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Physiotherapy following through-knee amputation

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Abstract

Physiotherapeutic treatment considerations specific to the through-knee amputee are presented. Treatment is determined by the assessment findings. The physiotherapy programme includes post-operative exercises, early weight-bearing, bed to chair transfers, bandaging techniques, the counteracting of contractures and gait training. Physiotherapy is a vital part of the rehabilitation of through-knee amputees. Principles of treatment are based on normal human locomotion, the individual patient's health status, biomechanical changes and expected stump functions. The through-knee stump is generally problem free, functional and end-bearing, allowing for a high rehabilitation rate in independent ambulation. It is therefore well suited for the geriatric amputee.

Introduction

The physiotherapist will see fewer patients with knee disarticulation compared to patients with below-knee (BK) and above-knee (AK) amputations during lower limb rehabilitation. Although all recent lower limb amputation levels have common functional treatment goals such as:

healing of the surgical suture,
stump maturation prior to definitive prosthetic fitting,
gait training,

each stump level will present different ambulation and prosthetic fitting problems. These have to be dealt with on an individual basis. Therefore, the treatment planning for a recent through-knee (TK) amputee has to be directly related to the amputee's physiological, functional and mechanical losses.

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Assessment

An assessment for physiotherapy treatment planning includes the following considerations (Holliday, 1981; Mensch and Ellis, 1982).

1. *Reason or reasons for surgery*
   These will help to indicate the expected activity tolerance and the rate of treatment progression.
2. *General health of the patient*
   The amputee's energy output depends on his general medical condition which will also influence the setting of the treatment goals, e.g. independent locomotion, assistive devices necessary, aiming toward wheelchair independence.
3. *Stump condition*
   This evaluation has to be specific. Test and observe stump length and shape, muscle strength, range of motion of the hip joint, healing of the surgical suture, stump oedema, skin sensation, the presence of pain and response to weight bearing. All stump functions and conditions will affect leverage control and gait cycle performance. It will also indicate the ability of the stump to tolerate stresses of weight bearing and skin friction.
4. *Proprioception and balance*
   Prior to amputation surgery, the patient's gait was automatic. However, the loss of the shin and foot will contribute to an initial proprioceptive disturbance and lack of co-ordinated muscle action, which will affect balance.
5. *Condition of the remaining leg*
   The remaining leg will become the dominant limb. It will hold the body weight, balance while donning the prosthesis, pivot, control stairwalking, initiate standing up and sitting down, control driving, etc. When signs of intermittent claudication are present, standing activities are restricted.

6. *Pre-amputation ambulation*
   An investigation into the ambulation pattern prior to amputation surgery will determine the post-amputation level of ambulation which may be achieved.

The assessment findings will help to establish realistic treatment goals.

Through-knee amputations—specific characteristics

Ambulating a patient with a knee disarticulation is closely related to AK gait training. Similarities include the loss of knee function and learning prosthetic knee control. However, the knee disarticulation stump has several distinct functional, physiological and mechanical advantages because during surgery, bone and muscle tissues remain intact (Harris, 1970; Baumgartner, 1979; Kostuik, 1981; Murray and Fisher, 1982).

Factors aiding ambulation

1. Total end-bearing through the femur contributes to stump-socket comfort.
2. Balanced muscular control of all thigh muscles allows for co-ordinated stump movement.
3. End-bearing and stump length provide rotational stability between stump and socket.
4. Proprioceptive awareness is better as muscle tissues have not been surgically disturbed. This results in quicker readjustment to balance and stump position sense.
5. The stump shape permits a relatively easy socket suspension by contouring the socket wall above the femoral condyles.

Because of stump length, end-bearing, balance muscle control and socket comfort, the prosthesis is comparatively easy to manage.

Disadvantages specific to through-knee amputations

1. The actual stump length presents a problem during prosthetic fitting (Bell, 1970) as the placement of the mechanical knee axis falls below its anatomical position. This results in increased thigh length and a shorter shin section.
2. The thigh-shin imbalance affects the biomechanics of the gait cycle.
3. The cosmetic appearance of the prosthesis is disproportionate.

Physiotherapy treatment

Following surgery, the amputee attempts to adapt his stump motions and his locomotor pattern by *what he feels*. He perceives by touch (Mensch and Ellis, 1982). Therefore, correct guidance is indicated immediately. Sensory feedback can be provided by using stump-hand contact. The therapist assists, resists and guides the stump manually through the expected joint ranges helping the amputee experience stump control. Manual feedback also stimulates proprioception; it gives the amputee an awareness of the intensity and/or speed with which he needs to control his stump motions. Manual guidance encourages the re-establishment of automatic muscle control in preparation for prosthetic ambulation.

