ABSTRACT

Hip fracture can drastically change functional level for the elderly. Between 22% and 75% of hip fracture patients do not recover their previous ambulatory or functional status after the event of fracture. The purpose of this case report is to show how to use the principle of overload in the training of a hip fracture patient, here related to an 86-year old woman. After 36 times of prolonged strength training there was both observed and clinical evidence of an improvement in the patient's functional status. The program comprised four exercises performed at 80% of maximum. The outcome measurements was the Berg Balance Scale, the sit-to-stand test, Timed Up-and-Go test, maximal gait speed, 6-minute walk test, Nottingham Extended Activities of Daily Living scale, and the SF-12 health status questionnaire which all showed improvement both at six and nine months follow up. These findings show suggest that a program of progressive and prolonged strength training can help in recovery from hip fracture. It seems to be of importance for this patient to participate in strenuous exercise for overcoming bodily limitations to achieve increased vitality and improved quality of life.

Keywords: hip fracture, strength training, principle of overload

INTRODUCTION

Hip fracture is a common medical problem that can drastically change the quality of life for the older adults. In US, more than 300 000 older people are expected to fracture a hip each year (National Center for Health Statistics., 1999). The annual number of hip fractures will rise greatly with the continued ageing of the population (Johnell & Kanis, 2005).

A hip fracture is associated with a mortality of 5–20% the first year post fracture, a costly hospitalization of the patient and lengthy rehabilitation procedures (Magaziner et al., 2000; Osnes et al., 2004). Between 22% and 75% of patients do not recover their previous ambulatory or functional status 6–12 months after the event, and a significant functional decline has been documented even among individuals who were functioning at a high level before the fracture (Melton, Therneau & Larson, 2005). Hip fracture patients are often older adults with a fall history, weight loss, sarcopenia, low physical activity, cognitive decline and depression (Juliebø, Krogseth, Skovlund, Engedal & Wyller, 2010).Immobilization after major surgery and during hospitalization can cause a severe decline in muscle strength and muscle functioning, and physical training seems to improve strength and functional performance in hip fracture patients (Osnes et al., 2004). However, a systematic review (Johnell & Kanis, 2005) indicates that the evidence is insufficient with respect to best practices in rehabilitating hip fracture in older adults. The patient group is a heterogeneous one, and, consequently, rehabilitation efforts need to be individualised (Johnell & Kanis, 2005). A review of recommendations for the management of hip fracture rehabilitation showed that strength- and balancetraining were the most frequently reported interventions (Handoll & Sherrington, 2007).

A method for improving strength in healthy elderly as well as in hip fracture patients is the principle of overload (Suetta et al 2004). Generally, throughout the resistance training program, the training volume or total amount of work performed must be periodically increased to continue overloading the muscle so that the person can make further improvements in strength (McArdle and Katch, 1991). For effective resistance programs, these principles must be followed (Hagerman et al., 2000). Guidelines for progressive strength program designs outline 70–80% 1RM in 8–12 repetitions in more than one set for six weeks or more to develop strength in untrained persons (ACSM 2003). Furthermore, a maintenance program consisting of three sets of 10 repetitions at 80% of their 1RM once a week seems to be effective for older adults to maintain muscle strength and size (Trappe, Williamson & Godard, 2002). However, it is not unambiguous if the principle of overload is useful for a hip fracture patient and which assessments are useful on a fracture patients' balance, mobility, activity of daily living and health related quality of life.

Thus, the purpose of this case report was to show how to use the principle of overload in the training of an 86yearold woman after surgery followinghip fracture at an outpatient clinic in Norway. Furthermore, to present outcomes in terms of balance, mobility, activity of daily living and health related quality of life after three and six months follow up, finally to discuss barriers and motivational factors in relation to performing progressive strength training following hip surgery.

