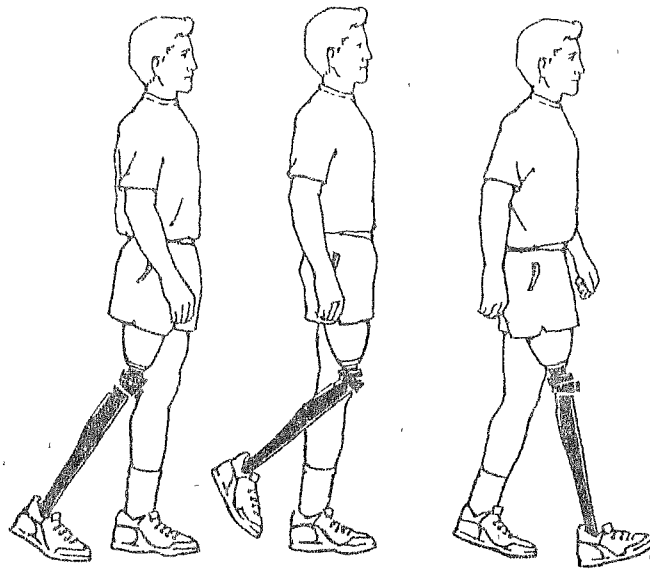


PROSTHETIC GAIT TRAINING PROGRAM FOR LOWER EXTREMITY AMPUTEES



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PUBLICATION

PART I: ABOVE-KNEE AMPUTEE STRENGTHENING PROGRAM

Equipment:

1. Towel roll of 5-7 inches in thickness.
2. A foot stool of 7 inches in height.
Initially, you may want to use a towel roll for greater comfort, progressing to a stool as tolerated.
3. A large, firm resting surface such as a floor or exercise mat.
4. Loose comfortable clothing, i.e. shorts and a T-shirt.

General Instructions:

Each repetition should be performed for 10 seconds. This will allow you to perform each repetition slowly, moving your body in a controlled manner.

- 2 sec. initiate contraction (raising the body)
- 6 sec. maintain the contraction (hold the position)
- 2 sec. release contraction (lowering the body)
- 10 sec. total time of each repetition

Note: A 10 second contraction may be too difficult to maintain initially. You may begin with a 6 second repetition by decreasing holding time to 2 seconds.

- 2 sec. initial contraction
- 2 sec. maintain the contraction
- 2 sec. release contraction
- 6 sec. total time

- Progress to 10 second repetitions when possible.
- Between each repetition, a 5-10 second rest period is recommended to allow the muscle ample time to recover in order to perform the next repetition correctly.
- Start with 10 repetitions of each exercise for the first week, adding 10 repetitions each week thereafter up to 50 repetitions.
- Perform each of these exercises twice a day for four weeks or until you can perform 50 repetitions for 10 seconds each with correct form. At this stage, you may perform these exercises once a day for eight weeks or make them a part of your daily exercise program.

Program Example:

$(10 \text{ sec. contraction} + 10 \text{ sec. rest}) \times 10 \text{ repetitions} = 200 \text{ sec. or } 3 \text{ min. } 20 \text{ sec.}$
 $7 \text{ exercises} \times 3 \text{ min. } 20 \text{ sec.} = 23 \text{ min. } 20 \text{ sec. per session}$

Note: As your strength and endurance increase, less rest between repetitions will be needed, thus decreasing total amount of exercise session time.

1. HIP EXTENSION

- a. Lie on your back with the towel/stool placed securely under the residual limb. Both arms rest comfortably at your sides.
- b. Depress the residual limb firmly into the towel/stool, raising your buttocks off the resting surface.
- c. Hold this position for ____ seconds, then lower your buttocks slowly to the resting position.
- d. Repeat this exercise for ____ repetitions.

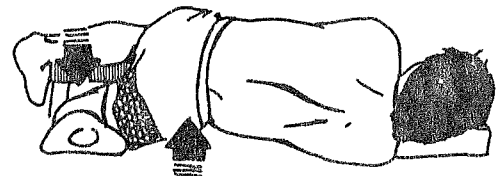
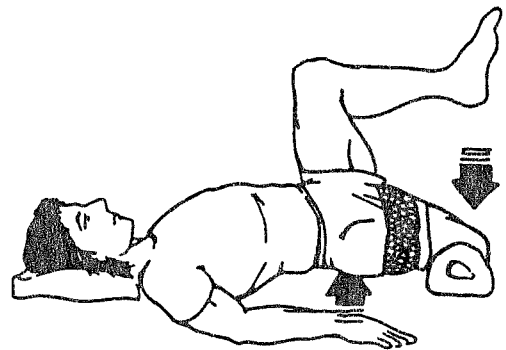
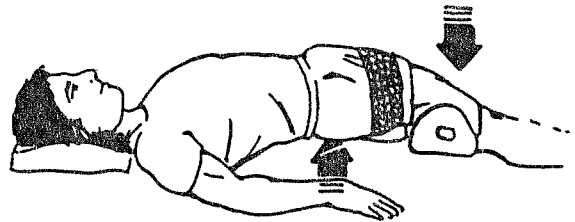
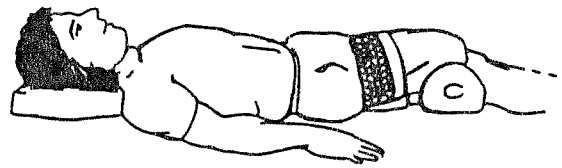
Variations: As your strength increases, raise the unaffected limb off the resting surface throughout the exercise. Additional resistance may be achieved by resting a weight on the pelvis.

Primary Muscles: Gluteals and Hamstrings

Gait Considerations: Terminal Swing, Initial Contact, and Loading Response

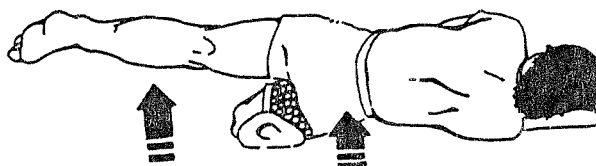
2. HIP ABDUCTION

- a. Lie on the affected limb side with the towel/stool placed securely under the residual limb. Place a stool directly in front of your hips, bending both your unaffected hip and knee to 90 degrees so that the leg rests comfortably on the stool.
- b. Depress the residual limb firmly into the towel/stool, raising your hip off the resting surface.



- c. Hold this position for _____ seconds, then lower yourself slowly back to the resting position.
- d. Repeat this exercise for _____ repetitions.

Variations: As your strength increases, begin to lift the unaffected limb off the stool, maintaining leg in an outstretched position held directly over the residual limb. Additional resistance may be achieved by resting a weight on the sound hip.

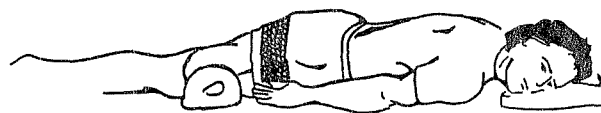


Primary Muscles: Gluteus Medius and Gluteus Minimus

Gait Considerations: Mid-Stance and Terminal Stance

3. HIP FLEXION

- a. Lie on your stomach with the towel placed securely under the residual limb. Both arms should rest comfortably at your sides.
- b. Depress the residual limb firmly into the towel raising the pelvis off the resting surface.
- c. Hold this position for _____ seconds, then lower yourself back to the resting position.
- d. Repeat this exercise for _____ repetitions.



Variations: Additional resistance may be achieved by resting a weight on the buttocks.

Primary Muscles: Iliopsoas and Rectus Femoris

Gait Considerations: Mid-Stance, Initial Swing, Mid-Swing, Terminal Swing, and Loading Response

4. BACK EXTENSION

- a. Lie on your stomach with a towel placed between your legs. Cross your arms behind your back.
- b. Squeeze the towel between your legs while simultaneously raising both legs, and head off the resting surface.
- c. Hold this position for ____ seconds, then lower yourself back to the resting position.
- d. Repeat this exercise for ____ repetitions.

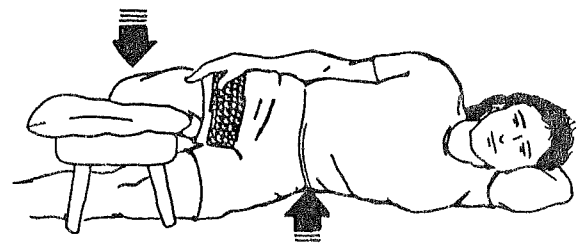
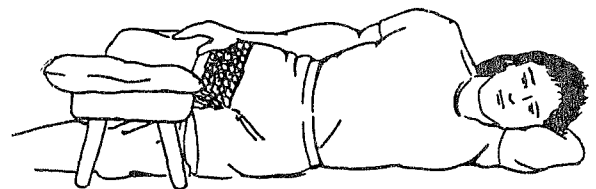
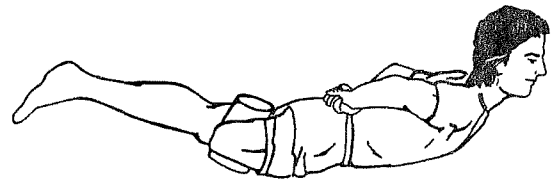
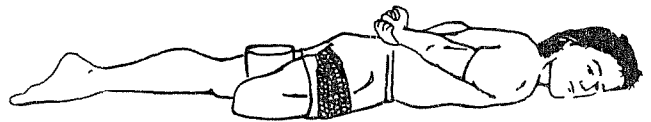
Variations: As your strength increases, begin raising more of your upper body during this exercise.

Primary Muscles: Back Extensors, Gluteus Maximus and Hip Adductors

Gait Considerations: Initial Contact, Loading Response, Mid-Swing, and Terminal Swing

5. HIP ADDUCTION

- a. Lie on the unaffected side, placing the stool over the unaffected limb. Place your residual limb on top of the stool, covering the stool with a pillow for comfort. Place the lower arm under your head, and the upper arm comfortably at your side.
- b. Depress the residual limb into the pillow-covered stool raising the lower hip off the resting surface.



- c. Hold this position for _____ seconds, and then lower yourself back to the resting position.
- d. Repeat this exercise for _____ repetitions.

Variations: As your strength increases, raise your unaffected leg off the resting surface during this exercise.

Primary Muscles: Hip Adductors

Gait Considerations: Mid-Swing, Terminal Swing, and Initial Contact

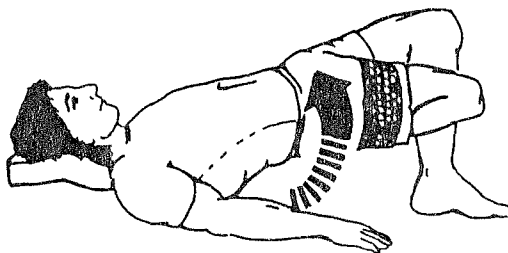
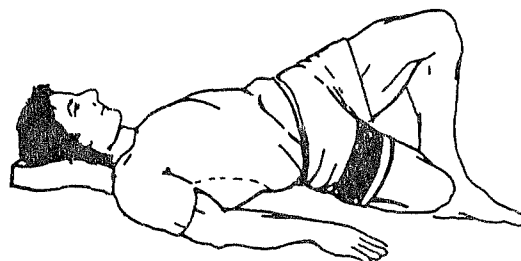
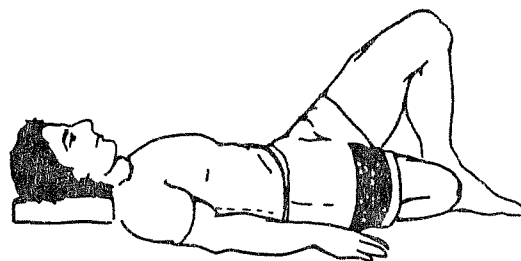
6. BRIDGING

- a. Lie on your back with the unaffected knee bent to 90 degrees and your foot flat on the resting surface. Place both arms comfortably by your sides.
- b. Push down with your foot into the resting surface, while raising your buttocks off the resting surface, until your hips are fully extended. Rotate the affected hip in an upward direction until both hips are of equal height.
- c. Hold this position for _____ seconds, and then lower yourself to the resting position.
- d. Repeat this exercise for _____ repetitions.

Variations: None

Primary Muscles: Gluteus Maximus, Back Extensors, Unaffected Side Internal Rotators

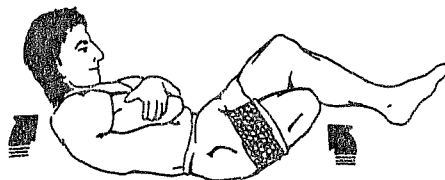
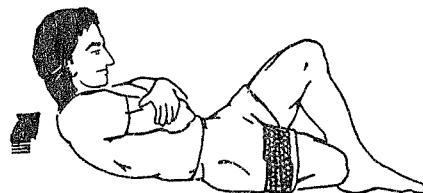
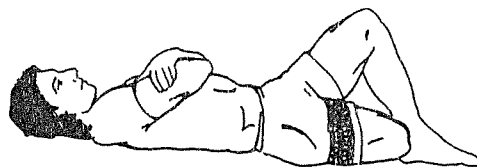
Gait Considerations: Loading Response, Mid-Stance, and Terminal Stance



7. SIT-UPS

- a. Lie on your back with your arms across your chest and your knee bent.
- b. Start with your head on the resting surface, tuck your chin and continue to raise your trunk until your shoulder blades come off the resting surface.
- c. Hold this position for _____ seconds, and then lower yourself to the resting position.
- d. Repeat this exercise for _____ repetitions.

Variations: As your strength increases begin to bring your knee to your chest as you raise your upper body off the resting surface.



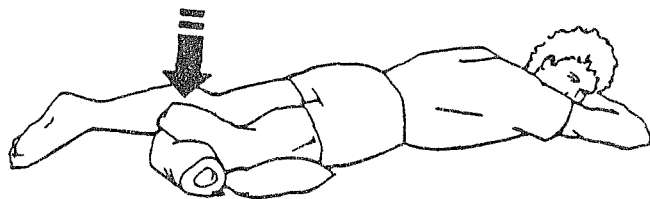
Primary Muscles: Abdominals

Gait Considerations: Mid-Stance

ADDITIONAL BELOW KNEE AMPUTEE EXERCISES

8. KNEE EXTENSION

- a. Lie on your stomach with a pillow placed securely under the thigh of the residual limb and another towel under the shin. The knee cap should not be touching the resting surface or the towels, so that no compression occurs. Both arms should rest comfortably at your sides.
- b. Depress the shin of the residual limb firmly into the towel extending the knee completely.