Post-operative phase

(for the casting technique and the post-operative soft dressing procedure.)

Phantom sensation

This is the phenomenon which makes the amputee feel complete (Koerner, 1969; Holliday, 1981; Murray and Fisher, 1982). The awareness of feeling and moving the amputated limb can be useful during treatment. The sensation is utilized to practice bilateral leg exercises which will stimulate stump proprioception and help in establishing a controlled and more automatic gait pattern.

Exercises

In preparation for ambulation, isometric exercises are initially practiced. *Extension* is *emphasized* because:

1. The trunk extensors hold the body erect.
2. Stump extension stablizes the artificial knee on stance.
3. Hip extension places the centre of gravity through the hips and permits standing with ease.

Flexion exercises are *secondary* because:

1. The amputee practices flexion routinely when sitting up and getting in and out of bed, chairs, etc.
2. He uses his stump actively as a balancing lever (in a hip flexion position) when standing on one leg and when attempting to walk.

Early weight-bearing

In TK amputations, early weight-bearing is practiced (Holden, 1981; Mensch and Ellis, 1982). This is done by providing manual distal pressure, either over the post-operative cast or

over the soft dressing. The amount of gentle intermittent compression that can be tolerated is judged by the amputee's comfort. Weight-bearing practice can be continued regularly during the day by the amputee himself by using a sling over the stump end to provide distal end bearing pressure (Fig. 1).

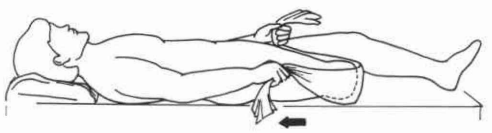

Fig. 1. Controlled, graduated weight-bearing as well as stump desensitization can be practiced using the sling or towel technique.

Graduated compression gives the TK amputee a feeling of comfort and support. This feeling is experienced because the femur is intact. Distal pressure:

1. Reduces stump swelling.
2. Aids in stump desensitization.
3. Eases the stump throbbing sensation which may be experienced when the stump is initially in a dependent position.

Weight-bearing is gradually increased by allowing partial body weight-bearing in the gait-training unit (Mench and Ellis, 1982). Weight-bearing progression is observed when the amputee can decrease the amount of weight placed on the ambulatory aids, indicating an increase in weight-bearing through the prosthesis.

Transfers

Transfers require balance, muscle co-ordination, strength and abdominal control (Holliday, 1981). Supervision or assistance must be given initially to assure that the amputee practices safe transfer techniques.

Bed to wheelchair

1. The shoe is placed on the remaining foot prior to transfer.
2. The wheelchair is positioned next to the bed on the non-amputated side.
3. Secure wheelchair brakes.
4. Assist the amputee into sitting up by using thigh stabilization and the hand-pull technique (Fig. 2).
5. The remaining foot is placed on the ground.
6. Pause and encourage deep breathing to overcome possible postural hypotension.

Fig. 2. Thigh stabilization and the hand-pull method assist the geriatric amputee in getting to the sitting position.

7. The patient pushes on his hands using triceps and abdominal muscles to bring his trunk weight forward and attempts to stand. He then reaches for the wheelchair armrests and pivots.
8. The therapist stands on the amputated side at a 45° angle holding the amputee's hips and guiding the transfer. The therapist's position permits knee counter-pressure against the patient's knee providing stability in case the stance leg should buckle (Fig. 3).
9. Using both hands supported on the arm rests, the amputee then sits down.
10. If applicable, the base section is then attached to the non-removable cast or the training unit is donned. Early ambulation can begin.

Only in recent post-surgical BK amputations will the base unit be attached to the cast *prior* to the transfer procedure. This is done because the knee is cast in extension and supporting the base unit eliminates lever pressure over the anterior aspect of the stump end (Mensch and Ellis, 1982); in TK amputations, this is not necessary.

Sitting to standing with temporary prosthesis

1. Sit forward in chair.
2. Extend prosthetic knee with heel on the floor.
3. Bend the sound knee more than 90°.
4. Shift trunk weight forward placing body weight over thighs.
5. Push on arm rests while coming to a standing position with weight supported on the remaining leg as well as the ambulatory aid.
6. Draw prosthesis underneath trunk.
7. Place feet parallel and get the feeling of a balanced stance.