PATIENT HISTORY

We report on an 86-year-old woman who had a comminuted intertrochanteric fracture of the left hip 10 weeks previously. She reported taking medications for both diabetes type I and for a moderate hypertension, but need no assistance in activities of daily living (ADL), before fracture. The patient lived alone in an apartment. She reported no falls the last six months. Before the hip fracture, the patients was active, she was competent in outdoor walking and participated in social relationships with other older people. The hip fracture was surgically repaired with open reduction and internal fixation using an intramedullary rod and a gamma nail. Physical therapy interventions included three days of physical therapy in the acute care setting, and two home care visits over three weeks. Physical therapy in the acute care setting focused on bed and toilet transfers and gait training with a roller walker. The two home care physical therapy visits consisted of an examination of ADL and IADL, not using special tests, and training in climbing stairs. She used a cane for ambulation, both for indoor and outdoor walking.The patient said she was not satisfied with her recovery. She reported that she was unable to walk even shorter distances because of weakness in the lower-extremities. Furthermore, she was unable to perform activities such as shopping, because of body fatigue. She was fearful of falling again and she felt that the limping impaired her balance and walking ability. Her impaired walking ability and her fear of falling in activity limited her return to her previous functional level.

The patient was initially examined clinically by a physiotherapist. Limitations in the bilateral hip flexion were measured. In addition the patient was tested on the Mini-Mental State Examination (MMSE) (Folstein, Folstein & McHugh, 1975). Left hip flexion, active, was measured to 70 degree, and right hip flexion, active, was measured to 45 degree. Passive flexion was 85 degree at right side and 100 degree on left side. No other limitations in range of motion were found. At hospital her MMSE was 28, which means she not had signs of delirium (Folstein et al., 1975).

The history of her hip fracture and the fact that she not had returned to her previous level of function made her “typical” for a case report. Furthermore, she could be a good candidate to determine whether progressive strength training could improve her functional status and activity level and reduce her impairments and disabilities. Despite her fear of falling in activity and limitations, she was motivated to improve her current level of function by progressive strength training.

INTERVENTION AND OUTCOME MEASUREMENTS

The two-phase intervention consists of a 12-week progressive strength part twice a week (part I) and a 12-week maintenance part once a week (part II). Targeted lower-extremity exercises to develop muscle force were the main focus for the intervention. The patient received sessions of lower-extremity strengthening exercises, and aerobic training on a stationary bicycle. Exercises during the two phases were conducted by a physiotherapist. During both part I and part II the participant completed four exercises for training: standing knee flexion, lunge (pass forward), sitting knee extension, and leg press. The sitting knee extension and the leg extension were performed in a training machine (Steens Physical) and both exercises were done with one leg at a time. For the knee extension emphasis was placed on total extension of the knee. For the leg press the patient's hip and knee was flexed to 90 degrees, and then pushed the leg into full knee extension against the predetermined resistance.

For the standing exercises, standing knee flexion and lunge, the therapist was nearby the first session to help if the patient was in danger of falling. For both exercises the patient has to get down to 90 degrees in knee flexion. In standing knee flexion the patient stand with hip width distance and has to make a 90 degree flexion in hip and knee, almost like sitting down in a chair. For the lunge the patient had to set every other leg forward, and make a 90 degree flexion in hip and knee. Both exercises were done without dumbbells in the beginning and with one or two kilos weight in the last 6 weeks of the training period. Standing exercises requires both strength and balance.

Initially, in part I, the participant performed three sets of 15 repetitions of each exercise at above 60-70% of his or her 1RM for three weeks. The 1RM measurements were done after first three weeks of training and repeated every third week. The 1RM results were used to increase the exercise prescription progressively. After the first three weeks, the resistance was increased to 80% of the 1RM. The resistance was modified by the physiotherapist every third week, and more often if the participant was able to perform at that load, which was based on the 1RM measurements. The 1RM measurements were done for sitting knee extension and leg extension. For the maintenance trial period, the patient performed three sets of 10 repetitions of each exercise at 80% of maximum capacity once a week for 12 weeks. The 1 RM was measured every third weeks, in the same way as in the first period. The participant completed the same exercises in part II as in part I.

In both training periods the patient was instructed to do the exercises quickly in concentric phase and slow the eccentric phase. The intervention followed the classical principle of overload which means that exercises were performed at an intensity level higher than "normal" to facilitate physiological adaptations regarding neural recruitment or hypertrophy, which result in training response (Raastad et al., 2010). The intervention was performed at the same location where the measurements took place and the patient was assessed the first time they met. The patient received exercises that were individually tailored with respect to the level of strength. The intervention sessions took part in an outpatient clinic. The participant was required to attend exercise sessions twice per week for the first 12 weeks and once a week for the last 12 weeks.

