2).

Table 3. Score classification initially (n = 53) and at the end (n = 52) of the training period

	Number of patients	
	Before	After
Excellent/Good	16	30
Fair	19	15
Poor	18	7

Table 4. Changes in functional score in relation to changes in different RQ30 levels

RQ30 before	RQ30 after	n	Score before		Score after
≥0.9	≥0.9	9	82		85
≥0.8 <0.9	≥0.9	10	78		83
<0.8	≥0.9	10	65	***	87
≥0.8 <0.9	≥0.8 <0.9	6	81		93
<0.8	≥0.8 <0.9	7	72		81
<0.8	<0.8	8	57	**	64

*** $p < 0.001$, ** $p < 0,01$

Activity level

The preinjury activity level was generally high (median 8). The prerehabilitation activity level was lower (median 2), but was increased by training (median 4, $p < 0.001$). Fifteen patients increased their activity by three or more steps, 16 patients by one or two steps, and 17 patients had the same activity level at the end of the training period as before. Four patients had a

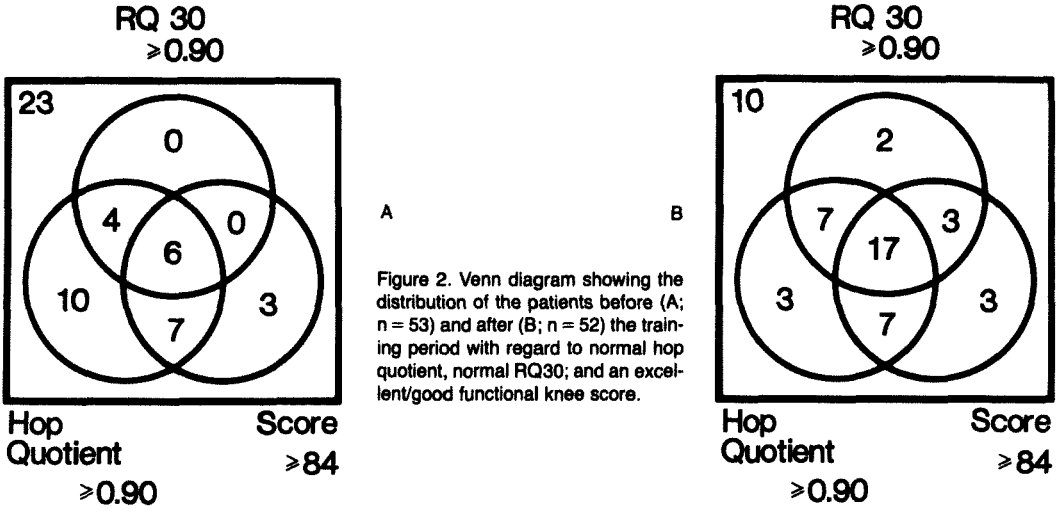

Figure 2. Venn diagram showing the distribution of the patients before (A; n = 53) and after (B; n = 52) the training period with regard to normal hop quotient, normal RQ30; and an excellent/good functional knee score.

lower activity level. Only one patient, however, reached the desired activity level. Twenty-seven patients expressed a desire for further increase by at least three steps at the end of the training period.

Further treatment

One patient suffered significant giving way of the knee during the training period and was therefore operated. Ten other patients also wanted a ligament reconstruction after the training period because their disability hindered them in activities of daily life and/or in sports. They had a lower score after the training period ($p < 0.001$), but their strength, activity level, and results in the functional test were equal to those of patients who did not require surgery. Seven patients were prescribed a derotation brace for wear during sports.

Discussion

The methods of evaluation used in this study have proved earlier to have good reproducibility and to give good assessment of knee function (Hamberg & Gillquist 1984, Lysholm & Gillquist 1982, Odensten et al. 1984b, Tegner & Lysholm 1985b, Tegner et al. 1986). All meniscus lesions were operated on arthoscopically before the training period was started.

We found that a 3-month strength training program results in considerable improvement in knee function, approximately 80 per cent of our patients responding favorably. However, 10 patients with a relative quadriceps strength at 30° per sec of at least 0.90 before training showed little improvement in score during the rehabilitation. They could probably have been excluded from the beginning. Four of them were operated on after the training period.

The aim of a training program should accordingly be to reach an RQ30 of 0.90 (Tegner et al. 1984b, Tegner et al. 1986). Almost half of the patients who had an initial RQ30 of less than 0.90 achieved at least this value after the 3-month training period. A prolonged training period for those who did not reach an RQ30 of 0.90 might possibly give improved results, because their muscle strength continued to increase throughout the training period. Especially patients who started with a very low RQ30 seemed to need a longer training period.

Before rehabilitation most of our patients had an involuntarily low activity level. After the strength training program, they were able to increase their activity level, although few reached the preinjury level and most not even the desired level. Nevertheless, they did not consider the limitation in activities severe enough to consider ligament reconstruction. Most of the patients in this study were referred to us for a ligament reconstruction. With commonly accepted indications for a reconstruction, i.e., significant instability problems in young and active patients (Alm 1974, Ellison 1979, Jones 1980, Losee et al. 1978, Odensten et al. 1983a), most of them would have been operated on.

Although comparison with other reported results is hazardous, we compared the results in the present series with the results after acute repair of the ACL (Odensten et al. 1984), the Ellison procedure (Odensten et al. 1983b) and the Losee procedure (Määttänen & Wredmark 1984). In these three studies a similar evaluation system was used. This comparison suggests that our results reported here are at least comparable or even better.

There were no differences in response to the training program comparing patients with ACL and PCL injury. The large variability in disability after PCL injury suggested in a recent study (Lindh et al. 1985) and the fact that symptoms in patients with combined PCL and ACL injury are mainly caused by the ACL tear (Strand et al. 1984) may explain this lack of difference.

A strength training program, such as the one used by us, can be an alternative to ligament reconstruction. We therefore agree with Noyes et al. (1983) that such a program should be instituted in most patients before surgery is considered. Although the improvement apparently lasts for at least 2 years (Tegner et al. 1984a), longer follow-up periods are needed to study the incidence of arthrosis, meniscus injuries, etc.

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