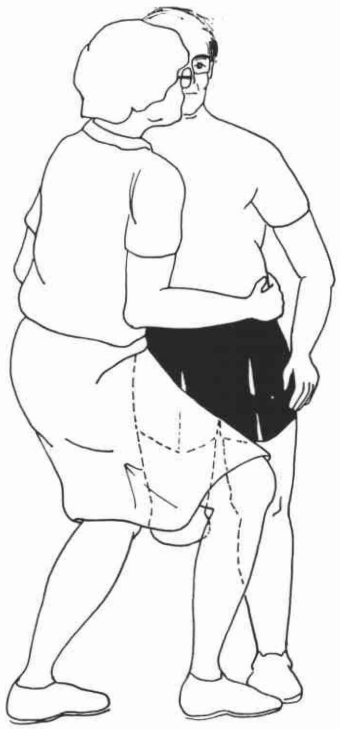

Fig. 3. The therapist's position controls the transfer counteracting a possible knee buckling of the amputee's stance leg.

Immediately post-surgically, when the stump is in a dependent position, a throbbing or pulsating sensation is experienced. This is normal and will subside within a short period of time.

Oedema

Stump oedema is common following amputation surgery and can affect the rate of healing of the suture line (Menzies and Newham, 1978), the TK amputation level is no exception. However, the severity of the oedema is usually not as marked as in AK stumps. Reduction in swelling is necessary to help the stump stabilize. Only a mature stump can act as a controlled lever and can be provided with a snug prosthetic socket fit (Fig. 4).

Stump oedema will decrease by walking regularly with a gait training unit. The alternating motions of swing and stance allow the stump muscles to contract and relax against the socket walls thus decreasing the stump circumference. The TK stump has to be reduced in girth to fully utilize the femoral condyles as socket suspension. A gradual reduction in stump volume can also be achieved by correct bandaging techniques.

Bandaging

Bandaging, if supervised and correctly applied, is an economical and effective stump shrinking and shaping method (Holliday, 1981; Mensch and Ellis, 1982). Fluid reduction is achieved by providing distal bandage pressure which is gradually decreased as the bandage continues proximally. A bandage should always feel comfortable giving firm support to the stump. A comparison can be made to a patient following abdominal surgery who will hold his hands over the suture to give comforting support when coughing. The stump bandage should provide the same support equalizing the internal and external pressures on the stump. Never apply a bandage in tight circular turns as this may restrict circulation and can have adverse effects on the stump.

Some clinicians are opposed to bandaging (Brady, 1982) claiming that the amount of bandage tension cannot be controlled. This is of particular concern in the vascular patient. These negative clinical findings reinforce the

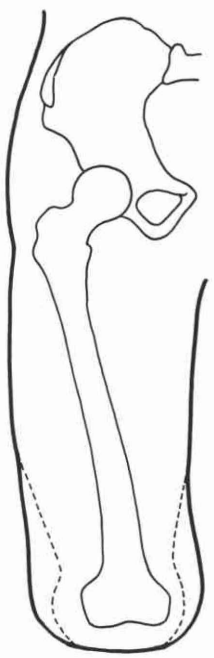

Fig. 4. Oedema reduction allows for socket suspension above the condyles.

importance of being selective in *all* treatment modalities used to reduce stump oedema. However, it can be argued that other rehabilitation treatment methods cause stump tissue stress of greater intensity than bandaging, e.g. during weight bearing. Maximal compression is experienced when the stump tissues contract during stance against the socket walls and again the amount of compression cannot be controlled or measured. However careful stump observations are made and the stump eventually matures so that it can act as a lever and support weight. Bandaging starts immediately after the post-operative cast is removed. Following a post-operative soft dressing application, bandaging starts' after initial healing of the surgical suture has taken place.

Through-knee bandaging technique

1. If right handed, stand on the right side of the patient.
2. Start the bandage diagonally over the stump end directing the bandage medially. This initial directional turn is important as it later guides the stump towards body midline. (If reversed, the stump would be pulled into abduction.)
3. Proceed in a figure of eight fashion repeating the stump end turns and continue proximally.
4. Extend the bandage across the pelvis anteriorly and around the back.