The exercise program started with 10-15 minutes of warm-up cycling on a stationary cycle and the intensity of the warm-up was set to 12 to 13 on the Borg Rating of Perceived Exertion Scale (Borg, 1982). Exercise sessions lasted 45–60 minutes, depending on the participant's ability and tolerance. In total, the patient participated in 31 sessions of a total of 36.

Outcome measurements were obtained at 10 weeks postoperative the week before the intervention started, and then after 24 sessions and then after further12 sessions. The patient was tested with the Berg Balance Scale (BBS) (Berg, Maki, Williams, Holliday & Wood-Dauphinee, 1992), the Sit-to-Stand test (Bohannon, 1995), the Six-Minute Walk test (6MWT) (Enright, 2003), Maximal Gait Speed (Bohannon, 1997), Timed Up-and-Go (TUG) (Podsiadlo & Richardson, 1991) and Step-High (Bergland, Sylliaas, Jarnlo & Wyller, 2008). In addition the patient were interviewed by using the The *Nottingham Extended Activities of Daily Living* (NEADL) (Lincoln & Gladman, 1992), and The *Short Form-12 Test* (SF-12) (Ware, 1993).

The BBS is a balance test developed by Berg et al. (Berg et al., 1992) and consists of 14 items, scored from 0 to 4; the total scores range from 0 to 56. It has been used in many studies and has demonstrated satisfactory reliability and validity, also for hip fracture patients (Berg et al., 1992; Steffen, Hacker & Mollinger, 2002). Riddle and Stratford (Riddle & Stratford, 1999) demonstrated that the recommended cut-off score of 45 on the BBS was relatively poor at identifying people who are at risk of falling but relatively good at identifying people who are not at risk of falling in a group consisting of people from 65-94 years old. An overall score of less than 42 points out of a maximum of 56 is associated with a 2.7 times increase in the risk of a future fall in a study including fifteen healthy older adults and 13 older adults with clinical balance impairment (Brauer, Woollacott & Shumway-Cook, 2001). The *Timed Up-and-Go Test* (TUG) is a functional mobility test used in the clinic to evaluate dynamic balance, gait and transfers (Podsiadlo & Richardson, 1991). The patient is asked to get up from a chair (46 cm high), with support for the arms, walk three meters, turn, go back and sit down, in their habitual pace. The test is valid and reliable and has been used in hip fracture studies (Bryant et al., 2009; Kristensen, Foss & Kehlet, 2007). In a recent study, Kristensen et al., (2007) showed that TUG is also a sensitive measure for identifying people with hip fracture at risk of new falls. The relationships between measures of functional mobility (TUG, Maximal Gait Speed and BBS) were determined in another study (Mendelsohn, Leidl, Overend & Petrella, 2003), and all three were found to be specific measures of functional mobility in patients with hip fracture. In patients with hip fracture, the TUG has been found useful as an outcome measure (Crotty, Whitehead , Miller & Gray, 2003; Mendelsohn et al., 2003) in predicting falls with a cut-off point of 24.0 seconds (Kristensen et al., 2007).

The *Sit-to-Stand* test is suggested as a measure of functional aspects of muscle strength in the lower extremities (Bohannon, 1995Guralnik et al., 1994; Janssen, Bussmann & Stam, 2002). We used a 46 cm high seat as the preferred chair and measured the time taken for 10 rises. Muscle power is often suggested as a better indicator of function than muscle strength (Skelton & McLaughlin, 1996).

The *Six-Minute Walk Test* (6MWT) measures walking capacity, walked distance (m) (Enright, 2003), and allows calculation of gait velocity (m/s) (Kervio, 2003). The 6MWT is also used to assess exercise tolerance (Enright & Sherrill 1998), thus measuring the functional exercise capacity. The 6MWT has been used in studies with hip fracture (Bryant et al., 2009; Latham et al., 2008). It is a test for submaximal aerobic capacity, although in some patients with heart failure, it appears to be a maximal test (Kervio, 2003).