- c. Hold this position for _____ seconds, then relax the limb while returning to the resting position.
- d. Repeat this exercise for _____ repetitions.

Variations: none

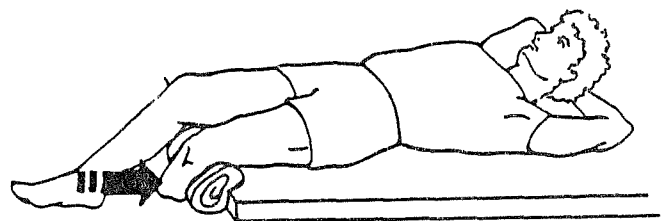
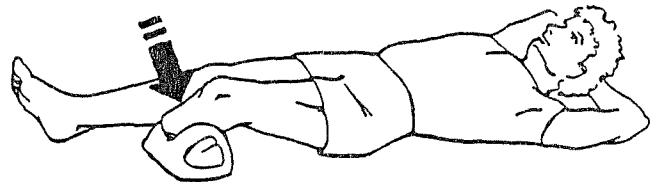
Primary Muscles: Quadriceps Femoris

Gait Considerations: Initial Contact, Loading Response, Mid-Stance

9. KNEE FLEXION

- a. Lie on your back with a firm towel roll placed under the calf of the residual limb. Place both hands comfortably at your sides.
- b. Pull down and back into the towel roll as your knee begins to partially bend. The towel should not slide. If it does, place additional towels under your thigh to prevent slipping.
- c. Hold this position for _____ seconds, and then relax the limb while returning to the resting position.
- d. Repeat this exercise for _____ repetitions.

Variations: For a firmer surface you can lie on a table or sofa with the knee bent over the end of the table and pull your leg into the table.



Primary Muscles: Hamstrings

Gait Considerations: Initial Swing, Mid-Swing

PART II: PRE-GAIT TRAINING PHASE

Equipment:

A step stool of 7 inches in height, and comfortable clothing as previously mentioned.

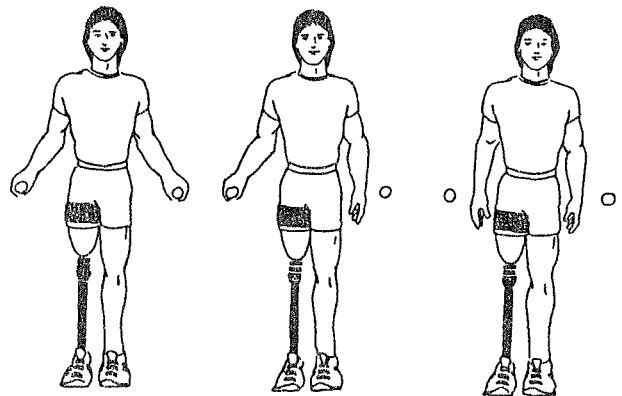
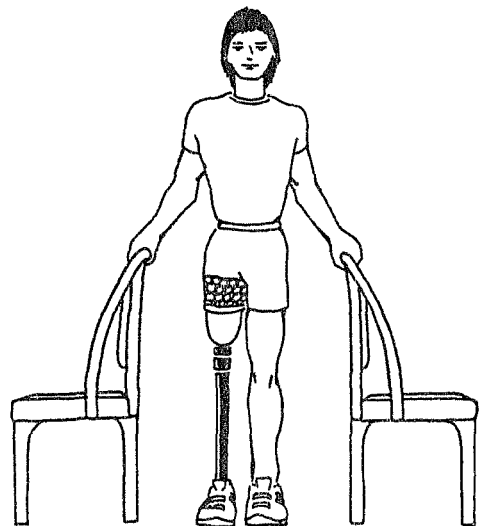
General Instructions:

The following exercises should be practiced at home using two straight back chairs in lieu of parallel bars, in front of a full length mirror.

1. INITIAL BALANCE TRAINING

Standing Balance:

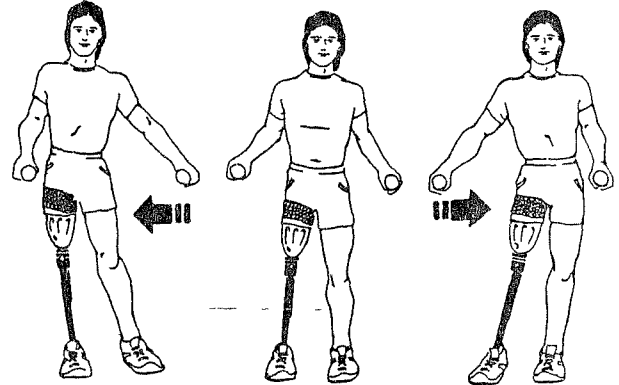
- a. Stand in the parallel bars (P-Bars) facing a full length mirror, placing both hands on the P-Bars. Your feet should be approximately 2-4 inches apart. This is the normal base of support (BOS) or distance between the feet.
- b. Without moving, orient yourself to your prosthesis noting the relationship at the stump/socket interface, or how your residual limb feels in relation to the socket. Once you feel comfortable with your balance, take the unaffected-side hand off the bar. Now feel the change in pressure at the stump/socket interface, due to the increased weight-bearing.
- c. When you feel comfortable using one hand for balance, remove both hands from the bars. Again, feel the change in weight-bearing at the stump/ socket interface.



2. WEIGHT SHIFTING EXERCISES

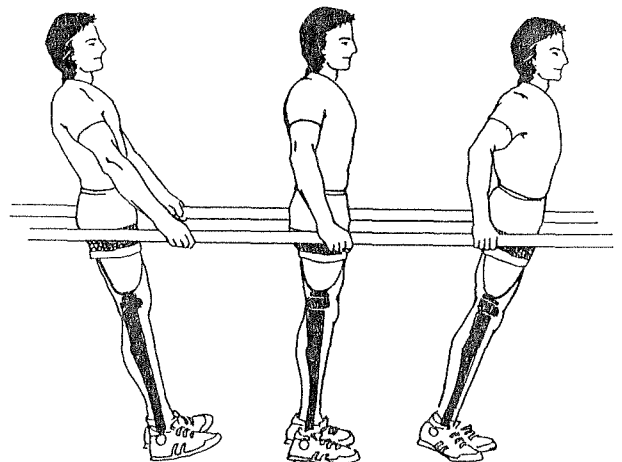
A. Side to Side:

- a. Stand in the P-Bars with both hands on the bars and your feet comfortably apart (2-4 inches).
- b. Shift your body weight from right to left. As you shift your weight note how the pressure changes at the stump/socket interface with the change in weight-bearing. Become familiar with the movements of your prosthetic ankle and knee joint, developing a feel for their capabilities and limitations.
- c. When this movement feels comfortable with both hands on the bars, remove the unaffected-side hand and continue the side to side movement.
- d. When you feel comfortable using one hand for balance, remove both hands from the bars. Again, feel the change in weight-bearing at the stump/socket interface.



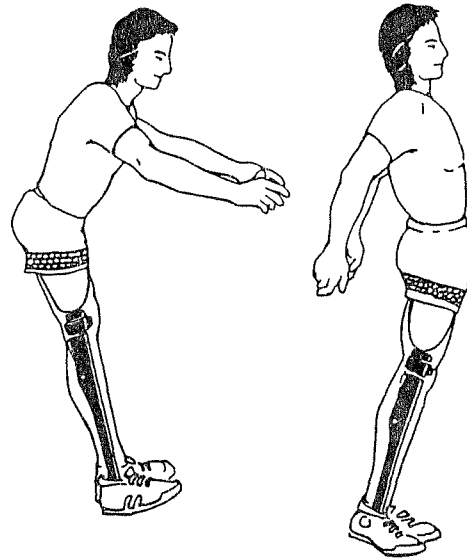
B. Forward/Backward:

- a. Stand in the P-Bars with both hands on the bars and your feet comfortably apart (2-4 inches).
- b. Shift your body weight forward and backward. Begin with a small degree of movement, progressing slowly to movements of greater amplitude. Continue to be aware of the weight-bearing changes as described above.
- c. When this movement feels comfortable with both hands on the bars, remove the unaffected-side hand,



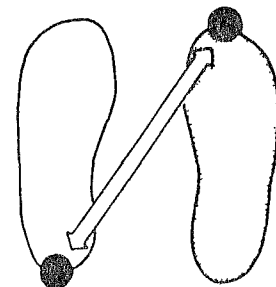
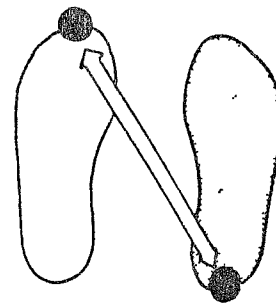
and continue the forward and backward movement. Remove both hands from the bars during this movement once you are comfortable balancing with one hand.

- d. Balance recovery tips:
If you shift your weight too far backward (over the heels) simply raise both arms forward and bend forward at the hips.
If you shift your weight too far forward (over the toes) simply stretch both arms behind you and arch your back.



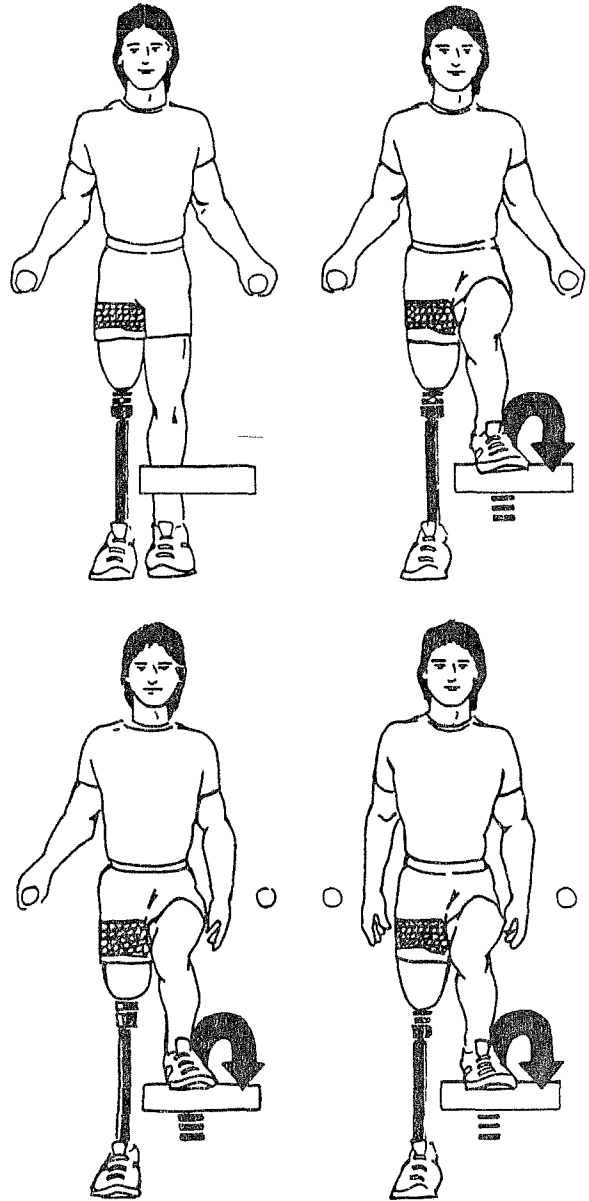
C. Diagonal Weight Shifting:

- a. Stand in the P-bars with both hands on the bars and your feet comfortably apart (2-4 inches).
- b. Shift your body weight from the prosthetic heel to the unaffected toe in a diagonal pattern. Begin with small movements, progressing to movements of larger amplitude. Continue to be aware of the weight-bearing changes as described above.
- c. When this movement feels comfortable with both hands on the bars, remove the unaffected-side hand and continue the diagonal movement. Remove both hands from the bars once you are comfortable balancing with one hand.
- d. After you become comfortable with the diagonal movement of shifting your weight from the prosthetic heel to the unaffected toe, reverse the pattern. Weight shift from the unaffected heel to the prosthetic toe, following the same progression as described above.



D. Stool Stepping:

- a. Stand in the P-Bars with both hands on the bars and your feet comfortably apart (2-4 inches). Place a 7-9 inch step stool in front of the unaffected leg.
- b. With both hands on the bars, step onto the stool with the unaffected leg as slowly as possible. Repeat this movement several times until you are comfortable with it.
- c. When you are comfortable with this movement, remove the unaffected-side hand from the bar. Again, slowly step onto the stool with the unaffected leg. Once you can perform this movement slowly, remove both hands from the bars, and continue stepping onto the stool in a slow and controlled manner.
- d. Stool stepping tips: Most individuals will experience difficulty in stepping with the unaffected leg in a slow controlled manner, as well as maintaining their balance over the prosthesis during this exercise. This is largely due to the lack of strength, balance and coordination in the hip of the residual limb. Concentration should be placed on controlling the prosthetic limb, rather than simply moving the unaffected limb slowly.