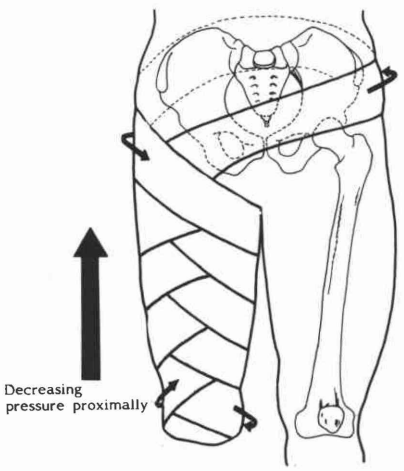

Fig. 5. Distal bandage compression aids in stump shrinkage.

5. The completed pelvic turn is then directed medially high into the groin area covering the adductor region. (Fig. 5). The pelvic turn is repeated and the bandage end secured with safety pins.

Some throbbing stumps will get relief from bandage support. Compression markings seen on a swollen stump when the bandage is removed indicate that the reduction of fluid is successfully being controlled by the bandage application. Do *not* confuse these bandage turn markings (which quickly disappear) with irritated or angry looking skin areas which can be caused or aggravated by compression. Different stumps take different compression tension. The clinical guide to a correct bandage application is the expressed comfort of the amputee. Objective stump girth measurements are recorded weekly to act as a guide since definitive prosthetic fitting can only proceed when measurements stabilize.

The bandage is removed

When the stump pain is biting in nature combined with a sensation of cold or in case of reddish-blue discolouration of the stump skin or venous restriction.

Contractures

Through-knee amputation stumps demonstrate a lesser number of contractures clinically because the surgical procedure leaves the thigh muscles intact. If a hip flexion contracture exists, the gait pattern is affected for several reasons:

1. The iliopsoas muscle is tight.
2. The amputee leans forward on prosthetic stance.
3. The gluteus muscles are overstretched and do not have enough power to hold the prosthesis in extension.

All these factors result in gait deviation and higher energy consumption. Moderate hip flexion contractures can be treated. However, marked hip flexion contractures cause major fitting problems due to the TK stump length (McCollough et al, 1971).

Preventive measures to counteract contractures

Prone lying is important for the TK amputee. The prone position is restful (Holliday, 1981), allows all joints to be in mid-position and provides stump position control without stress by turning the head toward the sound side. Frequent daily prone lying periods are indicated following activity sessions. A firm wheelchair seat supports the pelvis and counteracts a pelvic

drop. A hammock seat permits stump internal rotation and adduction. Sitting on one buttock also can lead to scoliotic compensation. Therefore, equip the chair with a sitting board. A firm mattress during supine rest periods will prevent the pelvis from sagging counteracting hip flexion contractures.

Stretching of hip flexion contracture for TK amputees

1. The amputee lies on his sound side with the leg in flexion. The flexed leg provides a stable side lying position and also flexes the lumbar spine (Mensch and Ellis, 1982).
2. The therapist kneels at buttock level behind the amputee using his/her position to counteract spinal motion. This is done to get a true hip extension stretch and to prevent the joints above from compensating thus reducing the actual stretch on the hip joint.
3. One hand provides counterpressure against the posterior aspect of the hip, while the other hand stretches the stump into hyperextension.

The passive stretch technique is indicated for muscle tissue shortening only. If fixed joint contractures limit joint range, do not attempt to stretch. Stretching is done only within pain-free limits. Producing pain will cause a reflex hip flexion to avoid the painful stimulus of the stretch. Following passive tissue stretching, practice gluteus contractions to encourage active hip extension which will counteract hip flexion. Individuals who demonstrate joint hypermobility do not develop contractures while people with pre-existing kyphotic postures are more inclined to develop stump contractures.

Gait practice

Stump placement in the prosthesis must be precise because the socket is constructed to adhere to the anatomical contours of the stump. If the stump is not positioned properly, the pressure distribution will be incorrect causing stump pain and the prosthesis will be malaligned.

The TK amputee *donning* his prosthesis sits forward on a chair.

1. The artificial knee is positioned in extension.
2. The stump is placed into the socket. If the patient wears a double wall socket, the inner soft liner is donned first and then inserted into the outer rigid socket (Baumgartner, 1979).
3. The sound leg stands up.
4. The stump pulls the prosthesis backwards into a stance position.
5. Full weight-bearing is necessary to judge the correct socket fit.
6. Additional suspension, if applicable, is then secured.

