Κατάγματα χαμηλής βίας του ισχίου: ιδιαίτερες επισημάνσεις στη φυσικοθεραπευτική παρέμβαση

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ΠΕΡΙΛΗΨΗ

Τα κατάγματα χαμηλής βίας του ισχίου σε άτομα της τρίτης ηλικίας αποτελούν μείζον πρόβλημα υγείας με σημαντικές οικονομικές, κοινωνικές και ψυχολογικές επιπτώσεις. Η πτώση θεωρείται ως ο σημαντικότερος παράγοντας πρόκλησης των καταγμάτων αυτών και η οστεοπόρωση έχει ενοχοποιηθεί ως η κυριότερη παθογενετική αιτία τους. Προϋπάρχουσες συνοδές παθήσεις ή η ύπαρξη νευρολογικού ελλείμματος, μπορεί να επηρεάσουν τη λειτουργική αποκατάσταση του καταγματία ασθενή. Κύριος σκοπός της φυσικοθεραπευτικής παρέμβασης είναι ο σχεδιασμός και η εφαρμογή εξατομικευμένων προγραμμάτων αποκατάστασης. Μεταξύ των γενικών αρχών που διέπουν τη μετεγχειρητική φυσικοθεραπευτική αποκατάσταση είναι η πρώιμη κινητοποίηση του ασθενούς για την πρόληψη των μετεγχειρητικών επιπλοκών, χωρίς όμως να φορτίζεται υπέρμετρα η χειρουργημένη άρθρωση του ισχίου. Ιδιαίτερη προσοχή πρέπει να δοθεί στην επανεκπαίδευση της ισορροπίας, με στόχο τη σημαντική μείωση της πιθανότητας ενός δεύτερου κατάγματος. Η επανεκπαίδευση της ισορροπίας θα πρέπει να ενσωματωθεί νωρίς στο πρόγραμμα αποκατάστασης και να συνεχίζεται μέχρι την ολοκλήρωσή του. Στη διαμόρφωση του προγράμματος αποκατάστασης θα πρέπει να λαμβάνονται υπόψη ο τύπος του κατάγματος, η χειρουργική προσπέλαση και η χειρουργική σταθεροποίηση του κατάγματος. Η αποφυγή συγκεκριμένων κινήσεων ή ο συνδυασμός τους, είναι ιδιαίτερης σημασίας κατά την κρίσιμη φάση της νοσηλείας. Τέλος, στην εργασία αυτή προτείνεται ένα αυξανόμενης δυσκολίας πρόγραμμα ελεύθερων ενεργητικών ασκήσεων, κύριοι στόχοι του οποίου είναι η αύξηση της κινητικότητας και του εύρους τροχιάς των επιμέρους κινήσεων, η ενδυνάμωση των μυών και η βελτίωση της λειτουργικότητας του μέλους.

Λέξεις κλειδιά: *κατάγματα ισχίου, χειρουργικές προσπελάσεις, φυσικοθεραπεία, αποκατάσταση*

Low-Energy Hip Fractures; Special Considerations Regarding Physical Therapy Intervention

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ABSTRACT

Low-energy fractures of the hip in elderly adults are a major health problem with serious financial, social and psychological consequences. The predominant cause of hip fractures in elderly adults is falling. Osteoporosis is implicated as the main pathogenetic cause. Pre-existing disease or pathology may also affect rehabilitation, with neurological impairment having a significant negative impact. The main purpose of physical therapy is the design and the implementation of individualised rehabilitation programmes. Among the general principles underlying physical therapy intervention following surgical treatment is the early mobilisation of the patient for the prevention of postoperative complications, without overloading the fractured hip. Special consideration should be given to retraining balance in order to prevent a new fall, thus minimising the possibility of a second fracture. Balance training should be incorporated early in the rehabilitation programme and remain an important part until its completion. Specific aspects of rehabilitation should be taken into account according to the type of fracture, the surgical approach and treatment. Of particular importance is the avoidance of single movements or movement combinations during the crucial phase of hospitalisation, as herein discussed. Finally, an active exercise programme of increasing difficulty, with imposed hip loads, a focus on strengthening key muscles and increasing the associated ranges of motion, is proposed.