Maximal Gait Speed has commonly been reported in the literature as an outcome, with walking distances varying from a few metres up to 30 metres (Bohannon, 1997, Schlicht, Camaione & Owen, 2001). Gait speed is measured over a relatively short distance and thus does not include endurance as a factor. Walking speed measured over different distances has been reported to be reliable in healthy and impaired walking populations, even hip fracture patients (Binder et al., 2004; Bryant et al., 2009; Suetta, Magnusson, Beyer & Kjaer, 2007). In the studies we choose 10 meters as a preferred distance (Bohannon, 1997).

The *Maximum Step Height Test* is a test of climbing stairs and measures the ability to mount boxes of increasing heights (10, 20, 30, 40, 50, 60, and 70 cm) without support (Bergland et al., 2008). The height of the highest box mounted is recorded. There is correlation between the ability to climb steps and the performance-based tests is high, primarily for the tests related to mobility and balance, such as maximal walking speed and one leg stands (Bergland et al., 2008). The test was also significantly correlated with maximum walking speed in a study by Frändin and Grimby (Frändin & Grimby, 1994).

The *Nottingham Extended Activities of Daily Living* (NEADL) score comprises 22 activities with the sum score ranging from 0 to 66. NEADL is frequently used to explore the competence in instrumental activities of daily living (Lincoln & Gladman, 1992). The scale assesses instrumental ADL including physical ambulation, toileting, feeding, dressing, grooming and bathing. Each domain has four levels (0: dependent; 1: needs some help; 2: can do alone with difficulty; 3: independent). The scores for the domains are added to produce a sum score (30) with higher scores indicating lesser functional impairment. A higher score indicates better functioning in instrumental ADL (Lincoln & Gladman, 1992).

The *Short Form-12 Test* (SF-12) is based upon self-report and is used as a measurement of the participant's perceived health. We used the summary measures PCS-12 (physical domain of SF-12, scores ranging from 0 to 100) and MCS-12 (mental domain of SF-12, scores ranging from 0 to 100) (Ware, 1993). This tool has been well validated under Norwegian conditions; age group and sex-matched comparative data are available (Loge & Kaasa, 1998). This widely used tool examines eight domains: physical function, physical role, bodily pain, general health, vitality, social functioning and emotional and mental health (Ware, 1993).

All tests used are recommended for hip fracture patients (Bryant et al., 2009). The patient was retested, after three and six months training, using the same method as the initial examination for tests and measures.

One repetition maximum

In resistance training, specificity is of importance when measuring and training muscle strength. One repetition maximum (1 RM) was chosen because it measures dynamic muscle strength, it is easier to implement in a clinical setting as it is a clinical test, and it gives the opportunity to standardize and dose the intensity of the muscle strength training program (Raastad, Paulsen, Refsnes, Rønnestad & Wisnes, 2010). One of the disadvantages of 1 RM is that it measures muscle strength at the weakest point in the range of motion of a joint (Jones, Bishop & Richardson, 2006). However, as the reliability of 1 RM has been questioned, it is important to interpret results with caution. In some cases 5 RM is used, which is also reliable (Schroeder et al., 2007).

OUTCOME

As shown in figure 1 and 2 the patient increased in 1-RM in both Leg Press and 1-RM Knee Extension during the two training periods. The patients IADL scale increased with 63 %for the training period. In special her results regarding outdoor moving, travelling by public transport and managing her own shopping increased from the first to the last retest. As shown in table 1, following both part I and part II, the patient in total increased her result at the Sit to stand test with 59 %, and at the 6MWT with 94 %. Furthermore, the gait speed increased with 114 %, the BBS with 31 %,) she at the TUG with 70 % and the maximum step height test increased in total with 191 %. At last her results regarding the SF-12 increased from the first to the last retest, in special the questions related to mental health, the MCS-12, which increased with 63 %. By the end of the two training periods, the patient reported that she had little or no difficulty doing her usual hobbies and recreation, performing heavy activities around the home, getting in and out of a car, walking four floors, making her own shopping and goes by public transfer.

