The Effect of Strength Training on Old Cruciate Ligament Injuries

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INTRODUCTION

All treatments of cruciate ligament injury aime at reducing or eliminating the functional instability, that is, reducing the feeling of instability and the giving way episodes. In the literature there exist many different opinions of how to best deal with this problem.

In 1974 Alm and Gillquist (1) claimed that «In order to obtain a normal function of the knee joint after an old rupture of the anterior cruciate it would be necessary to reconstruct the ruptured ligament». Jones (2) — the man behind «the Jones procedure» — stated «that there is no acceptable alternative treatment for the surgical repair of the ruptured anterior cruciate ligament». Many other authors have since claimed that patients with cruciate injuries and a functional instability should be treated surgically.

On the other hand Darrach (3) already reported in 1935 that «the thigh muscles were the most important structures for maintaining stability of the knee joint : the cruciate ligament injured knee». And DeLorme (4) when presenting his «heavy resistance technique» for strength training said that «this training gave splendid result and that surgery may not offer more».

More recently Giove (5) stated in 1984 that «strengthening of the hamstring muscles provides an alternative to extensive surgical procedures». Noyes et al (6), on the other hand, when presenting his 8-point rehabilitation programme showed that about one third of his patients became better, one third deteriorated and one third was unchanged.

From these divergent opinions it seems as if restoration of knee function may be done either with a reconstruction of the ruptured

ligament or with training of a compensatory mechanism such as muscle strength.

As the role of strength training in the treatment of old cruciate ligament injuries seems to be slightly confused, a prospective study was started. It is postulated that there exists a relationship between muscle atrophy, that, is reduced strength, and functional instability in the unstable cruciate injured knee.

MATERIALS AND METHODS

In order to perform this study 85 patients with old cruciate ligament injuries were put on a strength training program. There were 63 men and 22 women in the group and the mean age for the group was 27 years. This group of patients were consecutive patients coming to the Orthopedic Clinic in Linköping.

Most of the patients had an injury to the anterior cruciate ligament. 24 had an injury to the posterior cruciate ligament — 5 in combination with an anterior cruciate insufficiency, and 2 in combination with a posterolateral rotatory instability.

The time between the index injury and the start of training was approximately 3 years, over 70% of these patients were injured during sport participation — either recreational or competitive. Many patients have had an earlier unsuccessful repair or reconstruction of the ruptured cruciate ligament.

Almost half of these patients had earlier been meniscectomised. The medial meniscus was more often injured than the lateral.

Evaluation

When evaluating the results after tratments it is very important to use an evaluation system that is both objective and reproducible. A standardized evaluation system that fulfills these criteria has been created.

This evaluation system consists of the following parts; arthroscopy, strength measurements with the Cybex dynamometer, evaluation of the disability with a functional kneescore (7), a performance test (8) and grading of the handicap with an activity grading scale (7).

The patients were evaluated before and after the training period and at two follow ups — 1 and 4 years after the start of training.

During arthroscopy the full extent of the injury could be established. All patients having a meniscus injury were treated with an arthroscopic meniscectomy and the status of the cartilage and ligaments was noted.

Strength measurements were done in the Cybex-II dynamometer, and measured isokinetically for both hamstring and quadriceps at 30° and 180°/sec and isometrically at 60° of knee flexion. The peak torque values were used for comparison (Fig. 1).