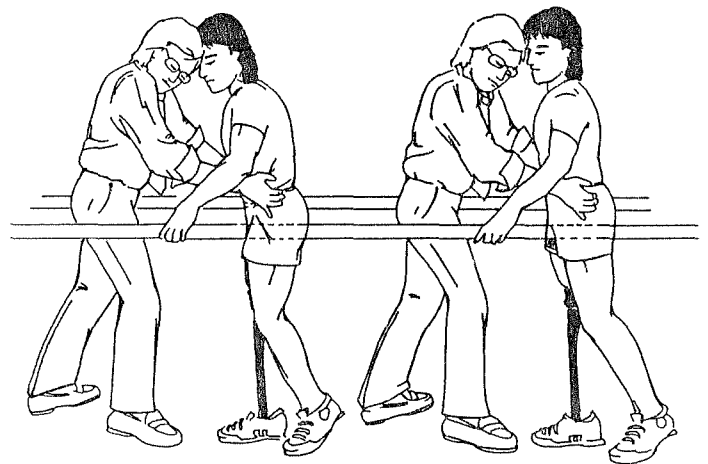
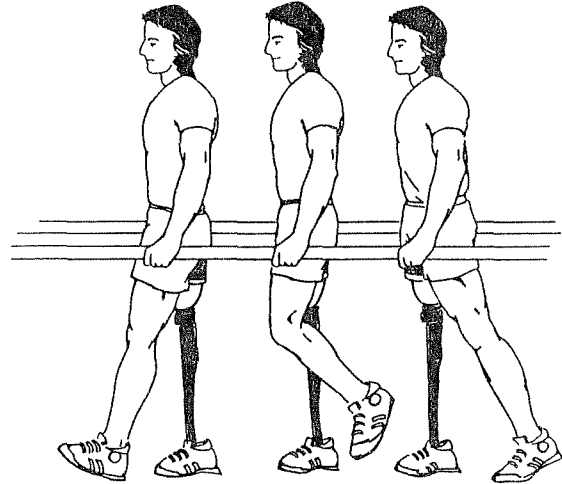
Note: Try to concentrate on the following three tips when stepping up:

- 1) Muscular control of the hip on the prosthetic side.
- 2) Controlling the prosthesis with the distal end of the residual limb.
- 3) Visualize controlling the movement of the prosthetic ankle/foot assembly. Once you master this exercise, you will be able to control and maintain full weight-bearing through the prosthesis.

PART III: GAIT TRAINING PROTOCOL

1. SOUND LIMB STEPPING PARTIAL WEIGHT BEARING

- a. The patient assumes an erect standing posture with feet 2-4 inches apart, both hands placed on the parallel bars.
- b. The patient is asked to take repetitive steps forward and backward with the sound limb (heel rise to heel strike).
- c. The therapist observes: 1) forward pelvic rotation, 2) knee flexion, 3) ankle movement, 4) stride length, 5) foot placement.
- d. As the patient continues the stepping movement, the therapist places their hands on the patient's ASIS to feel for forward rotation of the pelvis. If the patient does not present with normal pelvic rotation the therapist may facilitate this motion with quick stretch techniques, progressing to resistance through the hips to familiarize the patient with this movement.



Note: It is important that the patient understand this movement so that they will be able to reproduce it on the prosthetic side.

2. PROSTHETIC LIMB STEPPING PARTIAL WEIGHT BEARING:

- a. The patient assumes the same initial position as described above.
- b. The patient is asked to take repetitive steps forward and backward with the prosthetic limb (heel rise to heel strike).

c. The therapist observes: 1) forward pelvic rotation, 2) knee flexion, 3) stride length 4) foot placement.

d. As the patient continues the stepping motion, the therapist places their hands on the patient's ASIS to feel for the forward rotation of the pelvis. Rarely will a patient have this motion. The therapist must facilitate this motion by breaking down each of the phases of gait, from heel rise to heel strike as follows:

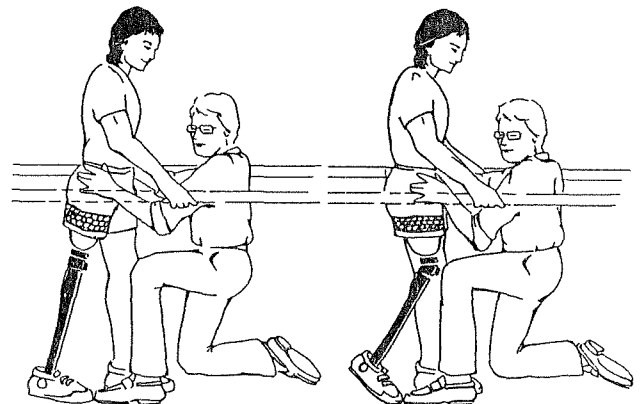
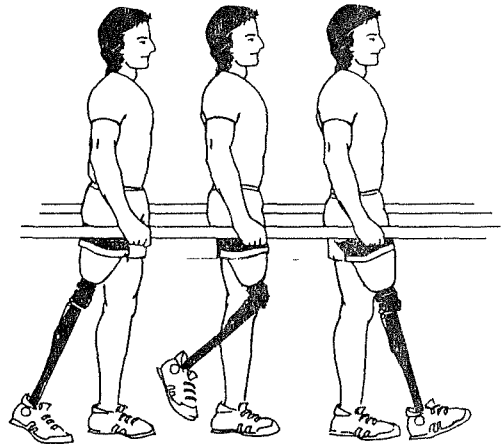
1) Place the patient's prosthetic leg behind the sound limb in the terminal stance position. Rhythmic initiation is employed, giving the patient the feeling of rotating the pelvis forward, and flexing the prosthetic knee prior to swing.

2) As the patient gains a feel for the pelvic motion, use quick stretch techniques, progressing to resistive techniques to improve this movement.

3) Alternating from the prosthetic limb to the sound limb can assist the patient in understanding the desired movement.

4) As the patient perfects the movement with the prosthetic limb still in the stance position, the movement may continue through swing and on to heel-strike.

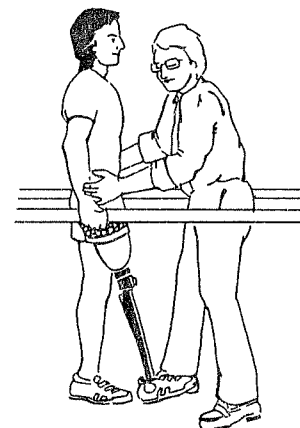
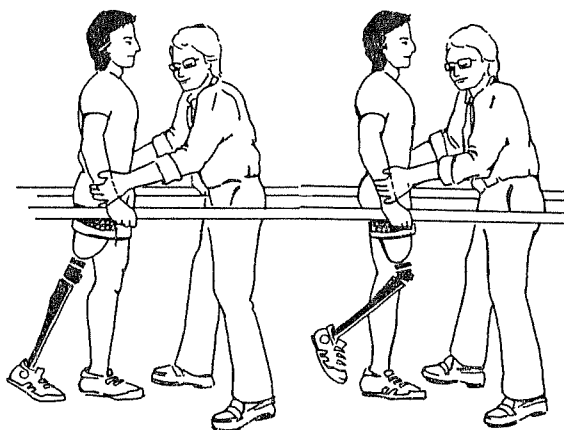
Note: The prosthetic limb may have difficulty clearing the floor at this time. Two common reasons are: 1) poor timing of the hip flexors, 2) inadequate strength of the hip abductors. Often this problem resolves itself with very little practice.



3. PROSTHETIC LIMB STEPPING WEIGHT BEARING:

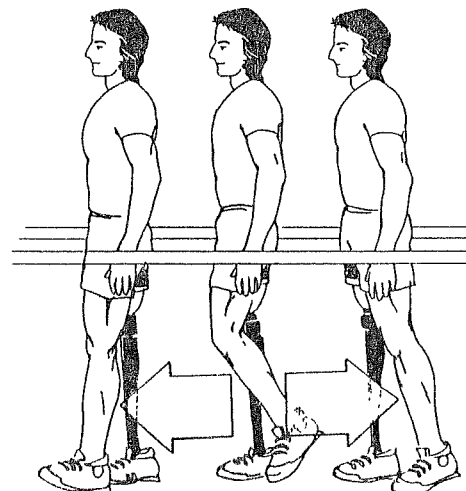
- a. The patient assumes the initial position as described above.
- b. The patient continues to step forward and backward with the prosthetic limb. Once the therapist is satisfied with the patient's biomechanics with two hands on the parallel bars, the patient is asked to remove the unaffected-side hand from the parallel bars. When the patient and therapist are comfortable with single hand support, both hands are removed from the parallel bars as the patient continues the stepping pattern.
- c. The therapist observes: 1) pelvic rotation by maintaining light hand contact on the ASIS, 2) the prosthetic knee should be flexing during terminal stance, increasing the degree of flexion through mid-swing, 3) the hip should not be flexing excessively leading to terminal impact; the movement should be controlled.

Note: The sound limb may tend to drift medially as a result of habit from crutch walking and single limb hopping.



4. SOUND LIMB STEPPING WEIGHT BEARING:

- a. The patient assumes the same position as described above.
- b. The patient steps forward and backward with the sound limb, beginning with both hands on the parallel bars. Once comfortable with this movement, the patient removes the unaffected-side hand from the parallel bars. The patient is instructed to concentrate on the prosthetic limb,



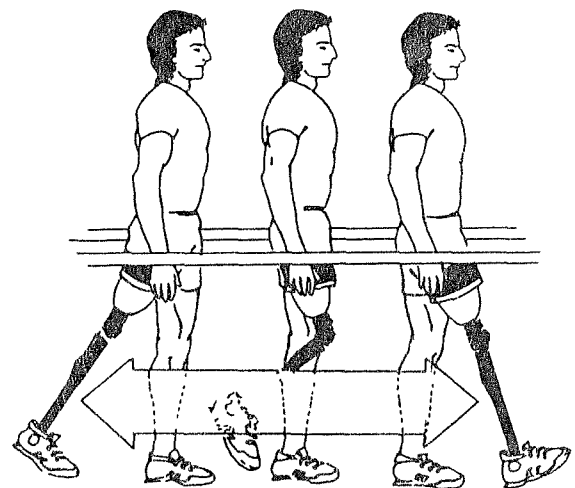
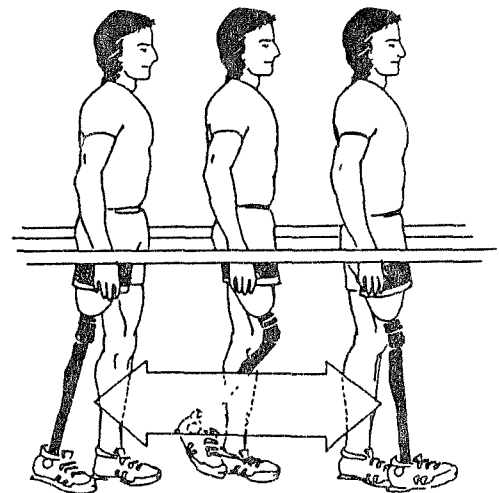
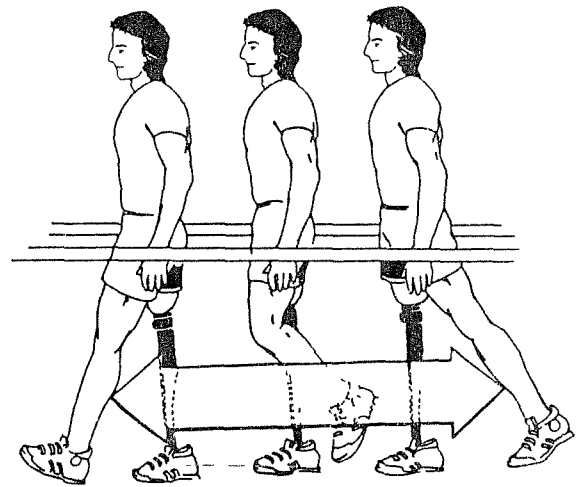
improving balance and weight bearing to increase prosthetic stance time.

- c. The therapist observes: 1) the speed of the advancing sound limb, 2) the stride length of the sound limb, 3) lateral trunk leaning over the prosthetic limb, 4) base of support: the sound foot will have the tendency to cross mid-line, narrowing the base of support.
- d. After the patient is able to perform this movement comfortably with the prosthetic side hand on the parallel bars, remove both hands.

Note: The patient should be reminded that it is important to concentrate on the prosthetic limb, and that this movement is similar to the stool stepping exercise.

5. STRIDE LENGTH AND PROSTHETIC CONTROL:

- a. The patient assumes the same position as described above.
- b. The patient steps forward and backward with the prosthetic limb, with both hands on the parallel bars starting with a comfortable step, usually longer than normal. Ask the patient to take very short steps, long steps, and then medium length steps. The patient then repeats this exercise with the sound limb.
- c. The therapist observes: 1) the length of each step, giving the patient feedback as to what is considered normal for them, 2) base of support, as the sound limb may continue to cross mid-line, 3) continue to monitor gait biomechanics.

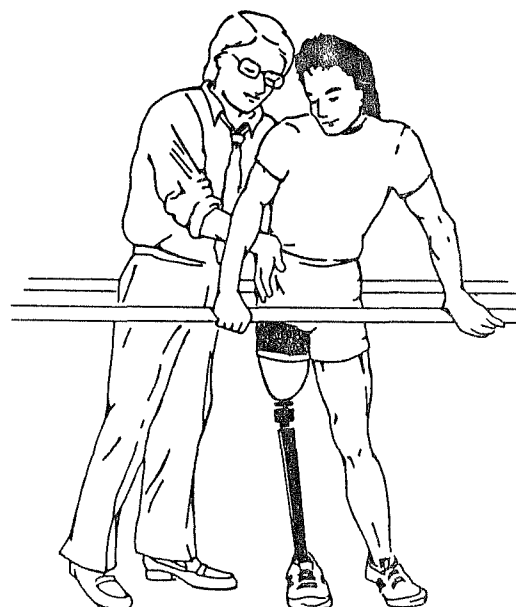
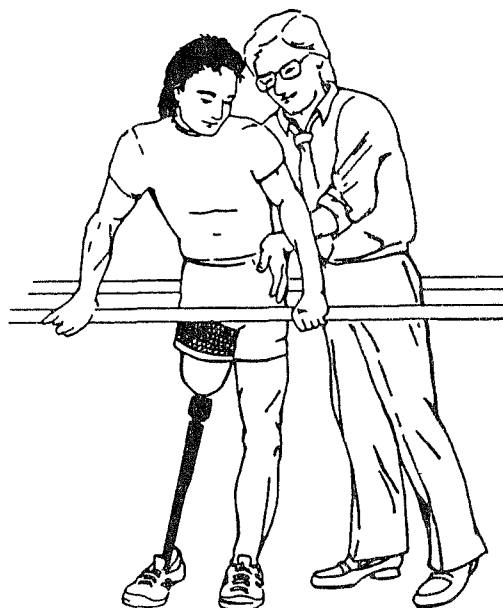


- d. Once the patient is comfortable with their step length with both hands on the parallel bars, remove the unaffected side hand, and finally practice stride length with both hands free.

Note: The therapist can determine normal stride length for the patient by observing the sound limb step length with both hands on the parallel bars.