Key words: *hip fractures, surgical approaches, physical therapy, rehabilitation.*

INTRODUCTION

Fractures caused by low-energy impact loads on the bone are designated as low-energy fractures[1]. Low-energy fractures include the femoral neck, intertrochanteric and some types of subtrochanteric fractures. The subtrochanteric fractures are mainly intertrochanteric with the fracture line extending to the femoral shaft[2].

Osteoporosis is the suspected main cause for low-energy fractures. There are several risk factors predisposing to osteoporotic fracture. However, the dominant cause of hip fractures in the elderly is falling. The fall phenomenon does not only involve accidents, but is also a consequence of the normal ageing process[3], with an estimated 1% of falls by community-living elderly persons resulting in a hip fracture[4] and over 90% of hip fractures being the result of a simple fall[5].

The incidence of hip fractures is almost double for women in comparison to men. Women have greater bone loss associated with age and menopause, an increased frequency of falls and a longer life expectancy[6]. Sex-ratio data indicate that the relative fracture risk for a woman over the age of 50, is almost triple in comparison to a man of the same age. The risk increases exponentially for both sexes and continues to increase with age. Consequently, at some point during the rest of their lives one in three women and one in five men will suffer from a low-energy hip fracture[7].

There is an interesting geographical distribution in the incidence of hip fractures, independent of age and gender, with higher hip fracture rates recorded in North America and northern European countries compared with southern Europe. The lower physical activity level of residents in northern cities and in economically developed countries, as well as the limited exposure of those populations to the sun, seem to contribute to the increase of fractures[8]. It is thus expected that the fracture risk will be significantly higher in ten years in the Nordic countries, compared with other regions of southern Europe, given that the lack of sun exposure in the former countries leads to a lower production of vitamin D[9]. It has been scientifically established that vitamin D deficiency may not only lead to increased loss of bone mass and bone mechanical stability, but may also have a negative effect on neuromuscular function, with an increased risk of falls[10].

In the U.S. it is estimated that, in the year 2000, low-energy hip fractures reached 1,460,000 cases, while in Europe the equivalent was 890,000 cases[11]. Corresponding data from Greece for the year 1997 reveal incidences of these fractures amounting to 118.6 cases per 100,000 people in the general population. The hip fracture incidence in Greek women over the age of 50 years was 448.87 per 100,000, while in Greek men of the same age it was significantly lower and amounted to 216.1 cases per 100,000 people[12]. Worldwide, the number of hip fractures may reach 21.3 million by the year 2050[13], with approximately 5,000,000 cases recorded in the U.S[14]. In Europe, the frequency of low-energy hip fractures is also expected to increase significantly by 2050, when one third of the population will be over 60 years, and is expected to approach 6.3 million cases annually[15].

The financial cost related to treatment is very high, because the majority of cases require admission to hospital and surgical treatment. A period of rehabilitation is usually needed after surgery, requiring help from many different specialists. In the U.S., the cost of the medical treatment of hip fractures varies between 8 and 20 billion dollars annually[16] and for 2025 it is expected to reach 25 billion dollars[17]. According to EU estimates, in Europe 4.8 billion Euros are spent annually on the hospitalisation and inpatient care of patients with hip fractures[18]. The amount is expected to reach 51 billion Euros by the middle of the century[19]. Data from Greece for the year 2002 indicated that the cost of recovery reached 46.3 million Euros[20].

Hip fractures are a serious threat to life, because of the large number of related concomitant disease and/or serious postoperative complications. However, the risk of death in the immediate postoperative recovery period depends significantly on the fracture and is inversely proportional to the pre-fracture physical and health status of the individual[21]. Notably, the mortality in the first year after a hip fracture remains high (20-24%)[22].