Weight shifting and posture control

Prior to walking, the amputee exercises, repeatedly practicing weight shifting and step position exercises (NYU 1975). This is done between the parallel bars in front of a mirror using visual feedback. Heel contact, foot flat and toe off positions provide feedback from the ground which enhances proprioceptive awareness. In this way, the stump also learns to adjust to the weight and the functions of the prosthesis.

The most important gait function based on controlled weight shifting which the TK amputee has to learn, is to initiate hip flexion following toe off (Fig. 6). This movement will accelerate the prosthesis forward into the swing phase. This phase proves difficult to master because of the length of the thigh lever. Careful hip-knee-ankle

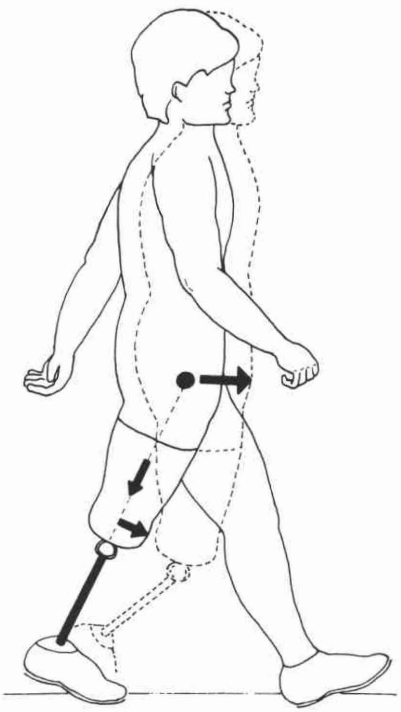

Fig. 6. Learning to initiate prosthetic knee flexion proves difficult for some TK amputees.

alignment can over-compensate when the thigh is longer by providing too much knee stability. The patient feels "glued" to the ground.

Instead of keeping the weight on the prosthesis and dropping the pelvis, allowing the prosthetic knee to flex and accelerate, the amputee will hoist his pelvis eliminating weight bearing and swing his prosthesis forward by either circumducting abducting or by vaulting on the sound side. He will almost walk stiff legged and does not control his prosthesis (Foort, 1979). The position of the prosthetic knee axis is crucial as to how well the amputee can utilize its function and shift weight. Prosthetic heel contact is often achieved by excessive impact in order to secure immediate knee extension (Hughes, 1970). The socket vibrations on prosthetic knee extension, as well as the auditory feedback, will indicate to the amputee that weight can be placed on the prosthesis without the knee collapsing.

Standing balance

This is tested by "pushing" the amputee in various step positions to see how well he will recover from unexpected postural changes.

The TK stump is able to bear weight on its distal end, therefore it serves extremely well in giving the remaining leg total relief during prosthetic stance. In non-weight-bearing stumps, stance on the sound side is increased, thus tiring the remaining leg somewhat more quickly and possibly affecting balance.

The TK amputation should therefore be considered for the elderly who usually lose their leg due to vascular insufficiency. End bearing and the improved proprioception and balance achieved with a TK amputation help the elderly patient to be a prosthetic candidate.

Gait pattern

Each phase of stance and swing is individually practiced, reinforced and corrected. Progression to crutches is indicated when the TK amputee controls heel-strike, foot-flat, mid-stance, heel-off and toe-off rhythmically, and when his sound leg oversteps the prosthesis. An upright posture placing the centre of gravity over the hip joints is stressed (Mensch, 1979) throughout gait practice as it is energy efficient. The therapist teaches posture control by utilizing hand contact to correct the trunk posture, thus providing feedback by touch. Other modalities include mirrors and videotape recording (Netz et al, 1981) for visual feedback and limb load monitors for audio feedback during gait training. It is also important to practice trunk rotation and alternating arm swing to assist the accelerating and decelerating body motions which are normal in human locomotion but are restricted by ambulatory aids.

If the treatment is aimed towards independent locomotion, *do not* allow the TK amputee, during the early post-operative phase to walk stiff legged by using a pylon, because the amputee tries early on to readjust his locomotion by what his stump perceives.

1. A stiff knee prohibits proprioceptive awareness of the hip extension function and thus deprives the amputee of the feeling of stability on stance.
2. A stiff knee does not allow the swing phase to follow its normal cycle (Fig. 7).
3. A stiff knee encourages gait deviations such as prosthetic circumduction and abduction or vaulting on the sound side.
4. A stiff knee gait is more energy consuming because the natural acceleration and deceleration of the prosthesis cannot take place.