6. SIDESTEPPING:

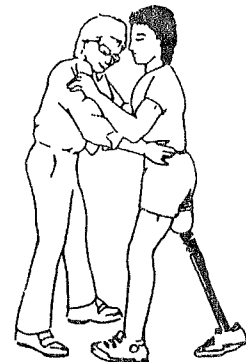
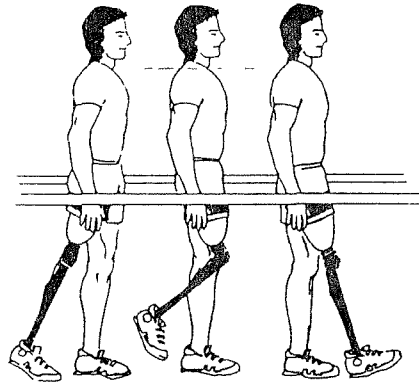
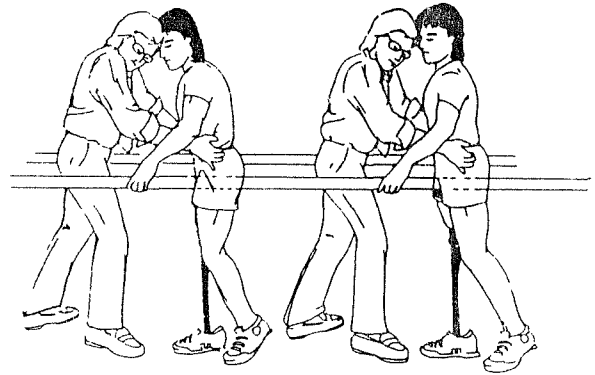
- a. The patient stands at one end of the parallel bars facing the bar, with both hands on the same bar.
- b. The patient begins by side stepping first to the sound side. As the patient abducts the sound limb, resistance is applied by the therapist through the sound hip in order to facilitate the contralateral hip abductors.
- c. The therapist observes:
1) maintenance of pelvic height while the sound limb is being abducted, 2) lateral trunk leaning over the prosthetic limb.
- d. The patient may also perform this exercise abducting the prosthetic limb while the therapist applies resistance through the prosthetic hip to facilitate the sound side hip abductors.



Note: If the patient has difficulty in clearing the prosthetic limb during forward walking, there may exist the possibility of sound limb hip abductor weakness.

7. RESISTIVE GAIT TRAINING:

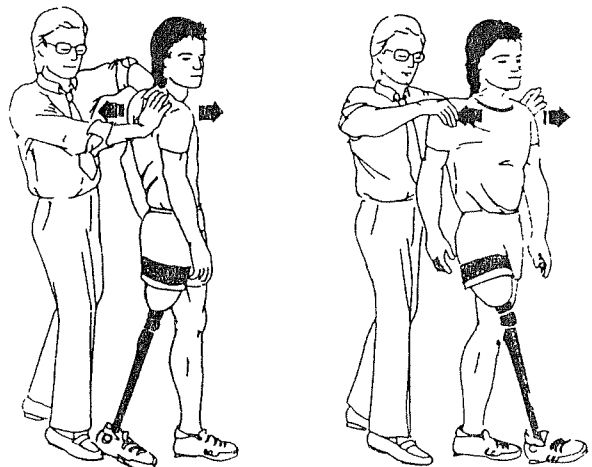
- a. The patient assumes an erect standing posture with both feet 2-4 inches apart, both hands on the parallel bars. The therapist places both hands on each of the patient's ASIS.
- b. The patient begins to ambulate in the bars, maintaining both hands on the parallel bars. The therapist applies resistance through the hips of the patient as they walk. The degree of resistance is determined by the desired amount of movement occurring throughout the patient's lower extremities. The greater the resistance, the greater the movement required by the patient. For example, if more hip flexion or knee flexion is desired, apply more resistance, and the patient will have to produce a stronger contraction in order to meet the resistance. This will result in a greater degree of flexion at both joints.
- c. The therapist observes: 1) pelvic rotation, 2) hip and knee flexion, 3) width of base of support, 4) lateral trunk leaning, 5) prosthetic stance time, 6) speed of sound limb advancement, 7) bilateral stride length.
- d. As the patient begins to ambulate with the desired gait biomechanics, begin decreasing the resistance given. Eventually, the proprioceptive stimulation of simple light touch to the ASIS will be enough to continue proper gait. The patient may progress to single hand support on the parallel bars with the prosthetic hand, and finally with both hands free.



- e. Once the therapist is satisfied with the patient's gait, repeat the resistive gait training procedure outside of the P-bars in an open area. The patient may place their hands on the therapist's shoulders or arms for stability.

8. TRUNK ROTATION AND ARM SWING:

- a. The patient stands in the parallel bars facing a mirror, with both arms free.
- b. The patient begins by stepping with the prosthetic limb, forward and backward. Once a comfortable step is observed, the therapist places one hand posteriorly on the sound side shoulder, the other hand anteriorly on the prosthetic side shoulder, initiating a movement of trunk rotation. The hands reverse as does the movement when the patient steps back. When the prosthetic limb moves forward, the contralateral trunk rotation is initiated. After the patient is comfortable with this movement, the therapist switches hand placement to apply gentle resistance to further facilitate this movement.
- c. The therapist observes: 1) The patient's lower extremity gait biomechanics, closely observing pelvic rotation, 2) that the patient is rotating the trunk and not just flexing the elbows, 3) lateral trunk leaning should be avoided.
- d. When the patient is comfortable with the above movement, reverse the action so that the patient is now stepping with the sound limb and forward trunk rotation is with the prosthetic side. The movement is considerably more difficult for the patient since they will be required to

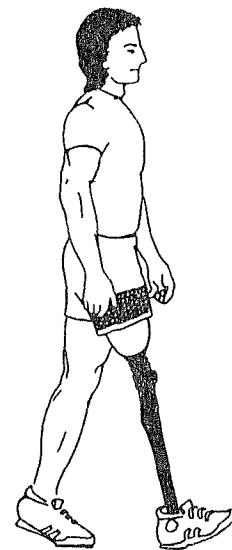
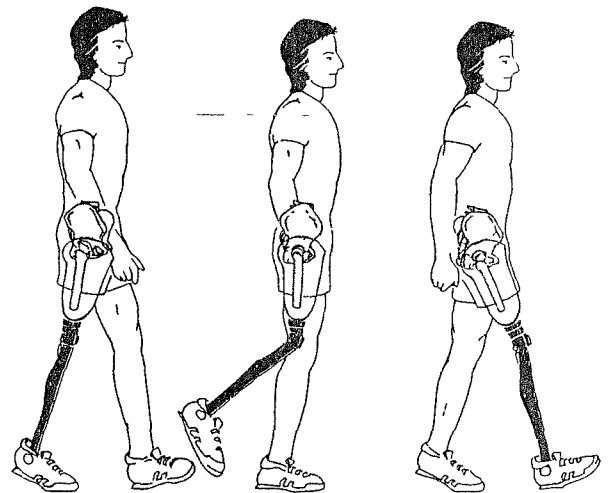


move the trunk over and behind the prosthetic knee. Patients appear to have a fear of the knee collapsing, and have a tendency not to follow through completely with this movement.

Note: In most cases it is better to go back to trunk rotation after the patient has mastered the lower extremity biomechanics, and has been ambulating out of the parallel bars for a while.

9. UNASSISTED AMBULATION:

- a. The patient assumes a position of good posture in front of a relatively long walkway with a mirror at either end for visual feedback.
- b. The patient begins walking at a slow cadence working on each of the gait skills previously learned. Gradually have the patient increase the speed of cadence, after the gait biomechanics are mastered at slower speeds of walking.
- c. The therapist observes; 1) trunk rotation, 2) lateral trunk leaning, 3) pelvic rotation, 4) pelvic dip in the horizontal plane, 5) hip flexion, 6) knee flexion, 7) prosthetic stance time, 8) speed of sound limb advancement, 9) bilateral stride length, 10) maintenance of base of support.
- d. The patient should be questioned at this time to identify any gait deviations, so that they will have the ability to recognize them when ambulating away from the clinic.



Note: The patient may require some resistive gait input initially, just to gain the confidence in walking without the security of the parallel bars. Even simple light touch to the ASIS appears to help initiate good walking biomechanics out of the parallel bars.

4. Racquet Sports

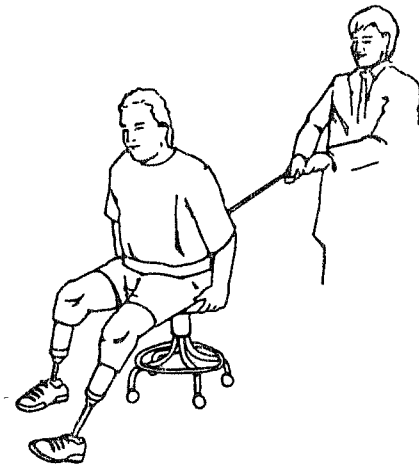
Equipment: A racquetball, badminton, or tennis racquet, and a shuttle cock or a lightweight ball

- a. The amputee sits on a mat table, floor, chair, or rolling stool. If appropriate, standing should be encouraged.
- b. The amputee holds the racquet as the shuttle cock or ball is tossed within hitting range of the racquet.
- c. As the amputee becomes familiar with the mechanics of swinging the racquet, begin to increase the level of difficulty by tossing the ball further away from the racquet's range.
- d. Encourage weight shifting from one limb to the other as contact is made between the racquet and ball. Even in sitting, weight shifting of the body during the swinging motion is an important skill that will transfer to standing and gait training.

Variation: Frequently, it is easier to introduce this skill with a shorter racquetball racquet and progress to the more difficult, longer tennis racket. The longer the racquet or the heavier the ball, the greater the skill required.



Variation: 1) Push down on the heel of the prosthesis, extending the knee, causing stool to roll backward. 2) Alternate movements between the prosthetic and sound limb, either forward or backward. 3) Rubber rubbing around the waist may be used to add resistance.

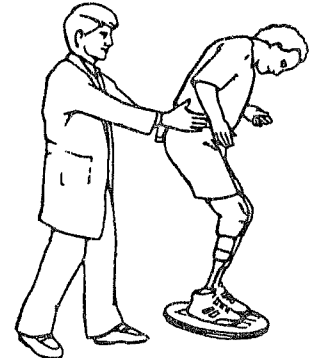
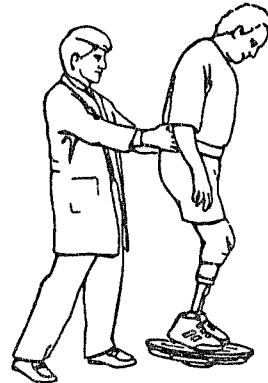


3. Balance Board

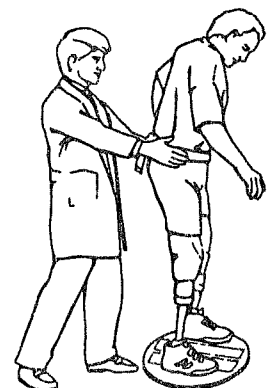
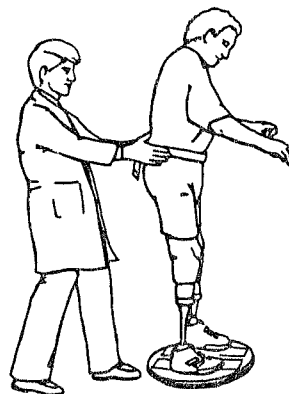
Equipment: Balance board or tilt board

a. The amputee sits, kneels, or stands on a tilt or balance board. If standing on the balance board, they should be placed in the parallel bars for safety.

b. Initially, the amputee works to establish equilibrium on the balance board. The ability to balance dynamically may be promoted by re-educating the amputee to maintain the center of gravity over the base of support on an unstable surface such as a tilt or balance board.



c. Once confidence develops, and the ability to safely maintain an upright posture is demonstrated, the therapist perturbs or gently moves the amputee out of equilibrium, while verbally encouraging them to maintain balance. Perturbations should first be applied at the pelvic region, moving upward to the shoulder region to increase the level of difficulty.



d. To assist the amputee in learning how to maintain balance, provide verbal cues to contract appropriate muscle groups, or to move the head or trunk in the suitable direction.

Variation: If appropriate, single limb balance may be attempted once bipedal balance is established.

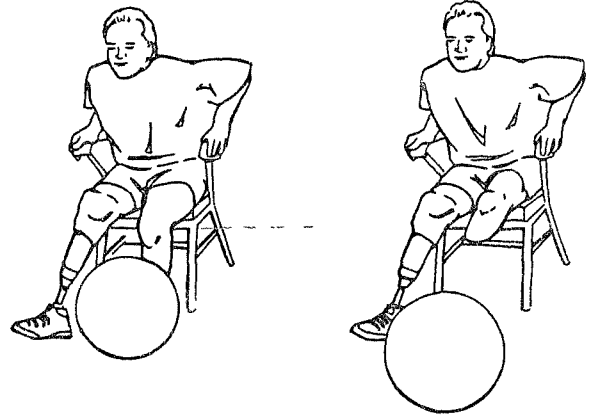
PART II

Advanced Coordination and Agility Exercises with the Prosthesis

1. Ball Kicking

Equipment: A chair or mat table, and ball

- The below-knee amputee sits on a chair or the edge of a mat table, with or without the prosthesis depending on the desired outcome.
- A ball is placed in front of, or is rolled toward the kicking leg.
- The amputee kicks the ball in an attempt to control the direction and speed that the ball will travel.



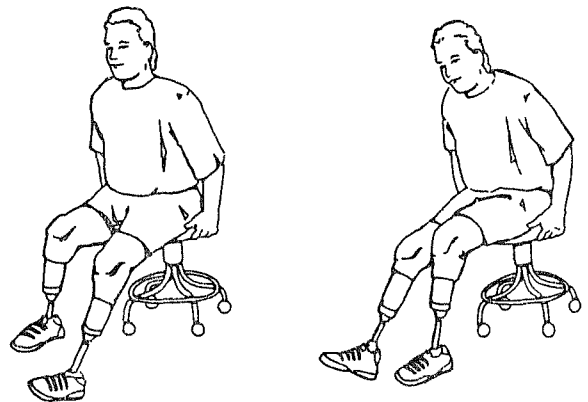
Note: Always be careful of skin integrity and potential areas of skin irritation.

Variation: 1) A heavier, or smaller ball may be used to increase the level of difficulty or 2) Several amputees may participate to make a game out of the exercise.