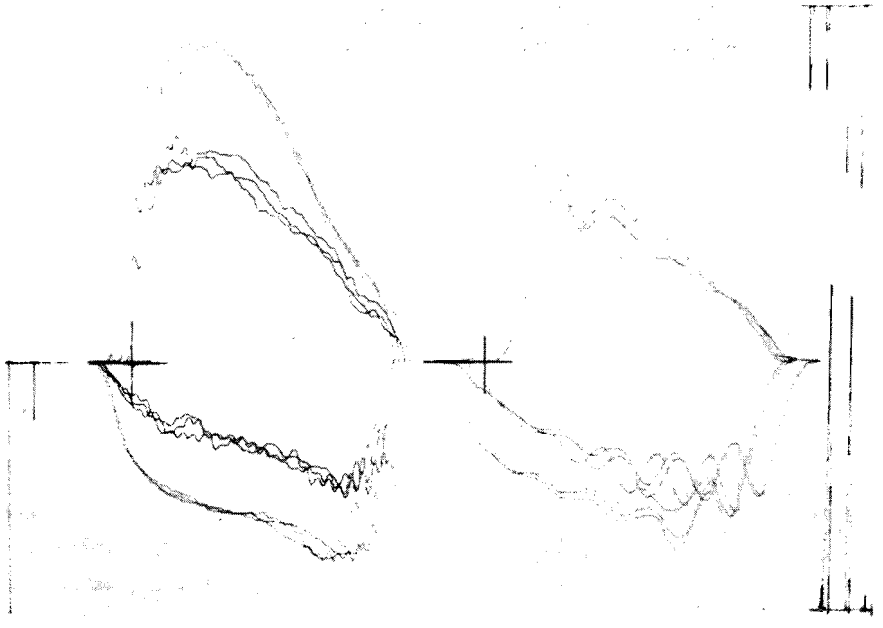


Fig. 1 Cybex-curves, from left 30°/sec, 180°/sec and isometric. Curves going up is quadriceps and down is hamstring muscles.

There was special interest in the functional instability as experienced by the patient, a performance test was created to evaluate the disability in sport-like situations (8). This test consisted of four different parts:

1. A one leg hop. The patients hopped on both the injured and the

uninjured leg. The quotient between injured and uninjured leg was calculated.

2. The time to run in a figure of eight (Fig 2).
3. The time to run up and down a 55 meter long indoor slope.
4. Finally the patients ran up and down a 25 step spiral staircase.

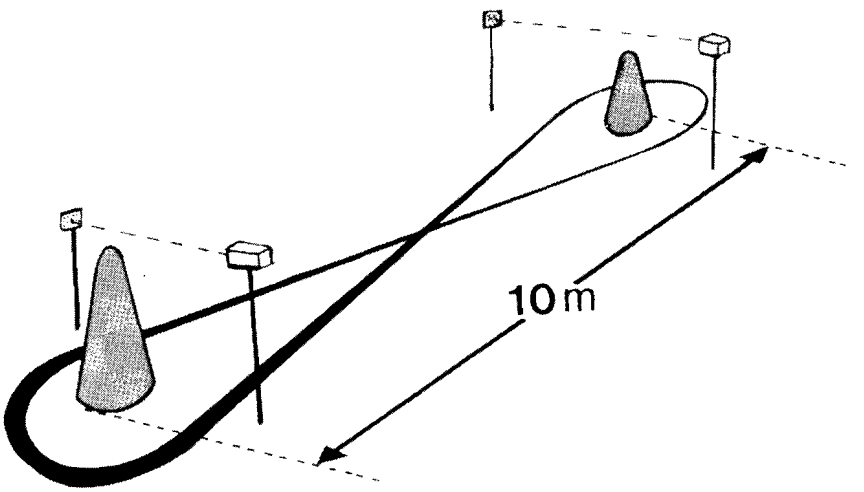


Fig. 2 Schematic drawing of the figure of eight running. Time is taken electrically with the aid of photoelectric cells, thus making it possible to separate running straight and running in the curves.

In order to evaluate the symptoms of the patients the Lysholm knee scoring scale was used (7). This scoring scale evaluates the 8 most common symptoms in the cruciate-deficient knee namely; instability, pain, locking, swelling, ability to go on stairs, limp, support and squatting. The maximum score was 100 points and the knee function was considered good when the score was above 84 points and poor when the score was below 65.

As different activities put different demands on the knee a new activity grading scale was used (7). In this scale the patients activity in sports and daily life was graded in 11 different grades. A soccer player on high

national or international level was graded in level 10, an elite jogger in 5 and a patient on sick leave because of the knee was graded zero.