The majority of people who survive a hip fracture have residual mobility disabilities[23,24]. For these people, dependency in the functional activities of daily living persists for more than 2 years of recovery, with up to 20% needing help putting on trousers, 50% needing assistance to walk, and 90% being dependent when climbing stairs. Between 40% and 60% of older people with a hip fracture fail to regain pre-fracture mobility and are unable to return to community activities[25,26].

The history of an osteoporotic fracture is known to be a significant risk factor for future fractures[27].The rehabilitation of hip fracture patients is a difficult process that requires the cooperation of health professionals from different medical disciplines, including physical therapists. Several *active*-protocols are available, which physical therapists may follow. However, in the design of the physical therapy intervention for hip fractures two specific factors concerning the patients should be taken into account. First, the patients are mainly elderly, osteoporotic individuals who should be mobilised as soon as possible with full weight-bearing. Thus, mobilisation of these patients as early as possible is essential for full rehabilitation and reintegration into daily life, as this reduces the risk of postoperative complications, deformities, and disabilities[28]. Second, to avoid a new fall, and by extension a new fracture, the patients must be trained to improve their balance[29].

Mangione et al[30] maintain that physical therapy interventions after hip fractures are regarded as "black box" interventions, meaning that the physical therapy is undefined. Also, they reported that, when designing low-energy fracture interventions, clinical physical therapists may rely on experience rather than evidence for best practice[30]. The definition of post hip-fracture interventions should be multifactorial, taking into consideration any substantial clinical variations (mental or health status, physical capacity, etc.) that may exist between patients with similar orthopaedic diagnoses.

The aim of this review is to present considerations of physical therapy intervention for low-energy hip fractures, especially during hospitalisation. The physical therapy interventions should vary in relation to the pre-fracture status of the patient, the fracture type, the selected surgical approach and treatment. This knowledge may contribute to the effective, safe and individualised rehabilitation of the patient.

FACTORS AFFECTING THE REHABILITATION OUTCOME AFTER LOW-ENERGY HIP FRACTURES

The pre-existence of certain comorbidities and the patient's age status constitute factors that may affect the level or the time course of the functional recovery. Assessment of these factors is necessary for predicting the rehabilitation outcome. Hagino et al[31] identified seven preoperative factors that may impact on recovery: the age of the patient (<65 or >65); the mental status (dementia); the pre-injury residence (own home or nursing home/hospital); anaemia; electrolyte abnormality; respiratory pathology; and chronic systemic diseases (diabetes, chronic renal disease, etc.)[31]. Ishida et al[32] reported that dementia is the only significant predictive factor that negatively affects the patient's functional recovery[32]. The rehabilitation of hip fracture patients with dementia is complicated by cognitive and communicative problems typical of the disorder[33]. McGilton et al[34] identified that three cognitive symptoms were interfering with the rehabilitation care of hip fracture patients with dementia: (a) memory problems, (b) lack of insight or judgment, and (c) loss of purposeful movements. The memory impairment reduces recall of instructions and carry-over of therapy routines. Patients' lack of insight leads to safety issues—for example they are not able to understand the reason for their hospitalisation and sometimes try to walk without supervision and/or an assistance device too soon after their hip surgery. Impaired insight also affects patients' compliance with therapy, because patients do not always understand the relationship between rehabilitation activities and functional outcomes that affect their everyday life. Loss of ability to carry out purposeful movements may limit patients' ability to engage in the rehabilitation interventions[34]. Often, they do not attain their pre-fracture level of functioning, which leads to subsequent admission to chronic or institutional care[35].