2. Stool Scooting

Equipment: A standard rolling stool or, for greater safety, a rolling chair with arms

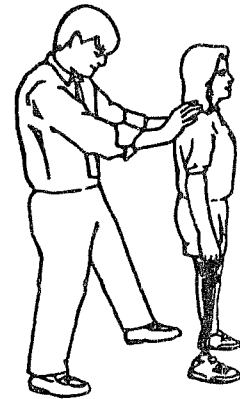
- The below-knee amputee sits on the stool with the prosthesis properly donned. The ability to maintain balance on the stool or chair must be checked by the therapist.
- Using the prosthetic limb, the amputee places the heel of the prosthesis on the floor, pulls back on the heel causing the knee to flex and the stool to roll forward. This action is repeated for _____ repetitions, or for a distance of _____ feet.



11. Manually Resisted Trunk Extension

- a. Patient stands in front of a mat table for safety or free-stands with therapist guarding.
- b. Therapist places hands on posterior surface of both shoulder joints, gently pushing patient into trunk flexion. Patient resists movement by extending trunk, promoting physiological overflow throughout the lower extremities.
- c. Therapist/patient repeat the exercise for _____ repetitions.

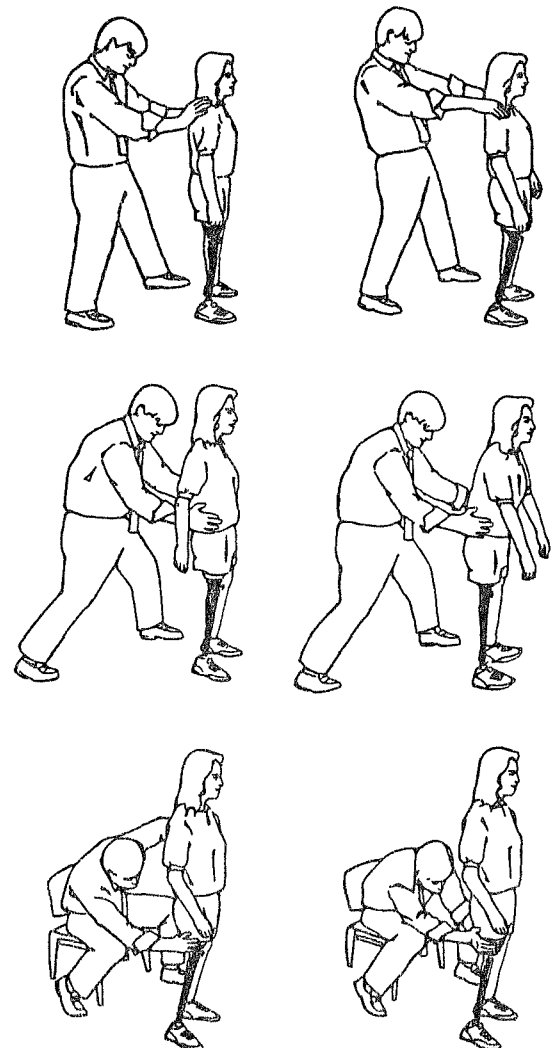
Variation: Therapist varies the amount of resistance given to trunk extension.



12. Manually Challenged Balance

- a. Patient stands in front of a mat table for safety or free stands with therapist guarding.
- b. Therapist alternately places hands on posterior and anterior surfaces of shoulder joints, gently pushing patient into trunk flexion, extension, or rotation. Patient resists movement by opposing the resistance given with necessary musculature.
- c. Therapist/patient repeat the exercise for _____ repetitions.

Variation: Therapist varies hand placement, the amount of resistance given, and the speed of hand placement change. Two alternative hand placements to facilitate prosthetic control are: 1) at the waist to promote hip stability with minimal trunk involvement, or 2) at the socket to promote greater knee control via the residual limb.

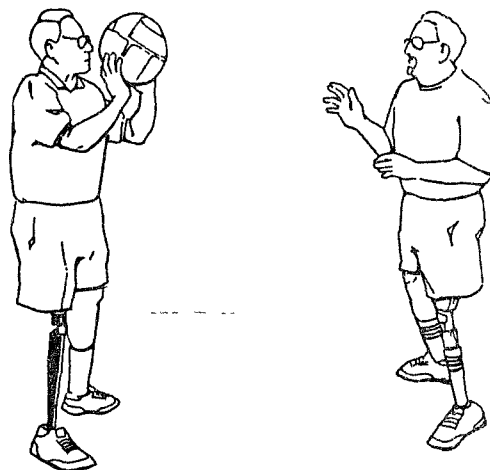


9. Plyoball Throws

Equipment: medicine ball or plyoball

- Patient stands in front of a mat table for safety or free-stands with therapist guarding. Patient holds a medicine ball with both hands.
- Chest Pass:** Patient raises ball to chest height and throws to therapist in front of them for ____ repetitions.
- Overhead Pass:** Patient raises ball overhead and throws to therapist in front of them for ____ repetitions.
- Rotational Pass:** Patient raises ball to chest height or overhead, and throws to therapist standing diagonally to the left or right of them for ____ repetitions.

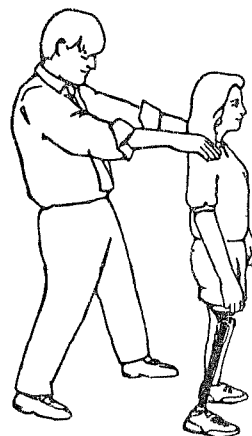
Variation: Patient throws and catches ball with another patient seated on mat or standing, with therapist guarding.

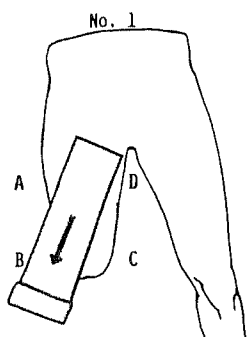


10. Manually Resisted Trunk Flexion

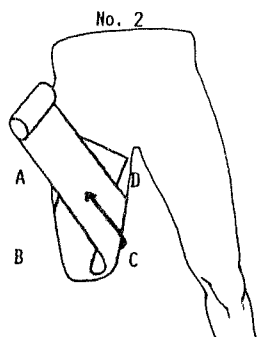
- Patient stands in front of a mat table for safety or free-stands with therapist guarding.
- Therapist places hands on anterior surface of both shoulder joints, gently pulling patient into trunk extension. Patient resists movement by flexing trunk, promoting physiological overflow throughout the lower extremities.
- Therapist/patient repeat the exercise for ____ repetitions.

Variation: Therapist varies the amount of resistance given to trunk flexion.

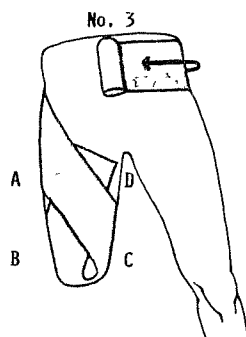




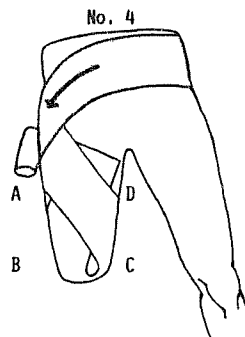
BEGIN BY PLACING A DOUBLE LENGTH 6" ELASTIC BANDAGE AT LETTER "D", CROSSING DOWN TO CORNER "B". NOTE THAT THE PRESSURE SHOULD BE UNIFORM THROUGHOUT PART I OF THE WRAPPING PROCEDURE. (No. 1)



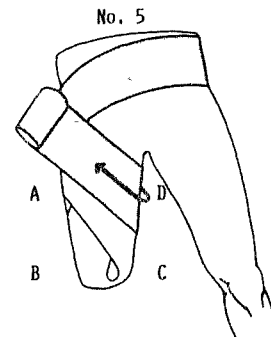
CONTINUE THE BANDAGE AROUND CORNER "C" CROSSING FRONT UP TOWARD "A". (No. 2)



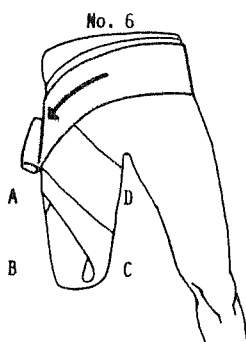
WRAP AROUND THE WAIST, WITH THE THIGH EXTENDED; AND THEN BACK TOWARDS "A". (No. 3)



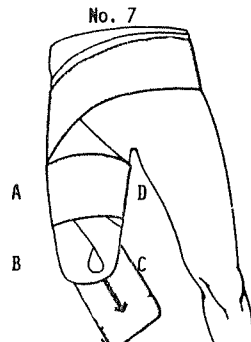
CONTINUE AROUND THE BACK OF THE THIGH TOWARDS "D". (No. 4)



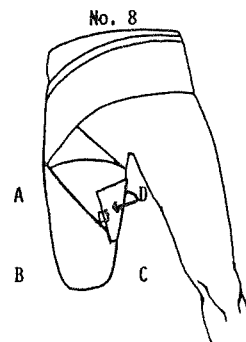
CROSS TO "A" WRAPPING THE UPPER MOST INNER THIGH. (No. 5)



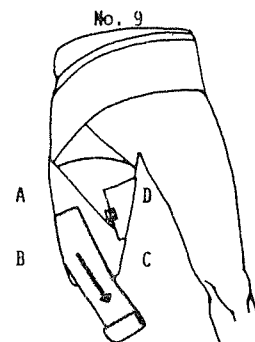
AGAIN: WRAP THE BANDAGE AROUND THE WAIST TO "A", AND THEN AROUND THE BACK OF THE THIGH TO "D" COVERING THE UPPER INNER THIGH AGAIN. (No. 6)



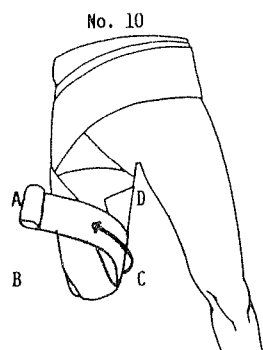
RETURN TOWARD "A" AND THEN WRAP THE BANDAGE DOWN AND ACROSS THE BACK TO CORNER "C", AND THEN AGAIN RETURN TOWARDS "A". (No. 7)



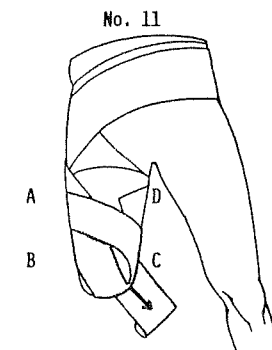
WRAP AROUND THE BACK AND ANCHOR WITH TAPE. THIS COMPLETES PART I WITH THE 6" BANDAGE. (No. 8)



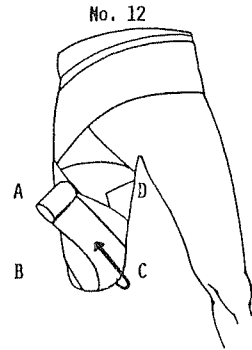
PART II: BEGIN BY PLACING A DOUBLE LENGTH 4" ELASTIC BANDAGE ON THE RESIDUAL LIMB BETWEEN "A" AND CORNER "B". WRAP DIAGONALLY AROUND CORNERS "B" AND "C". (No. 9)



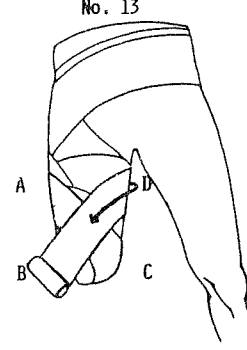
CROSS UPWARD TOWARDS "A" AND ANCHOR THE WRAP. (No. 10)



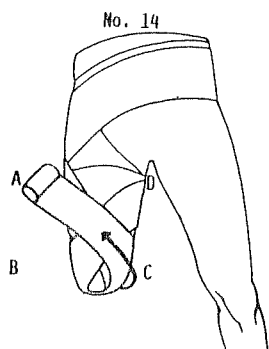
CONTINUE AROUND THE BACK, AND DOWN TO CORNER "C". (No. 11)



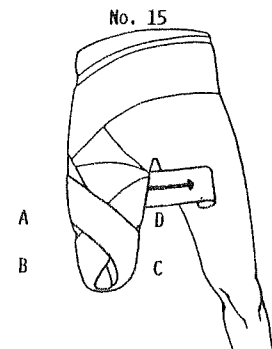
WRAP UPWARD AND ACROSS TO "A", AND THEN AROUND THE BACK TOWARDS "D". (No. 12)



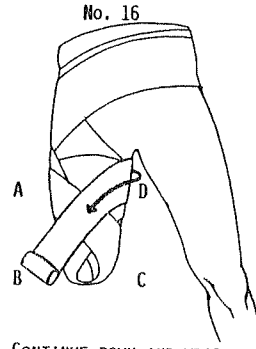
CONTINUE DOWN AND ACROSS TO COVER CORNERS "B" AND "C". (No. 13)



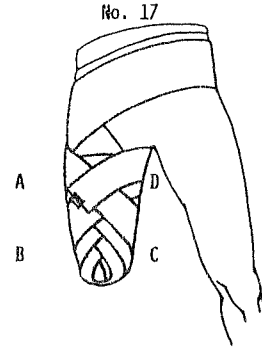
CONTINUE UPWARD AND ACROSS TO "A". THIS IS YOUR FIGURE 8 PATTERN GUIDE. (No. 14)



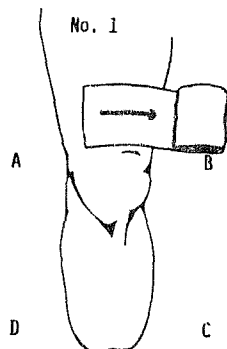
WRAP AROUND THE BACK TOWARDS "D". (No. 15)



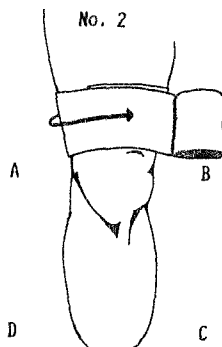
CONTINUE DOWN AND WRAP CORNERS "B" AND "C" BUT WRAP SLIGHTLY HIGHER THAN THE PREVIOUS TIME AROUND. CONTINUE WRAPPING HIGHER ON THE RESIDUAL LIMB UNTIL FIGURE 8 IS COMPLETED. (No. 16)