Rehabilitation

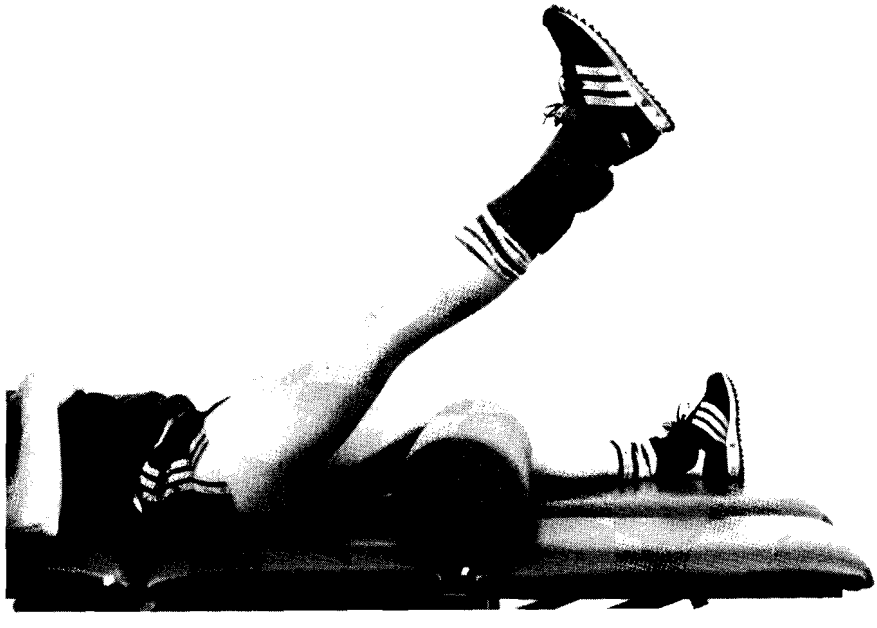
All patients were put on a strength training programme for three months. The training programme was so designed that the patients could do their training at home without the aid of a physiotherapist. The patients were instructed to train at least 3 times per week and should train according to the progressive resistance technique (4) with weekly increase in weights. Every month the patients were given a check-up at the physiotherapist department.

As is generally known, the quadriceps muscle is an antagonist of the anterior cruciate ligament, since this muscle pulls he tibia forward when contracting. On the other hand, this muscle is also an important and powerful decelerating muscle, and as subluxations often appear when decelarating and cutting, it is logic to train this muscle in order to reduce the patient's disability. The programme specially emphasized quadriceps training.

Dynamic training of mainly the vastus medialis muscle was performed by leg stretching and raising with a small pillow under the knee (Fig. 3 a-c). Weights were placed on the lower leg. All parts of the quadriceps were trained with leg raising, sitting on a table by extending the knee (Fig 4). As a matter of training of the hamstring muscles were also performed. These muscles were trained by having the patient standing and flexing the knee with weights on the lower leg. The calf muscles were trained by toestanding.

a

b



c

Fig. 3 Training the quadriceps muscle. a: starting position with a pillow under the knee. The weights are placed on the lower leg. b: The knee is first extended c:The leg is then extended and an isometric hold is performed.

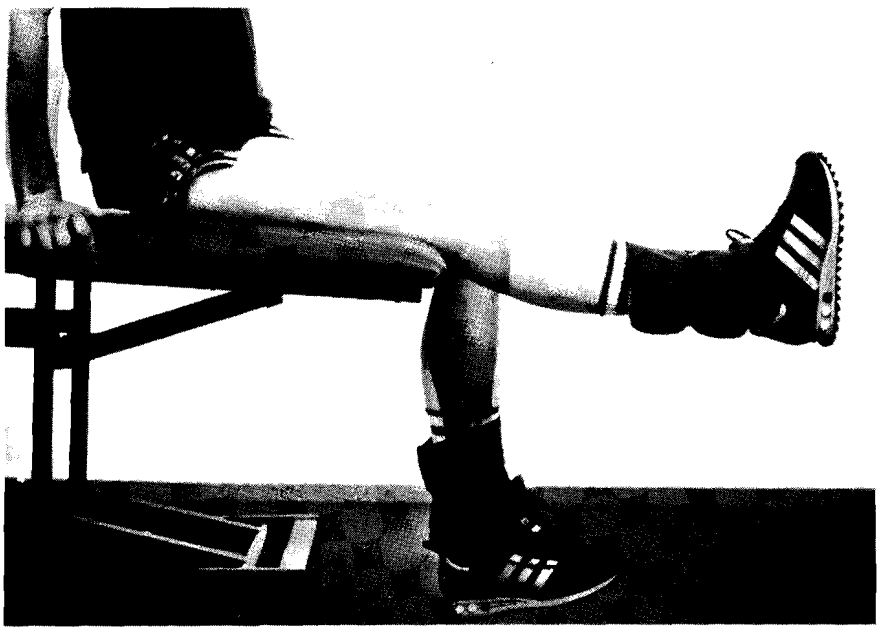


Fig. 4 Training all parts of the quadriceps muscle sitting on a table and extending the knee.

RESULTS

The results after the 3 month training period were generally good.