Another significant factor which negatively affects the rehabilitation outcome of hip fracture patients is a pre-existing neurological impairment. Osteoporosis develops rapidly after stroke, in conjunction with the immobilisation imposed by hemiplegia or hemiparesis[36]. Individuals with neurological impairment have increased falling risk and, by extension, fracture risk. In particular, a reduction in bone mineral density (BMD) and muscle atrophy, coupled with a high incidence of falls, may contribute to 2-4 times higher risk of hip fractures in individuals with stroke when compared to healthy individuals of the same age. Most hip fractures in hemiplegic patients are a result of a fall on the paretic side[37]. Fracture risk seems to be somewhat less in patients with severe impairments, i.e. those who are unable to walk without assistance or are totally bedridden, perhaps because of reduced mobility and exposure to the risk of falling[38]. In individuals with neurological impairment, 48% of falls occur during walking[39]. Similarly, retrospective and prospective cohort studies have suggested that Parkinson's disease increases the risk for both bone loss and fractures in community-dwelling people[40,41]. More than 50% of Parkinson's disease patients fall at least twice in an one-year period and one fifth of these patients experience trauma, including bone fractures[42]. In population-based studies with Parkinson's disease patients, the cumulative incidence of hip fractures by ten years after the diagnosis was 27%[43], and factors associated with osteoporosis were implicated in the genesis of the fractures[44]. Because of the neurological impairments, the surgical treatment after hip fracture may vary; however, the postoperative goal is the same: the functional recovery of the patients to the highest level they can achieve[45]. In a study focusing on the functional outcome after hip fracture in patients aged 65 years and older, the functional recovery was not affected by the neurological impairment when controlling for pre-fracture level of function. However, the length of stay in the hospital was significantly higher in the patients with neurologic impairment than in the controls[46].

It is reasonable to assume that, if the hip fracture patient has neurological impairments with reduced neuromuscular coordination, then gait training may be delayed. However, the exercise programmes, bed transfers as well as balance training programme in the short-sitting position should be performed as for the non-neurological patients. The physical therapy intervention for hip fracture patients with neurological impairment should differ only in time of session and in intensity of each exercise programme.

BALANCE CONSIDERATIONS IN THE REHABILITATION OF LOW-ENERGY HIP FRACTURES

Special consideration should be given to retraining balance in patients who have sustained a low-energy hip fracture, in order to prevent a new fall and a possible second fracture[47]. Quite often, the fear of a new fall constitutes a psychological aggravating factor that affects the patient's willingness to participate actively in his balance retraining[48]. Thus, preparation for balance retraining should start while the patient is in bed, which includes informing the patient of what the process will entail.

It is important to note that differences do exist between younger and older individuals' ability to maintain an upright stance; people over the age of 65 years have been shown to have greater co-contraction of the trunk and lower limb muscles, greater sway in the sagittal plane, and reduced ability to use corrective micro-movements of the ankles to maintain their balance[49]. Studies on postural balance during upright stance after total hip arthroplasty have shown that patients had a greater medial-lateral sway[50] and less ability to control their centre of gravity during gait[51] when compared with control subjects[52]. Mackey & Robinovitch[53] have shown that elderly people tend to adopt hip strategies rather than ankle strategies as an adaptive or anticipatory response to either postural perturbations or when anticipating potential gait instability during gait, as when crossing an obstacle. Even if an ankle strategy is selected, the activation is significantly slower than in younger individuals[53].

However, after the surgical procedure for treating a hip fracture, the muscles that adhere around the hip joint have lost their proper activation and synergy. The hip joint may be stiff and its movements may be painful[54]. The elderly cannot use the hip strategy for balancing during upright stance, so they should be relearning to use the ankle strategy, to the extent that they are capable.

As elderly people usually have less than normal range of motion, and often have a degree of joint stiffness[55], mobilisation of the ankle and foot should start early in the postoperative phase. Ankle and foot exercises could be given to the patient as assisted, active or resisted and should be individualised for each patient. The next stage of balance retraining should be in a short-sitting position, with the patient's feet on the floor providing a better support base[56].