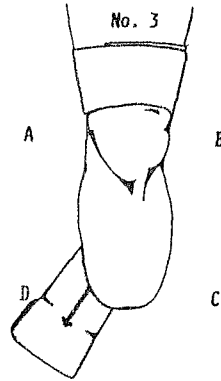
REMEMBER TO APPLY LESS PRESSURE AS YOU MOVE UP. COMPLETE THE WRAP BY ANCHORING IT WITH TAPE. NOTE THAT THE ANGLE BETWEEN THE FIGURE 8S SHOULD BE 80-90° AT THE CROSS OVER POINT TO AVOID A TOURNIQUET EFFECT. (No. 17)



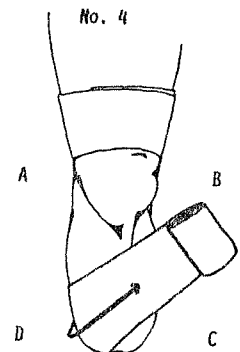
BEGIN BY PLACING A DOUBLE LENGTH 4" ELASTIC BANDAGE ABOVE THE KNEECAP (No. 1)



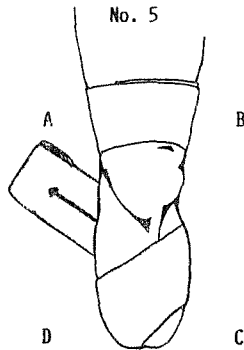
WRAP AROUND ONCE TO SECURE THE BANDAGE COMFORTABLY, BUT NOT TOO TIGHTLY. (No. 2)



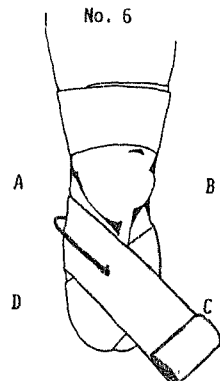
CONTINUE THE BANDAGE AROUND THE BACK, CROSSING TO CORNER "D". (No. 3)



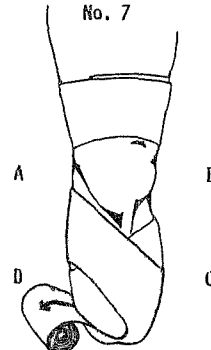
BRING THE BANDAGE AROUND CORNER "D", CROSSING UPWARDS IN A DIRECTION TOWARDS "B" (No. 4)



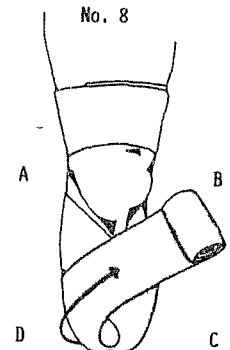
CONTINUE AROUND THE BACK TOWARDS "A". (No. 5)



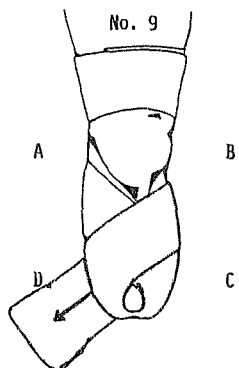
WRAP THE BANDAGE ACROSS AND DOWN TO CORNER "C". (No. 6)



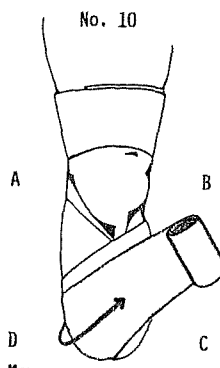
CONTINUE TO WRAP AROUND THE END AND COVER CORNER "D". (No. 7)



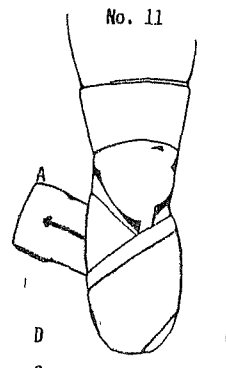
MOVE UPWARD AND ACROSS THE FRONT TOWARDS "B". (No. 8)



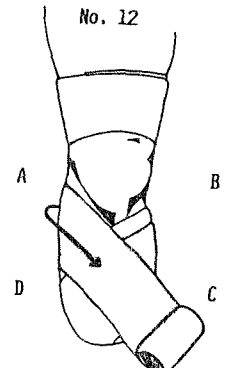
CONTINUE TO MOVE ACROSS THE BACK AND DOWN TOWARD CORNER "D". (No. 9)



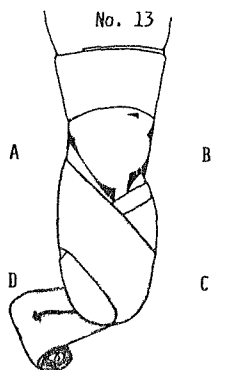
MOVE UPWARD AND ACROSS THE FRONT TOWARDS "B". (No. 10)



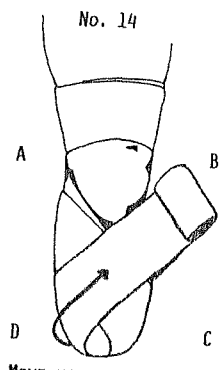
CONTINUE TO MOVE ACROSS THE BACK TOWARDS "A". (No. 11)



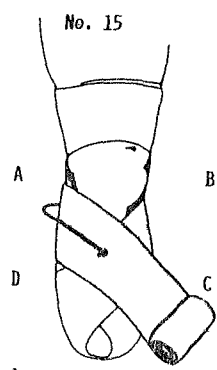
MOVE DOWN AND ACROSS THE FRONT TOWARDS CORNER "C". (No. 12)



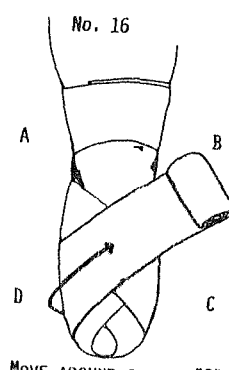
CONTINUE TO WRAP ACROSS THE END AND COVER CORNER "D". (No. 13)



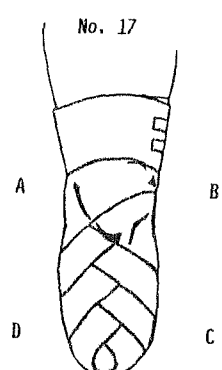
MOVE UP AND ACROSS THE FRONT TOWARDS "B". (No. 14)



CONTINUE ACROSS THE BACK AND MOVE DOWN AND ACROSS THE FRONT TOWARDS CORNER "C". (No. 15)



MOVE AROUND CORNER "C" TOWARDS CORNER "D" AND CONTINUE UP AND ACROSS THE FRONT TOWARDS "B". THIS IS YOUR FIGURE 8 PATTERN GUIDE. (No. 16)



CONTINUE WITH THE FIGURE 8 PATTERN, MOVING THE BANDAGE HIGHER ON THE RESIDUAL LIMB UNTIL COMPLETELY COVERED IN A FIGURE 8 PATTERN. REMEMBER TO APPLY LESS PRESSURE AS YOU MOVE UP. COMPLETE THE WRAP BY ANCHORING IT WITH TAPE. (No. 17)

During descent the prosthetic limb leads but remains slightly posterior to the sound limb. The prosthetic knee remains in extension again acting as a form of support so that the sound limb may lower the body.

For hip disarticulation or hemipelvectomy amputees, sidestepping is the most common alternative regardless of the grade of the incline.

Other advanced skills consist of walking on uneven terrain, grass, sandy beaches, and hills. The amputee should practice on the type of terrain on which they will be walking on a daily basis, or during recreational activities of interest.

The therapist should also spend time discussing recreational activities of interest to the amputee. Skills such as running, swimming, cycling, and other sports are important in returning the amputee to a positive and productive lifestyle. Time should be spent exploring the individual's capabilities, and suggesting possible organized programs in which they may choose to participate. A list of support groups and recreational organizations geared to the specific needs of the amputee can prove to be a valuable resource to the new amputee. Often during the early stages of rehabilitation, many amputees are not ready to participate in activities they once found enjoyable. However, if provided with a list of organizations prior to discharge, frequently the amputee will make the necessary contacts later when they are ready. A partial list of national organizations with in the United States can be found on page 31.

RESIDUAL LIMB WRAPPING

Currently, there are several methods of residual limb wrapping or bandaging. Elastic bandages and commercial shinkers are the most common methods of providing the amputee with a distal to proximal pressure gradient for edema control and residual limb shaping. Early intervention may provide several benefits including, but not limited to: decreased edema, assistance in residual limb shaping, skin protection, reduction in redundant tissue problems, assistance in counteracting contractures in above-knee amputees, desensitization of local pain and possibly a reduction in phantom limb discomfort.

The following charts offer methods of residual limb wrapping that have been received favorably by many therapists and amputees. The most important principles that must be applied are prevention of: 1) circulation constriction, 2) poor residual limb shaping, and 3) edema.

prosthetic limb is the first to ascend the stairs by rapid acceleration of hip flexion with slight abduction in order to achieve sufficient knee flexion to clear the step. Some above knee amputees will actually hit the rise of the following step with the toe of the prosthetic foot in order to achieve adequate knee flexion. With the prosthetic foot firmly on the step, usually with the toe against the step riser, the residual limb must exert a great enough force to fully extend the hip so that the sound foot may advance to the step above. As the sound side hip extends the prosthetic side hip must flex at an accelerated speed to achieve sufficient knee flexion to place the prosthetic foot on the next step above.

Descending stairs is achieved by placing only the heel of the prosthetic foot on the stair below, then shifting the body weight over the prosthetic limb, thus, passively flexing the knee. The sound limb must quickly reach the step below in time to catch the body's weight. The process is repeated at a rapid rate until a rhythm is achieved. Most above knee amputees who have mastered this skill descend stairs at an extremely fast pace, much faster than would be considered safe for the average amputee.

Ramps and hills - Ascending inclines presents a problem for all amputees because of the lack of dorsiflexion present within most prosthetic foot/ankle assemblies. For most amputees, descending inclines is even more difficult than ascending, primarily because of the lack of plantarflexion in the foot/ankle assembly. Prosthetic wearers with knee joints have the added dilemma of the weight line falling posterior to the knee joint resulting in a flexion moment.

When ascending an incline, the body weight should be slightly more forward than normal to obtain maximal dorsiflexion with articulating foot/ankle assemblies, or to keep the knee in extension. Depending on the grade of the incline, pelvic rotation with additional acceleration may be required in order to achieve maximal knee flexion during swing.

Descent of an incline usually occurs at a more rapid pace than normal because of the lack of plantarflexion resulting in decreased stance time on the prosthetic limb. Amputees with prosthetic knees must exert a greater than normal force on the posterior wall of the socket to maintain knee extension.

Most amputees find it easier to ascend and descend inclines with short but equal strides. They prefer this method since it simulates a more normal appearance as opposed to the side stepping or zig zag method.

When ascending and descending hills, the amputee will find side stepping to be the most efficient means. The sound limb should lead providing the power to lift the body to the next level, while the prosthetic limb remains slightly posterior to keep the weight line anterior to the knee and act as a firm base.

GENERAL ACTIVITIES:

Stairs

Stair climbing and descent, ramps and other skills valuable to the patient in their environment should be discussed and practiced at this time, if they have not already been addressed. Typically, Symes and below knee amputees will have little problem ascending and descending stairs in the normal fashion. The main difference is that in descent, only the heel is placed on the step below, in order to compensate for the lack dorsiflexion at the prosthetic ankle. However, very short below knee amputees and above knee amputees will experience greater difficulty with stairs. The traditional "step to" method of instructing stair ascent and descent, where one stair is overcome at a time is the easiest method.

"Step-over-step" stair ascent and descent is one of the most requested skills by well conditioned above knee amputees. Many amputees want to master this skill for two reasons. First, they want to have a more natural gait on stairs and second, the traditional method is slow, and many amputees find trying to keep up with the able-bodied frustrating. The unfortunate reality is that step-over-step stair ascent is also slow and extremely demanding, both in strength and energy consumption. Likewise, stair descent must occur so rapidly that the rate of descent is difficult to control and for most, this method is dangerous. Therefore, for safety as well as aesthetic reasons, rarely do above knee and short below knee amputees choose this method over the traditional "step to" method. Of course, the choice should be made by the amputee after instruction by the therapist.

*Good ↑
FIRST* Step To- This method is essentially the same for all levels of amputees. It is recommended for all hemipelvectomy and hip disarticulation amputees, as well as for most above knee and short below knee amputees. When ascending stairs, the body weight is shifted to the prosthetic limb as the sound limb firmly places the foot on the stair. The trunk is slightly flexed over the sound limb as the knee extends raising the prosthetic limb to the same step. The same process is repeated for each step.

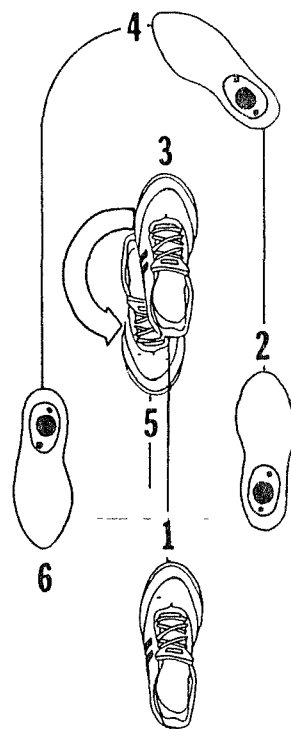
When descending stairs, the body weight is shifted to the sound limb as the prosthetic limb is lowered to the step below by eccentrically flexing the knee of the sound limb. Once the prosthetic limb is securely in place, the body weight is transferred to the prosthetic limb and the sound limb is lowered to the same step.

Step-Over-Step - Timing and coordination become critical factors in executing stair climbing step-over-step. It is recommended for Symes and below knee amputees, as well as a select few above knee and short below knee amputees. As the above knee (or short below knee) amputee approaches the stairs, the

6. Turning to the Sound Side:

Two factors must be remembered. First, pelvic rotation in the transverse plane must be maintained just as in walking; and second, the turn must be performed in two steps.