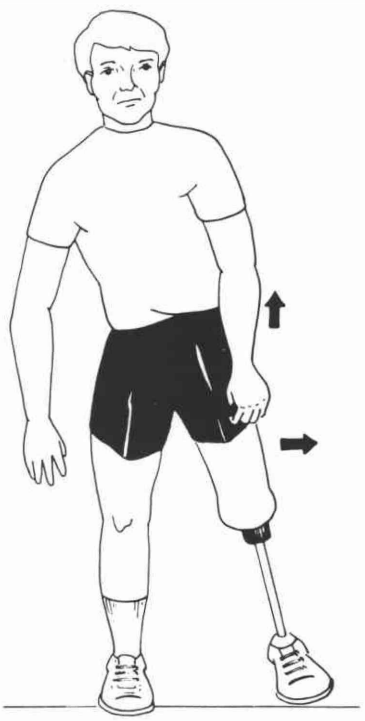

Fig. 7. Walking post-operatively with a stiff knee produces incorrect proprioceptive feedback.

If, however, the assessment indicates that the TK amputee will not be able to walk independently with a free swinging prosthetic knee, then a modified commercial gait device, which can hold the artificial knee position in locked extension, can be prescribed to help the more debilitated person to get about enough to cope with activities of daily living.

Stairwalking

Up: The sound leg proceeds; the prosthesis, held in extension follows (Alexander, 1978).

Down: The prosthesis is placed on the lower step first, held in extension. The sound leg which is able to hold the body weight in a knee flexion position, will follow.

Inclines

Up: The amputee approaches the incline in a sideways position with his sound side facing the uphill slope. The sound leg steps up and the prosthesis follows with the prosthetic knee in extension, stabilizing the position.

Down: The extended prosthesis leads, also in the sideways position, and the sound leg follows.

The sideways position to the line of progression is important to avoid buckling of the prosthetic knee on the incline.

Falling

Falling techniques should be as simple as possible because during the fall, the TK amputee does not have time to think which procedure to use for a forward or a backward fall.

Teach: Let go of the crutches and flex the body.

Reason: Body flexion reduces the impact of a fall. Body extension increases the impact.

Getting Up

Practicing to get up off the floor is important.

1. Flex the sound leg.
2. Extend prosthesis.
3. Roll trunk toward sound side and use momentum to achieve kneeling position.
4. Use arms to stabilize the kneeling position to allow the foot to come into a step position.
5. Bring trunk weight backwards with the prosthesis still backwardly extended.
6. Stand up by pushing on arms (holding on to walker or furniture if available) and place prosthesis into stance. Standing can also be achieved (step 6 repeated) by using the push-pull method. The therapist's hand pull provides momentum to get up.

Make sure the centre of gravity is positioned over the quadriceps. Getting up is difficult to learn and requires repeated practice. Once perfected, the amputee is less afraid of falling because he knows he can get up again.

Wheelchair independence

A programme aiming towards wheelchair independence is considered:

1. When the remaining leg is unreliable.
2. When other medical conditions do not allow the amputee to ambulate with walking aids.
3. When bilateral amputation deprives the elderly of having at least one knee joint.
4. When the amputee has lost all motivation regarding participation in a rehabilitation programme.

Discussion

Although the TK amputation stump has specific advantages over non-weight bearing stumps, the following considerations should not be over-looked:

1. The cosmetic appearance bothers patients more so when sitting because the thigh protrudes and the shorter shin sometimes does not allow for foot-ground contact. This emphasizes the fact that the limb is artificial.
2. The TK amputee practices an unnatural gait pattern (Oberg and Lanshammar, 1982). In normal locomotion, the knee on weight-bearing is held in slight initial flexion. However, the amputee has to stand on a completely extended prosthetic knee, which means he has to hold hip extension somewhat longer on the prosthetic leg compared to the sound side.

Rehabilitation potential of the TK amputee, as with other levels, depends on the general health and on the pattern of ambulation prior to amputation.

Conclusion

Physiotherapy treatments are a vital part of the rehabilitation of the TK amputee. A specific treatment plan is based on the sound knowledge and understanding of normal human locomotion, the health status of the patient, and the biomechanical changes and expected stump

functions resulting from the TK amputation. The TK stump is generally problem free, functional and end bearing, allowing a high rehabilitation rate in independent ambulation and is therefore, well suited for the geriatric amputee.

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