After the patient acquires good balance in the short-sitting position the patient can be trained in the upright position. Balance training in upright position can be performed using a walking device; appropriate precautions should be taken for the fractured hip. The patient should be working on standing sway with the addition of upper extremity activity and/or head movements. These exercises are aimed at activating ankle strategies. When full weight-bearing of the fractured hip is allowed, the patient can perform common centre of gravity exercises, which include closed kinetic chain exercises, such as writing the alphabet with one foot, thera-band kicks, stepping over a board and sit-to-stand. By changing the upper extremity positions, the exercises become more challenging, i.e. the shoulders placed in 90^o of abduction and progressively challenging the standing balance by placing the arms to the side or across the chest and then reaching forward and overhead. The patient should also be retrained to use the hip strategies with exercises practiced on narrow or on unstable surfaces. Examples of hip strategy exercises include posture correction in upright stance, after swing forwards, either backwards or in a lateral direction with open or closed eyes—touching a table or a wall for support, if necessary—standing on a beam and/or adding upper extremity activities, unipedal stance, tandem standing, tandem walking. Other exercises also include head and neck movements with and without the use of the upper limb patterns of the Proprioceptive Neuromuscular Facilitation (PNF) method and standing on a piece of foam or a pillow[57].

The final stage of the balance rehabilitation programme should include external perturbation exercises, expected as well as unexpected ones. These exercises require a proactive and or reactive response from the patient, using the ankle and hip strategy or the hip and step strategy combined. In this way, the ability to reinstate the centre of body mass (CoM) successfully over the base of support is increased[58].

Moreover, it may be possible to teach older individuals how to fall safely[59]. Groen et al[60] have indicated that fall training based on martial arts (MA) fall techniques may be useful to prevent hip fractures in the elderly, as it is likely to contribute to the reduction of the impact forces on the hip. An important characteristic of MA fall techniques is that a fall is changed into a rolling movement. By rolling, the forces are distributed over a larger impact site and the amount of energy to be absorbed during impact is reduced because kinetic energy is preserved during the rolling movement[60]. These fall techniques may increase the patient's ability to act properly in response to future loss of balance and to avoid a new traumatic fall.

REHABILITATION HIGHLIGHTS

Femoral Neck Fractures

The method of surgical treatment for any type of fracture depends on whether the fracture is characterised as stable or unstable. Other factors, such as the age and mental status of the patient, and osteoporosis, should be taken into consideration. The physical therapist should be informed about the selected surgical approach, as this information is very important during the crucial phase of hospitalisation. Depending on the surgical approach, there are single movements or combinations of movements of the operated hip that should be avoided.

Non-displaced femoral neck fractures in patients younger than 65 years are treated with multiple parallel screws or pins or a sliding hip screw. Unipolar or bipolar prosthetic replacement of the femoral head (hemiarthroplasty) is

Table 1. Summary of surgical approach and/or fracture type and movement to avoid during rehabilitation[64,71,75]

Type of fracture	Surgical approach	Avoid during kinesiotherapy
Femoral neck fractures	Posterior of the hip	Flexion over 90° Adduction past neutral position Internal rotation Combination of flexion & internal rotation SLR
	Transgluteal of the hip (Hardinge)	Extension over 0° (hyperextension) Adduction past neutral position External rotation Combination of extension & external rotation SLR
	Anterolateral of the hip (modified Watson-Jones)	Extension over 0° (hyperextension) Adduction past neutral position External rotation Combination of extension & external rotation SLR
Intertrochanteric fractures	Lateral	Active SLR Adductors strengthening
Subtrochanteric fractures	Lateral	Active SLR Adductors strengthening

used to treat unstable or displaced fractures in patients older than 65 years. In patients with pre-existing articular damage (i.e. osteoarthritis of the acetabulum) the method of choice is total hip arthroplasty. For elderly osteoporotic patients, cemented hemiarthroplasty or total hip arthroplasty allows early weight bearing of the fractured hip[61].

The surgical approaches that are commonly used for femoral neck fractures are the posterior, the transgluteal (Hardinge) and the anterolateral (modified Watson-Jones) approaches to the hip. The posterior approach does not interfere with the abductor mechanism of the hip, so the loss of abductor power is minimised in the immediate postoperative period. After a posterior approach, hip flexion must not exceed 90°, while hip adduction past midline and internal rotation must be avoided. The combination of flexion and internal rotation should also be avoided (table 1).