In fig 5 it can be seen that the hamstring muscle strength already was normal one month after training started but the quadriceps muscle did not reach its normal value even after 3 months of training. Notice that the most pronounced increase in strength occured during the first month of training. Those patients with the most pronounced increases were those whose strength was very low at the beginning.

The functional score increased significantly, showing, that patients had fewer symptoms after the training period (69 ± 16 vs 80 ± 16; $p<0.001$).

In the functional test, all running times were significantly improved. The hop-quotient also improved significantly and was normalized (Table I).

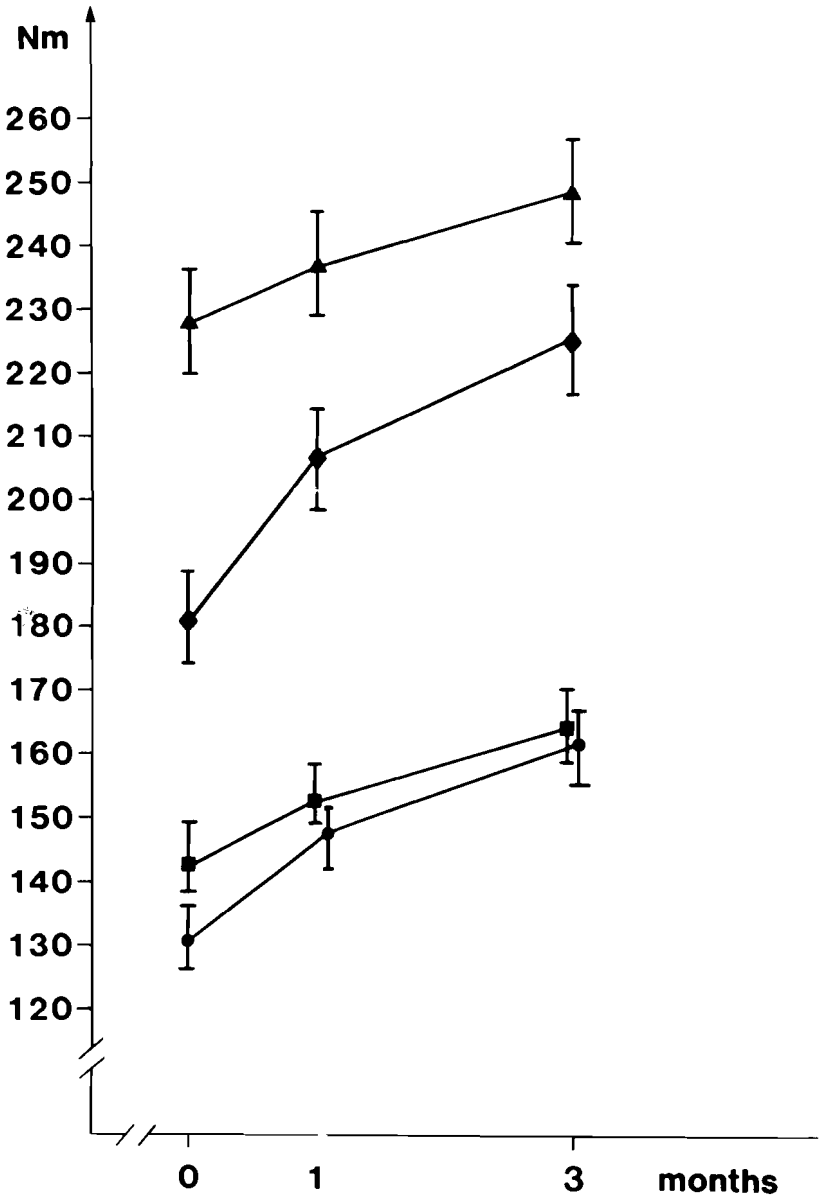


Fig. 5 Curves showing the strength increase for the quadriceps and hamstring muscles.
▲ = uninjured quadriceps
◆ = injured quadriceps
■ = uninjured hamstring
● = injured hamstring

TABLE I

Results in the performance test before and after training

	Before	After	p
Running in fig-of-8	12.2±1.7	11.7±1.3	<0.001
Hop quotient	0.88±0.15	0.93±0.10	<0.001
Stair running	10.3±1.9	9.4±1.2	<0.001
Slope running	21.0±3.1	20.0±2.7	<0.001

The activity level also increased (2 vs 4; $p<0.001$), but most patients did not reach their preinjury levels.