DISCUSSION

The changes in lower extremity strength measured both during training and in the 1-RM test, suggest that the patient's strength improved, in our study. There is strong evidence that high-intensity training is effective in increasing force production in elderly people (Fiatarone et al., 1994). A systematic review of progressive resistant training in elderly people has shown a strong positive effect on leg extensor muscle force with moderate- to high-intensity training (Latham et al., 2008). In a review Aagaard et al (2010) concluded that strength training appears to elicit effective countermeasures to sarcopenia and muscle atrophy in elderly individuals even at a very old age (Aagaard, Suetta, Caserotti, Magnusson & Kjær, 2010). The training-induced changes in muscle mass and nervous system function leads to an improved functional capacity during activities of daily living (Aagaard et al., 2010). This is also supported by the IADL results in our study.

In this case study, the participant improved with respect to all outcome measurements which are in line with other studies using the principle of overload (Binder et al 2004, Mangione & Palombaro, 2004). In contrast to their studies our intervention only consists of four strength exercises, and no use of special balance exercises. Her performances improved considerably in all the motor tasks, such as Bergs balance scale (BBS), chair rise (sit to stand), and TUG. In our study, the participant's BBS score improved during the intervention from below to above the cut off for increased risk of falling, indicating that the improvement was clinically relevant. TUG performance improved during the training period and at the post-intervention test result was 7.2 sec. Garber et al. (2010) state that a result better than 8.7 sec at the TUG-test is recommended for independed living. 6MWT measure sub-maximal aerobic capacity and functional limitations among mobility-limited elders (Bean, Kiely & Leveille, 2002). Improvements in 6 MWT may also indicate an improvement in endurance and functional performance.

According to the patient, she did not restore her pre-injury level of function during the training periods. Participants who were not satisfied with their functional recovery at one year reported that factors hindering their functional recovery included older age, medical complications, co morbidities, and unpleasant sensations such as pain (Young & Resnick, 2009). The healing process slows down with age (Pine, Gurland & Chren, 2002) and the training period in the case report may have been too short to achieve complete healing. Her impaired walking ability and her fear of falling (FoF) in activity limited her, initially. FoF is associated with several negative rehabilitation outcomes, such as loss of mobility, institutionalization, and mortality (Visschedijk, Achterberg, Van Balen & Hertogh, 2010). FoF is also related to less time spent doing exercise and an increase in fall incidence (Visschedijk et al. 2010). In this case report FoF was not systematically described, measured or analyzed, but after the training period the patient reported no fear of falling. The findings show that the patient, despite extensive impairments, multiple diagnoses, and advanced age, displayed a belief in the positive effects of the program, a strong desire to be active, and the will to strive to avoid further loss of capacity. Support from the supervisor and belief in personal success facilitated progression of the exercises. The patient related exercise progression to physical and mental improvements in her daily life, and, that exercising at the outpatient clinic was stimulating and created a sense of meaningfulness. She felt the effort was worthwhile because participating in strenuous exercise could help her overcome bodily limitations to achieve increased vitality and improved quality of life.

A study has shown that specific motivators and barriers to exercise differ with age, education, gender, psychological and physical well-being and current level of exercise (Newson & Kemps 2007). People over the age of 75 are more likely to be motivated to exercise purely to maintain an active lifestyle than those aged 63 to 74 years, but medical problems are more likely to prevent them from engaging in exercise compared with their younger counterparts (Newson & Kemps 2007). Men were found to be more likely than women to be motivated to exercise by the inherent challenging nature of exercise. High-level exercisers find the challenge to exercise to be more of a motivator than their low level counterparts, who reported health concerns to be a more important motivator. Low-level exercisers also noted a concern that factors associated with exercise and a lack of facilities and knowledge about exercise prevented them from exercising (Newson & Kemps 2007).

On the other hand, women are more likely than men to report health concerns as a reason to exercise, and they are more likely to report lack of exercise facilities and exercise specific knowledge as barriers to exercise (Newson & Kemps 2007). Remarkably, a positive view on ageing is a strong predictor for long term physical exercise habits (Wurm, Tomasik & Tesch-Römer, 2010). The authors conclude that intervention programs for older adults need to take into account the specific contextual factors of the individual. Regular physical activity has been associated with better outcomes in the post-hip-fracture period (Fiatarone Singh, Singh & Hansen, 2009; Zidén, Frändin, & Kreuter, 2008). Early findings from the Sarcopenia and Hip Fracture study (Fiatarone Singh et al., 2009) suggest that individuals who are less sedentary before sustaining hip fractures tend to have shorter acute-care lengths of stay. In the early post-hip-fracture period, participation in physical activity is predictive of functional recovery (Talkowski, Lenze, Munin, Harrison, & Brach, 2009). Furthermore, individuals who remain sedentary after hip fracture are at increased risk for a second hip fracture and further functional decline (Rodaro, Pasqualini, Iona, & Di Benedetto, 2004).