The anterolateral surgical approach (modified Watson-Jones) is mostly used for total hip arthroplasty. During surgery the normal functioning of the abductor mechanism is affected because the anterior part of the gluteus medius and the whole gluteus minimus are detached from the trochanter[62].

During the Hardinge approach, the posterior tissues are preserved, which leads to a lower incidence of posterior dislocation. The fact that the hip rotator muscle group is intact during the Hardinge approach permits early mobilisation of the patient, usually within two days[63]. After a Hardinge or modified Watson-Jones approach, the motion of the operated hip should not exceed 0° extension, while adduction and external rotation should not pass the midline. The combination of extension and external rotation should also be avoided (table 1). Another exercise that must be avoided after hemiarthroplasty or total hip arthroplasty is the straight leg raise (SLR), as this exercise generates torque that potentially rotates the femoral stem around its axis and can lead to femoral loosening[64].

Hip abductor weakness could lead to a Trendelenburg gait on the fractured site[65], so the hip abductors should be strengthened. Careful selection of exercises is required in order to prevent excessive loading of the hip joint during abduction exercises. Range of motion and abductor active exercises should be performed with gradual encumbrance in different body positions. Debevec et al[66] estimated acetabular loading in non-weight-bearing, in upright, in supported and unsupported supine, and in side-lying lower limb abduction. 3-D mathematical models of the hip joint reaction forces and the contact hip stress have been developed to simulate active abductor exercises in the above body positions. The results indicated that in the neutral lower limb position the absolute values of the hip joint reaction force and the peak contact hip stress are highest in the unsupported supine (1.3 MPa) and in side-lying abduction (1.2 MPa), while they become lower in standing abduction (0.5 MPa) and lowest in supported supine abduction (0.2 MPa). In both non-weight-bearing standing (figure 1) and in side-lying (figure 2) abduction, the equilibrium of gravitational and

Figure 1. The ending position of the standing mid-range abduction.

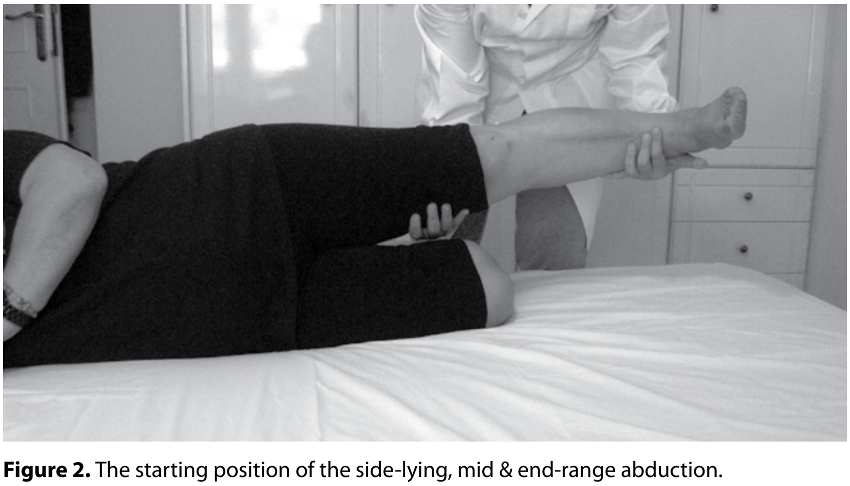

Figure 2. The starting position of the side-lying, mid & end-range abduction.

Table 2. Active and progressive exercise program of hip abductor muscles. Based on the findings of Debevec et al [42].