After the training period, 29 patients (34%) still had significant problems and had a reconstruction done. Two patients had significant problems during the training period and could not fulfill the training because of subluxations, and they underwent operations. Six patients considered their knee function so good after the training period that they did not want a reconstruction done. Follow up examination one year later indicated that knee function had deteriorated, their score was reduced and they underwent operations.

Follow ups on the patients were carried out one and four years after training started. 51 patients out of 61 could be reached for the first follow up. 29 of those 31 patients who started training 4 years earlier were followed up. Another 25 patients have not yet reached the 4 year time.

Over the four year period patients were able to keep up their strength with a normal hamstring and quadriceps quotient (Table 2) without any special training programme. Thus, it seems as if the patients who have regained their normal strength, can maintain without any special efforts.

The functional score also remained constantly high over the years (Table 2).

TABLE 2

Results of relative quadriceps strength at 30°/sec (RQ30), functional score and activity level

	Start	3 months	1 year	4 years
RQ30	0.78±0.17	0.90±0.12	0.90±0.13	0.91±0.13
Score	69±15	80±16	83±16	85±16
Activity	2 (1-4)	4 (2-6)	5 (3-6)	5 (3-7)

The activity level increased over the first follow up period (Table 2) and patients stated that they now trusted their knees more and could perform more kneestressing activities. Many patients claimed that over

the years they had learned how to avoid situations producing symptoms of cruciate insufficiency and therefore they could increase their physical activity.

Attempts have been made to find out if any specific factors predispose a good outcome of strength training. Analysis has been carried out on factors such as functional score, diagnosis, activity level, strength, sex, training ability, earlier operations, meniscus and cartilage status. Of all these factors, only functional score and diagnosis produced interesting data.

When functional scores of patients undergoing operations were compared with those who did not, it was found that those who underwent operations had a significantly lover score after the training period and also one year later at the follow-up examination.

Different diagnostic conditions responded differently to training. An injury to the medial collateral ligament did not influence the outcome. Almost 60% of the anterior cruciate injured patients were treated without reconstruction. Most patients with an isolated posterior cruciate injury were treated without an operation.

There was a significant difference between patients with posterior cruciate injuries and those with anterior cruciate injuries. It was necessary to operate on more patients with anterior cruciate injuries than on those with posterior. This may be a reflection on the state of surgical procedures since it is considered more difficult to surgically treat posterior cruciate injuries than anterior. The fact that the knee functional scores for non-operated patients at the four-year follow-up were significantly higher for those with anterior cruciate than for posterior cruciate injuries tends to support this suggestion.

There was a tendency that those patients who earlier have had an unsuccessful operation, more often had a new operation. About 50% of those who had been operated on earlier had a new reconstruction done whereas only 28% of those not operated before accepted. The difference, however was not significant at the 5% level.

Future - will the results of strength training improve?

During the last decade more sophisticated training methods have been developed. The isokinetic concept is becoming more widely accepted and today there is an isokinetic training machine at almost every physiotherapeutic department - at least in Sweden. Many studies have revealed the

superiority of isokinetic training in improving strength in injured patients.

A randomized study has been undertaken of isokinetic training compared to a training program based mainly on functional exercises without specific strength training. Patients are trained until they have reach an acceptable strength level, mostly defined as strength in the injured quadriceps muscle of at least 90% normal. Before and after training patients are evaluated using the same system as described earlier.

The patients train in an Orthotron 3 times per week. In the beginning they train at high speeds and they gradually lower thw speed during the training period.

The functional training program is constructed so that patients perform easy exercises during the first part of the training period. The difficulty is then progressively increased.

The theory behind functional training is that patients should learn progressively how to avoid subluxations and to learn how to use their muscles. Special emphasis has been placed on training decelaration. This has been done with jumping and cutting training.

23 patients have completed their training program. Of these 10 have been trained in the orthotron and 13 have been doing functional training. Preliminary results show that there are no significant differences between the two groups. All patients have taken about the same time to reach normal strength and the scores in the two groups are approximately the same. Thus it seems that if patients learn how to use their muscles they will gain strength.

As stated earlier from the results of the first study it was show that the most pronounced increase in strength occured during the first month of training. It has been shown by others that the initial increase in strength as measured by the Cybex dynamometer is a function of improved neuromuscular function and not a pure muscular hypertrophy. If training methods can be found that facilitate improvement of the neuromuscular complex, training could become more effective both postoperatively and as an alternative to operations.

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