We selected a person who had completed the routine care for two reasons: 1) to demonstrate ability of patients to perform exercises at higher intensities of resistance and after fracture surgery 2) to evaluate change in functional performance following an exercise program based on the principles of overload and specificity. It is not clear whether this program could have been implemented at an earlier stage post-operatively. Based on knowledge of the loss of muscle strength, it would be of importance with respect to the muscle atrophy to start with strength training as early as possible after surgery (Suetta et al., 2007). Another limitation is the 1 RM strength testing procedure. programOne of the disadvantages of 1 RM is that it measures muscle strength at the weakest point in the range of motion of a joint (Jones et al., 2006). However, isokinetic strength testing is far more expensive and rarely used in clinical settings. Furthermore, it is possible that improvements, in the presented case, could result from the "placebo effect" and additional contact rather than from the exercises. Social support, which can include support from relatives as well as from professionals, can also lead to increased efforts (Cress, Buchner, Prohaska, Rimmer, Brown et al., 2006) and has been shown to be related to higher physical activity levels (Annesi 2005). However, it can also be experienced as obligating and intrusive (Gabriele, Walker, Gill, Harber & Fisher 2005). Social support has been suggested to have an indirect effect on exercise behaviour through a higher sense of pleasure during training. Some of the outcome measures are subjective and/or potentially affected by the amount of motivation. The Hawthorne effect should be considered

(Fiatarone Sing et al., 2009). We have no objective knowledge of the patient's functional level before hip fracture and thus have no way to check if she is close to achieving pre-fracture status. The functional status pre-fracture is based on the patient's self-report. It would be of interest to consider a patient not having the same training program for comparing results.

CONCLUSIONS

This case report show that an exercise program based on supervised progressive strength training twice a week for three months can be performed by a patients who has undergone surgery after hip fracture, and, that the designed program has a positive change in balance, mobility, activities of daily living and health related quality of life was seen after participation. Furthermore, the maintaining period seemed to improve walking speed and self-rated health, in addition, for this 86-year old woman. It seems to be of importance for this patient to participate in strenuous exercise for overcoming bodily limitations to achieve increased vitality and improved quality of life. This is of importance for clinical practice.

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Table 1: Differences at baseline, and follow up after strength training for a hip fractured 86-year old woman

Variables	Outcomes		
	Baseline	Follow up I*	Follow up II**
Bergs balance scale (0-56)	42	48	55
Sit to Stand (s)	31.4	17.6	12.9
Six minutes walk test (meters)	278.20	353.45	538.85
Maximum gait speed, 10 m (m/s)	0.62	0.91	1.33
Timed Up and Go (s)	24.3	13.8	7.2
Step-high (cm)	12.0	20.0	35.0
NEADL sum score (0-66)	38	50	62
SF-12			
(PCS12)	49.5	56.5	74.7
(MCS12)	49.9	59.8	81..4

Abbrevations:

CI= Confidence interval

NEADL= Nottingham Extended Activity of Daily Living score

SF-12 = Short Form 12 questionnaire for perceived health
PCS12 = Physical domain of SF-12
MCS12 = Mental domain of SF-12