Body position	Requirements for proper performance	Range of hip abduction
Supine I	Neutral leg position with knee joint in extension & ankle joint in dorsal flexion	Midrange Mid- & end-range Full active range of motion
Upright	Good balance from standing position alone or with cane.	Inner & mid-range
Side-lying	Neutral leg position with knee joint in extension & ankle joint in dorsal flexion (The end- & midrange start with the limb supported by PT to allow for active abduction only in the requested part of the range of motion.)	End-range End- & midrange Full active range of motion
Supine II	Unsupported supine abduction (The limb moves out of bed)	Inner range Inner & mid-range Full active range of motion

muscular moments with respect to the centre of rotation of the hip joint is maintained by the activity of abductors. However, in side-lying abduction greater abductor force is required to compensate for the weight of the lower limb than in standing abduction, because of the larger lever arm of the weight in the former case. Unsupported supine abduction (figure 3) corresponds to the position of highest difficulty since the abductor force needed has to overcome a large weight moment arm, while the limb has a tendency to extend and hence additional muscular activity is required to retain unsupported movement in the horizontal plane. In unsupported supine abduction the activity of hip flexors is further required to maintain correct exercise posture. These muscles have small moment arms with respect to the hip joint and thus demand high flexor forces[66].

These findings are in agreement with existing clinical guidelines aiming at progressively loading the hip joint post-surgery, as they indicate that standing abduction should commence after supported supine abduction, followed—when appropriate—by side-lying and unsupported supine abduction[67].

Additional observations in the study of Debevec et al[66] are also important for exercise progression. They underline that, after increasing the angle of abduction in upright standing, the centre of gravity of the lower limb moves laterally, which further increases the gravitational moment. Hence, the counteracting muscle activity as well as the hip-joint load must be increased. On the other hand, increasing the abduction angle from the side-lying position decreases the gravitational moment of the lower limb with respect to the hip and the hip load and muscular activity necessary also decrease[66].

In summary, abductor active exercises should be performed from positions of increasing difficulty which load the hip joint progressively. The first position is the supine on bed (supine I). The hip abduction is performed in the midrange, the end-range and the full range of motion. The next position is the upright, where the hip abduction is performed in the inner and then in the mid-range of motion. Third is the side-lying position where the hip abduction is performed first in the end-range, then in the end- and midrange and finally in the full range of motion. The most difficult position is the supine where the limb moves out of bed (supine II) and the hip abduction is performed in the inner, then the midrange and finally in the full range of motion (Table 2).

It is worth noticing that the progress and the timing of the next stage of loading the hip joint may vary depending on the type of fracture, the orthopaedic surgery selected, and the physical condition of the patient. In addition, from

Figure 3. The ending position of the unsupported supine abduction.

the above variations, any of the body positions or some degrees from the range of abduction may be avoided.

Intertrochanteric Fractures

Two methods of surgical treatment are used for internal fixation of intertrochanteric fractures: the sliding hip screw and intramedullary nailing[68]. During the sliding hip screw nail, the lateral approach to the proximal femur is used. This approach induces stress and partial ischemia to muscle structures and increased postoperative pain because, throughout the surgery, the muscle structures are restrained by retractors to keep the operative field exposed[69]. During the intramedullary fixation, the surgeon uses the minimal access approach to the proximal femur, which depends on the type of nail[70]. This approach is preferred mostly because it is less invasive and lessens the lever arm of the abductors.

The physical therapy intervention should thus be specific to the fracture type and the selected surgical approach. Clinically, when the patient is asked to perform an SLR, additional pain may be experienced in the anterior surface of the hip joint. The additional pain may be explained by the fact that when the iliacus and psoas muscles (primary hip flexors) are contracted, they exert traction on their bone insertion, which is on the fractured lesser trochanter. Furthermore, another fact is that the vastus lateralis—which is stressed during surgery by the retractors—coheres with the rectus femoris anatomically and functionally, as they are two of the heads of the quadriceps and share the same insertion tendon. Thus, since the rectus femoris, iliacus and psoas act synergistically to achieve hip flexion, patients should not perform active SLR[71].