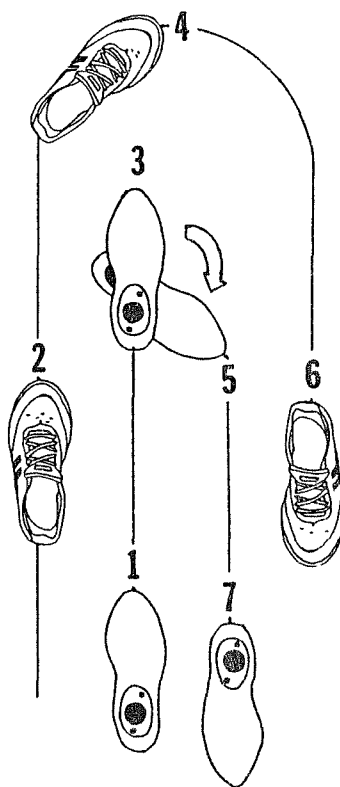
- Cross the prosthetic limb over the sound limb 45 degrees.
- Rotate the sound limb 180 degrees, or as close to a complete turn that is comfortable.
- Complete the turn by stepping in the desired direction with the prosthetic limb, while leading the motion with the pelvis to ensure adequate knee flexion.



7. Turning to the Prosthetic Side:

When turning to the prosthetic side, the same mechanics are practiced with one exception. Slightly more weight is maintained on the prosthetic toe, in order to maintain the prosthesis in extension and thus prevent the knee from flexing.

- Cross the sound limb over the prosthetic limb 45 degrees.
- The prosthetic limb rotates as close to 180 degrees as comfortably possible without losing balance (135 degrees is usually observed).
- Complete the turn by stepping in the desired direction with the sound limb.



necessary, use your arms for balance initially.

- d. Again, beginning at one end of the line, this time walk along the line, crossing one foot over the other, to place each foot on the opposite side of the line. Use your arms for balance initially, if necessary.

Note: These exercises should each be performed multiple times to improve balance. Once you have mastered these skills, perform them at increased speeds to improve your coordination.

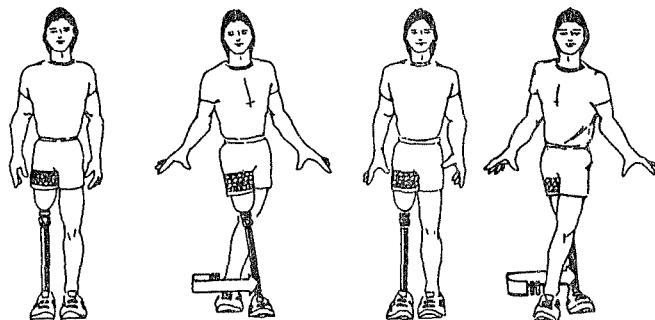
5. Braiding:

- a. Stand in an open area with both feet comfortably apart (2-4 inches).

- b. From the standing position, cross the prosthetic limb in front of the sound limb, then bring the sound limb from behind, to return to the original standing position. Repeat.

- c. From the standing position cross the prosthetic limb behind the sound limb, then bring the sound limb across the prosthetic limb, returning to the original standing position. Repeat.

- d. Repeat the maneuvers described in b and c, alternating each step as you move sideways. Use your arms, and rotate your trunk to assist with balance. As you become comfortable with these maneuvers, increase your speed.

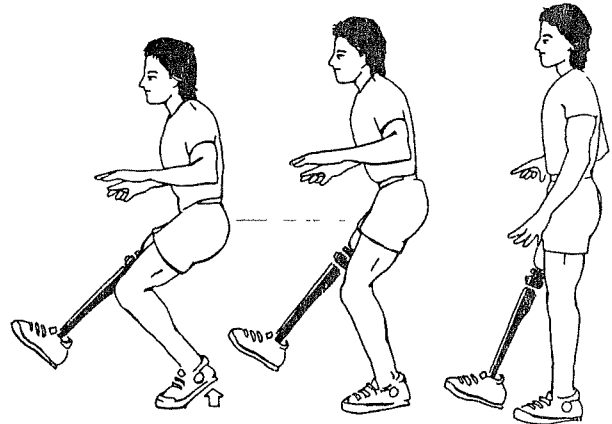


Note: When first attempting this exercise, practice maneuvers b and c independently in the P-Bars. Then, progress to an open area, again practicing maneuvers b and c independently, progressing gradually to d, or braiding.

3. Squatting Limb Balance:

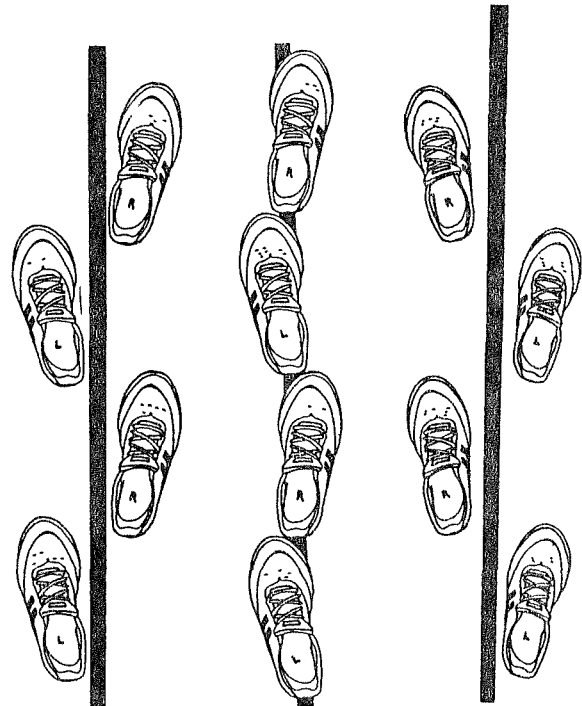
- a. Stand in an open area with both feet comfortably apart (6-8 inches).
- b. Double Limb Squats: From the standing position, begin lowering yourself slowly while maintaining equal weight distribution between both limbs. Only go as far as you can comfortably, maintaining the ability to return to standing. Progressively lower your body further with each attempt.
- c. Single Limb Squats: From the standing position, raise your prosthetic limb forward. Slowly lower yourself with the sound limb. Only go as far as you can comfortably, maintaining the ability to return to standing. Progressively lower your body further with each attempt.

Note: Initially holding on to a table in front of you will assist greatly in maintaining balance



4. Tandem Walking:

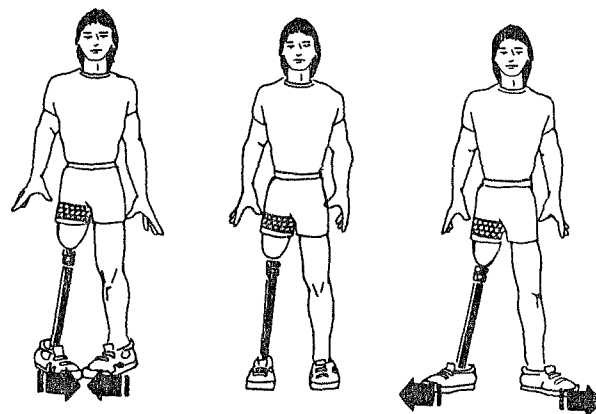
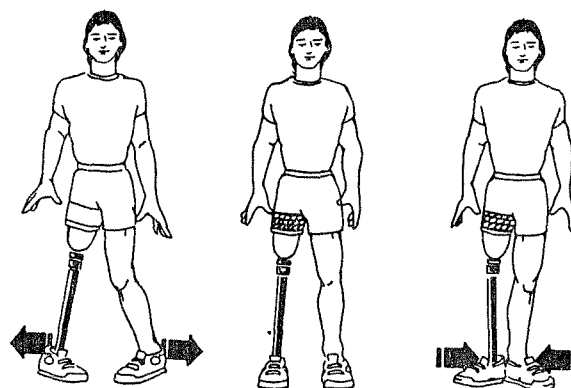
- a. Tape a 2-inch wide by 12-inch long piece of white tape in a straight line on the floor in an open area.
- b. Stand at one end of the tape line with your feet comfortably apart (2-4 inches). Begin walking normally along the line, keeping each foot on its own side of the line.
- c. Next, beginning at one end of the tape, walk along the line, this time placing one foot directly in front of the other, with the heel of the second foot abutting the toe of the first. If



PART IV: ADVANCED BALANCE TRAINING SKILLS

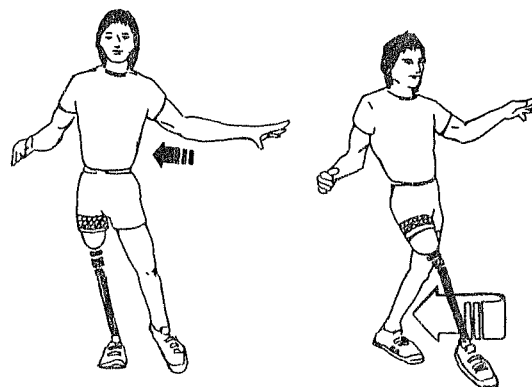
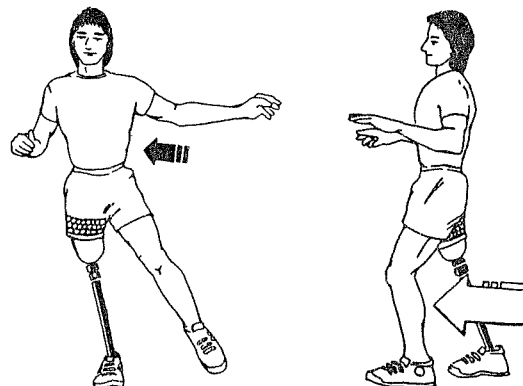
1. Toe and Heel Pivoting:

- a. Stand in an open area with both feet comfortably apart (2-4 inches).
- b. **Toe Pivoting:** lean forward slightly, placing the majority of your body weight on the balls of your feet. Move your heels inward and outward while keeping your toes in the same spot. If necessary, use your arms to assist with balance.
- c. **Heel Pivoting:** Lean backward slightly, placing the majority of your body weight on the heels of your feet, move your toes inward and outward while keeping your heels in the same spot. If necessary, use your arms to assist with balance.



2. 90 Degree Balance Recovery:

- a. Stand in an open area with both feet comfortably apart (6-8 inches).
- b. **Forward Pivot:** shift the majority of your body weight onto the prosthetic limb. Move your sound side forward, pivoting around the prosthetic limb 90 degrees, or a quarter of a turn.
- c. **Backward Pivot:** shift the majority of your body weight onto the prosthetic limb. Move your sound side backward, pivoting around the prosthetic limb 90 degrees, or a quarter of a turn.
- d. Once you feel comfortable with these maneuvers, practice turning and catching a ball, or repeating several pivots quickly in various directions.

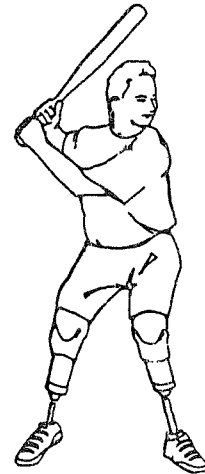
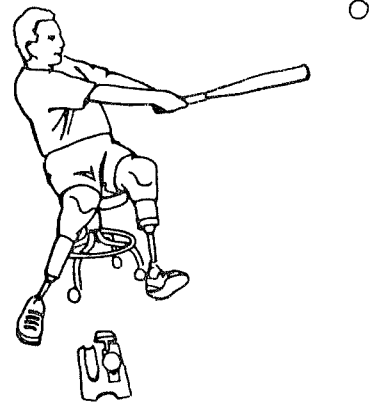


5. Baseball Hitting

Equipment: Plastic bat and ball

- The amputee sits on a mat table, floor or chair. If appropriate, standing should be encouraged.
- The ball may be placed on a batting tee, or tossed to the amputee who swings the bat in an attempt to make contact with the ball.
- Emphasis should be placed on trunk rotation, weight shifting and maintenance of balance.

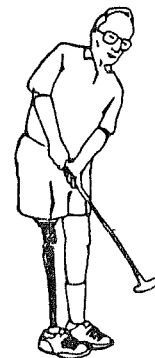
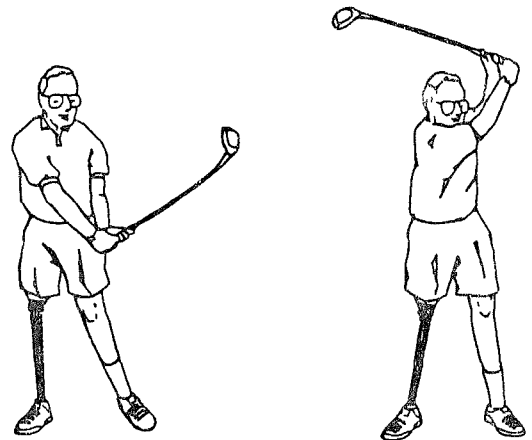
Variation: Several amputees may participate as fielders and pitchers to create a game atmosphere.



6. Golf

Equipment: Golf clubs, plastic or regular golf balls, and a cup or automatic ball return if available

- The patient assumes a golf stance over the golf ball, holding a golf club. Frequently, a wider base of support is preferred for comfort and stability.
- The amputee practices putting, while working on standing balance.
- As balance improves, chipping plastic golf balls may be attempted. The heavier the club and/or the greater the arc of swing, the more balance is required.



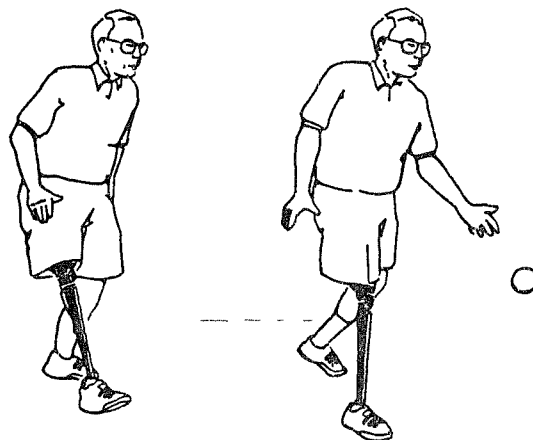
Variation: A small putting golf course around the clinic can provide an opportunity to practice several skills such as walking, agility, balance and picking up objects from the floor.