*Follow up I=after 24 sessions of progressive strength training

* Follow up II=after additional 12 sessions of strength training

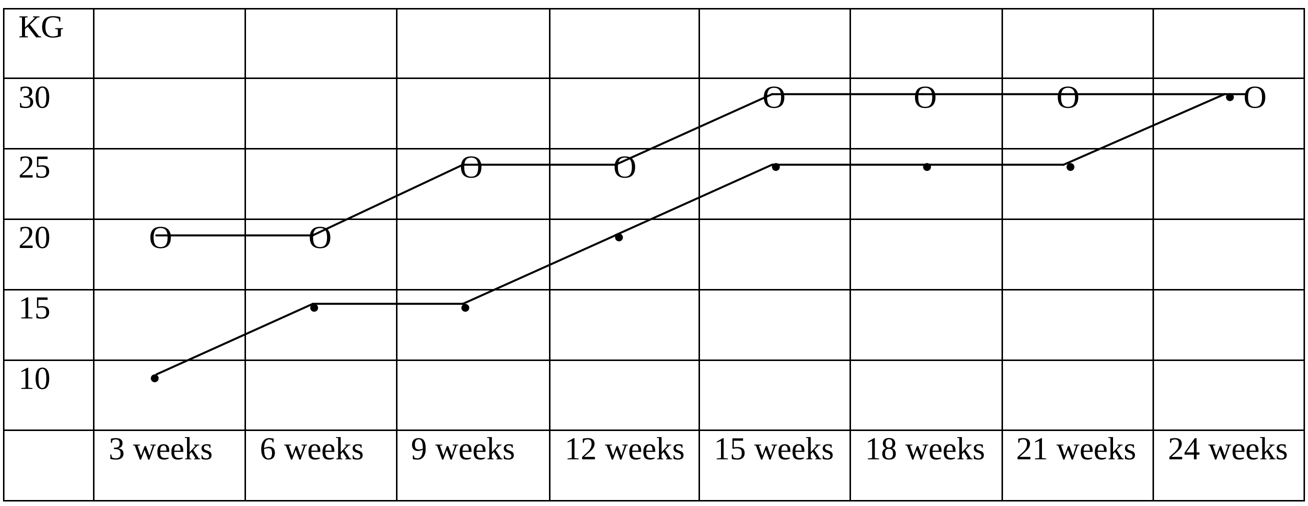
KG
30
25
20
15
10
3 weeks
6 weeks
9 weeks
12 weeks
15 weeks
18 weeks
21 weeks
24 weeks

Fig. 1 Changes in 1-RM Leg Press during the two training periods

•=fractured leg

O=unfractured leg

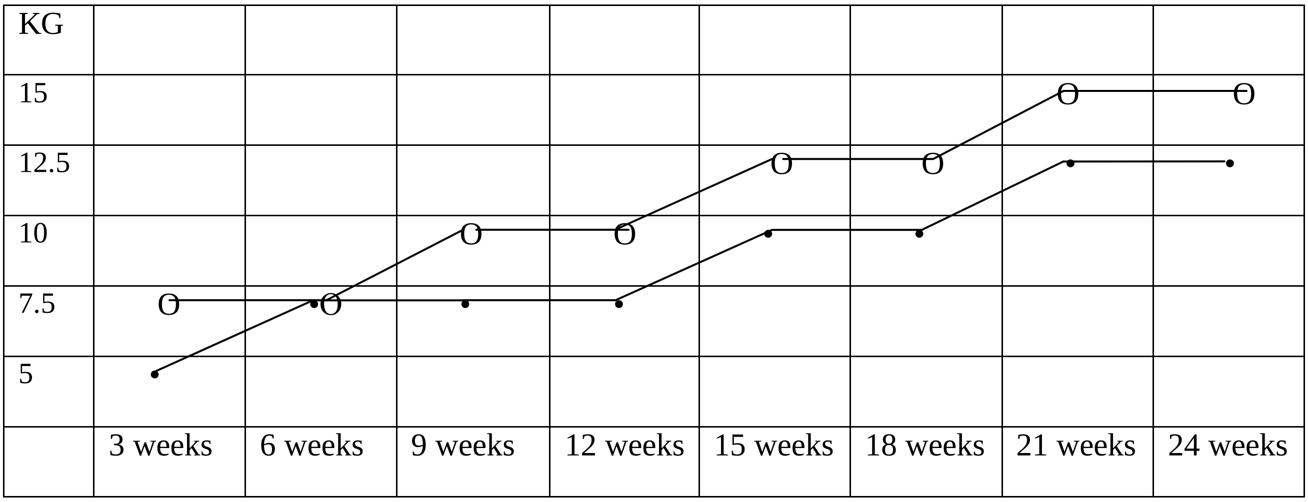

Fig. 2 Changes in 1-RM Knee Extension during the two training periods

•=fractured leg

O=unfractured leg