Lewis et al[72] used a three-dimensional musculoskeletal model to estimate—amongst other things—the effect of the decreased muscle strength of specific muscles during supine hip flexion. They simulated three different conditions for each exercise to estimate the hip joint force when the maximum muscle force value for selected muscles was reduced. The first condition (*Normal Condition*)[72] served as a control condition to which the other conditions were compared. For this condition, the hip joint force due to muscle was estimated using the maximum muscle force values (maximum isometric force, P_{Force} greater than 100%) specified in the original musculoskeletal model by Delp et al[73]. For the other altered conditions, the maximum muscle force values for the selected muscles were reduced by 50%. They confirmed that when the iliacus, psoas and rectus femoris were weak during SLR, the overall efficiency of the involved muscles was reduced. Specifically, when the iliacus and psoas muscles had decreased muscle strength, the three-dimensional musculoskeletal model increased the activation of the rectus femoris, tensor fasciae latae, sartorius, gluteus minimus (all fibres), adductor longus and pectineus muscles. When the rectus femoris, tensor fasciae latae and sartorius had decreased muscle strength, the three-dimensional musculoskeletal model increased the activation of the gluteus minimus (all fibres), gluteus medius (posterior fibres), piriformis, iliacus and psoas muscles. The authors concluded that the most difficult position for hip flexion is the supine, especially the inner range of motion. Furthermore, the vertical and transverse forces increased when in less than 11° and 7° of hip flexion respectively, compared to the *Normal Conditions*[72]. It is important to consider that these estimations are derived from a three-dimensional musculoskeletal model. It can be assumed that the hip flexion performance of elderly hip fracture patients will be worse than that seen in these musculoskeletal modelling estimations.

In summary, considerations for postoperative rehabilitation of intertrochanteric fractures should include SLR, performed passively or active assisted by the therapist, at inner- and mid-range of motion; gradual quadriceps muscle strengthening; and strengthening of adductors should be avoided until the early remodelling phase of bone healing (approximately 8 weeks), so as to avoid added stress on the fracture sites and on the implant (sliding hip screw)[71] (Table 1).

Subtrochanteric Fractures

The majority of subtrochanteric fractures are high-energy fractures. Those that are considered low-energy fractures are basically intertrochanteric, with the fracture line extending down to the femoral shaft. These types of fracture are treated as intertrochanteric fractures using an intramedullary method with a long nail, inserted using a minimal access approach and closed reduction where possible. A sliding hip screw may also be applied using a lateral approach[74].

Straight leg raise should be avoided in subtrochanteric fractures, as it exerts traction on the fracture site. Adductor strengthening should also be avoided, because the adductor magnus attracts the distal fractured end, where it is attached. The quadriceps should be examined, as it crosses over the fracture site and may have been contused during the moment of fracture. Likewise, attention should be given to the gluteus maximus, which inserts into the subtrochanteric region of the femur and might be affected by the fracture pattern. Weight bearing after subtrochanteric fractures with bone loss or comminution is not allowed until cortical bone continuity has been restored. The reason is that weight bearing transfers loads to the interlocking screws and eventually causes failure of the surgical fixation[75] (Table 1).

CONCLUSIONS

Special attention should be given to several aspects of low-energy hip fracture rehabilitation to achieve an effective, safe and individualised functional outcome. Physical therapy intervention must be designed according to the pre-fracture status of the patient, as well as the type of fracture and the orthopaedic treatment used. Careful selection of exercises is required in order to prevent excessive loading of the hip joint and/or the fracture sites. The active exercise programme for abductors should load the hip joint progressively. Depending on the type of fracture or the selected method of surgical treatment, straight leg raise must be avoided or performed in a passive or active assisted manner, at the inner- and mid-range of motion. Balance training should be incorporated early into the rehabilitation programme and must remain an important part until the terminal stage. Overall, the stages of physical therapy intervention differ with respect to the intensity and level of difficulty of each exercise. The major goal for all stages is functional resumption, and prevention of future falls and fractures.

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