7. Bocci or Bowling

Equipment: Bocci ball set, lawn bowling set or plastic bowling set

- Standing at one end of a carpeted room, the amputee prepares to roll the ball towards the area of play.
- Emphasis is placed on stepping and shifting weight onto the forward lower limb, while rotating the trunk and throwing the ball with the contralateral arm.
- As balance and coordination improve, skill with throwing will improve.

Variation: Alternate throwing with the affected and non-affected limb side from one game to the next to promote equal weight shifting bilaterally.

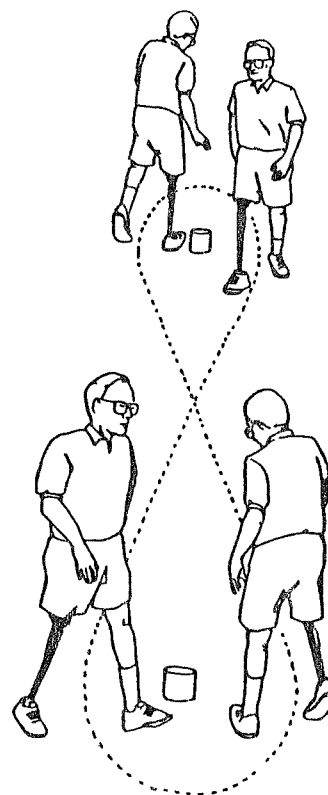


8. Figure-8 Walking

Equipment: Two cones, buckets or large objects which can be used as markers

- The amputee walks around the two cones, placed a pre-determined distance apart, in a figure-8 pattern.
- Emphasis should be placed on turning correctly to both the prosthetic and sound limb sides.

Variation: Place additional obstacles in the path of the amputee in order to practice stepping over, or going around objects. Have the amputee vary the speed of ambulation.

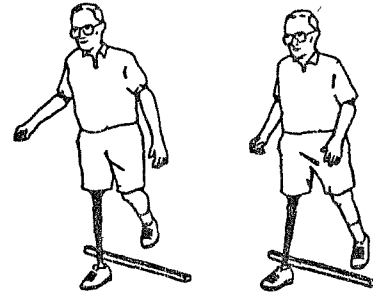
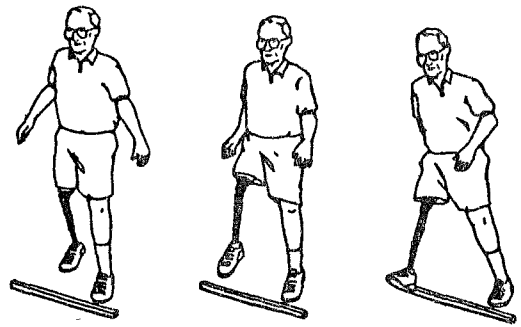


9. Progressive Stepping Over Objects

Equipment: Foam rubber, wood planks or any other objects of varying heights

- a. The amputee starts at one end of the room and walks forward, stepping over obstacles of varying heights placed appropriate distances apart.
- b. Emphasis is placed on maintaining gait biomechanics, balance, and control of the prosthesis. Stepping over the objects with the prosthetic limb and sound limb should be alternated.

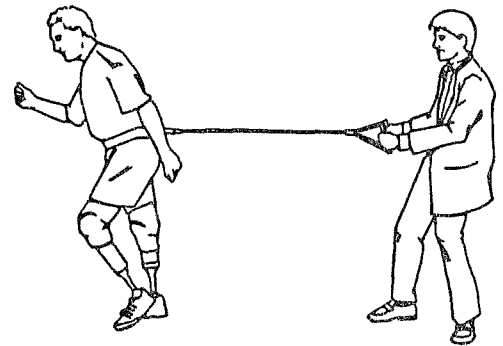
Variation: Incorporate turns and other challenges into an obstacle course.



10. Resistive Walking

Equipment: Rubber tubing with harness

- a. Securely fit the amputee with the harness and rubber tubing device.
- b. The amputee ambulates against the resistance provided by the rubber tubing. The therapist can either walk with the amputee allowing advancement against resistance, or remain stationary so that the amputee must walk in place against resistance.
- c. Emphasis should be focused on applying weight down into the prosthesis during stance phase of the residual limb.



Variation: Walking sideways and backwards may be attempted if the amputee is ready for such advanced skills.

PART III

Cardiovascular Endurance Exercise

Approximately 50% of all amputees had cardiovascular disease prior to their amputation, or will develop it due to a lack of physical activity.^{5,6,9,10} Therefore, the cardiovascular system must be of prime concern for the therapist when developing an exercise prescription for amputees. The benefit to the amputee of continuing a cardiovascular conditioning program learned during rehabilitation is the potential for a healthy, active lifestyle and an increased possibility for long term prosthetic wear. Achieving the necessary aerobic power to master the use of a prosthesis is paramount for the majority of elderly amputees, and the lack of training in this area is often the reason they fail to become successful prosthetic ambulators.

The American College of Sports Medicine recommends that cardiorespiratory endurance exercise prescriptions consider the following factors when designing a program.¹

1. **Mode of Activity:** Any type of aerobic exercise i.e. swimming, cycling, running, that uses large muscle groups and can be sustained for at least three minutes.
2. **Intensity of exercise:** Pre-determined percentage of VO_2 max or maximal heart rate are the most common measures of intensity. Caution must always be applied when determining the target heart rate for elderly amputees for two reasons: 1) medication prescribed for the amputee may alter heart rate. For example, beta-blocking medications that inhibit an increase in heart rate will prevent someone from reaching a predetermined target heart rate. As a result, heart rate may not be truly representative of the level of exertion being produced by the person. 2) Their general physical status can be severely compromised and/or secondary medical conditions may place many elderly amputees at risk with exertion.
3. **Duration of exercise:** Two types of training: 1) continuous, which is sustained over a relatively long period or 2) interval training, which employs a series of work and relief periods.
4. **Frequency of exercise:** The number of days per week exercise is performed.
5. **Rate of progression:** The intensity and/or duration increased over a number of sessions due to the conditioning effect. Measurable parameters can be adjusted accordingly.

Interval training programs (ITP) have several advantages over continuous cardiorespiratory training programs.^{2,5} First, the relief or rest periods that are incorporated into the program permit the amputee time to get off their

legs as they become accustomed to the prosthesis, in order to avoid skin irritation or abrasion. Second, the deconditioned amputee has an opportunity to build endurance gradually, while sustaining the total duration of the workout period. Third, the interval training program permits the therapist the flexibility of manipulating the variables of the program to achieve results specific to each individual. For example, increasing the training time per repetition while decreasing the number of repetitions can provide increases in total time of exercise, preparing the amputee for ambulating longer distances without a rest.

The basic goal of an introductory program is to increase one component of the program each week, such as work time, reps, sets or to decrease the relief time. Gradually, the amputee should begin to observe increases in cardiovascular endurance which will carry over into everyday life. Interval training programs can be formatted in a number of ways. For example, instead of time as a measure of work, distance may be used. Likewise, other goals of the program may be achieved through ITP. Increased speed or agility may be developed through designing a slightly different format for each workout, where short burst exercises are performed with greater relief or rest periods.

Table 2 shows an example of a walking log kept by an amputee. The patient records the date, time walked, distance covered, rest time and comments pertinent to the exercise session on a 3x5 card, providing the therapist with an impression of the progress being made in endurance and exercise walking. Additionally, the therapist is able to modify the program to assist the amputee with a steady, safe progression in their endurance program.

Table 2. Walking log maintained on a 3x5 index card

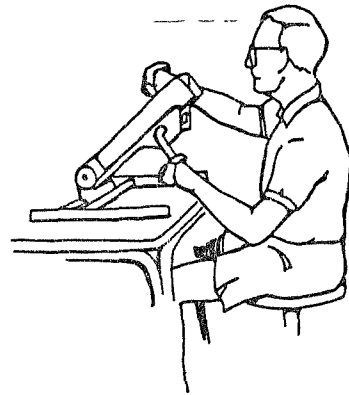
Walking log of: Mr. John Smith

Date	Walk Time	Walk Distance	Rest Time	Comments	Totals
5/5/93	4:30	2/10 mi	2:00	Good walk today	T = 18:50
	5:00	3/10 mi	2:00	My wife	D = 1.0 mi
	5:20	3/10 mi	3:00	joined me	R = 7:00
	4:00	2/10 mi			
5/7/93	4:00	2/10 mi	2:00	My leg was sore	T = 13:00
	5:00	2/10 mi	2:00	and I needed	D = .5 mi
	4:00	1/10 mi		another ply sock	R = 4:00
5/9/93	5:00	3/10 mi	1:30		
	6:00	4/10 mi	3:00	Very good day	T = 20:45
	5:00	3/10 mi	3:00	No problems	D = 1.3 mi
	4:45	3/10 mi			R = 7:30

Many of the exercise machines found in rehabilitation and fitness centers are stationary by design, and therefore, the ITP must be time based as opposed to distance based. Some machines do have odometers that indicate the distance traveled for those who prefer distance based ITPs. Regardless of the ITP measure selected, introducing the amputee to a cardiovascular endurance program should be initiated as soon as residual limb healing begins, and the person is medically cleared. The following are some of the most common forms of cardiorespiratory training methods utilized today.

1. Upper Extremity Ergometer

As an initial method of facilitating cardiorespiratory endurance, the upper extremity ergometer provides aerobic conditioning without the concerns of weight bearing through the lower extremities, or on the newly amputated limb. Additionally, because the smaller upper extremities are being used to generate the movement, instead of the larger muscle groups of the lower extremities, this form of exercise is less taxing to the cardiorespiratory system and as a result, probably a better introductory exercise.^{3,4}

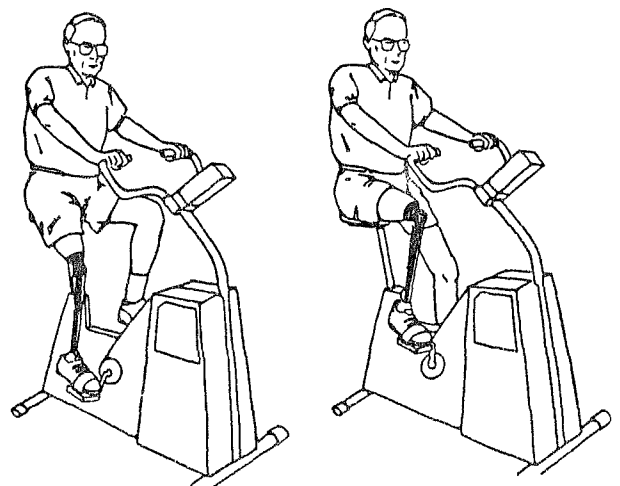


2. Lower Extremity Ergometer

Amputees of all levels are candidates for the lower extremity ergometer or stationary bike. However, in many cases, some minor adjustments will be necessary to accommodate the individual needs of a particular person.

Remember, single limb pedaling is always possible. In fact, many competitive cyclists do not use a prosthesis by choice. In many instances, the ergometer may be employed using a single limb prior to prosthetic fitting.

The following is a brief list of potential modifications that may make the use of lower extremity ergometry more comfortable.



a. Seat height - adjust for comfort, keeping in mind a slightly higher seat height is often required because some prosthetic fits do not permit full knee flexion.

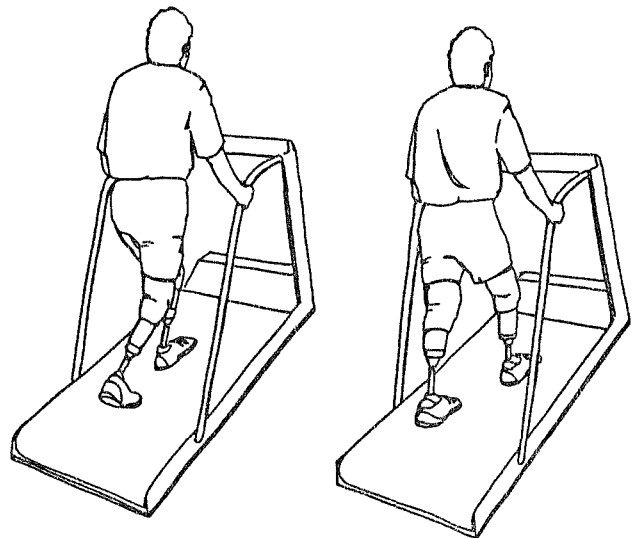
b. Seat width - Frequently a slightly wider seat width is found to be more comfortable for above-knee amputees.

c. Pedals - Most amputees have difficulty maintaining proper foot placement on the prosthetic side pedal. A set of stirrups help considerably in keeping the prosthetic foot in place.

d. Sports wear - Above-knee amputees who become cycling enthusiasts may want to invest in a pair of padded stretch nylon cycling shorts. They have been reported to assist with keeping the socket in place and helping to prevent pinching of the skin between the socket and seat.

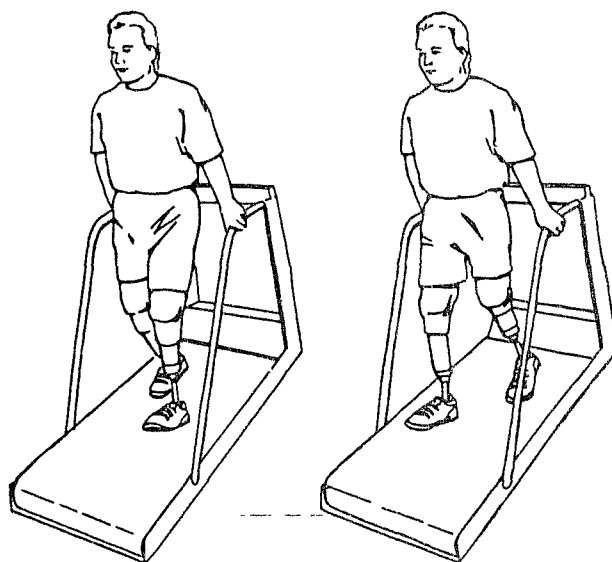
3. Treadmill Walking

Treadmill ambulation has been reported to be of significant benefit to amputees when developing walking endurance for several reasons: 1) The speed of walking can be controlled; 2) Grab bars are typically present for safety, and to reduce weight-bearing into the prosthesis, if necessary; 3) Some clinicians have incorporated an overhead harness for suspending the amputee to gradually increase weight bearing as appropriate.



4. Retro (backward) Treadmill Walking

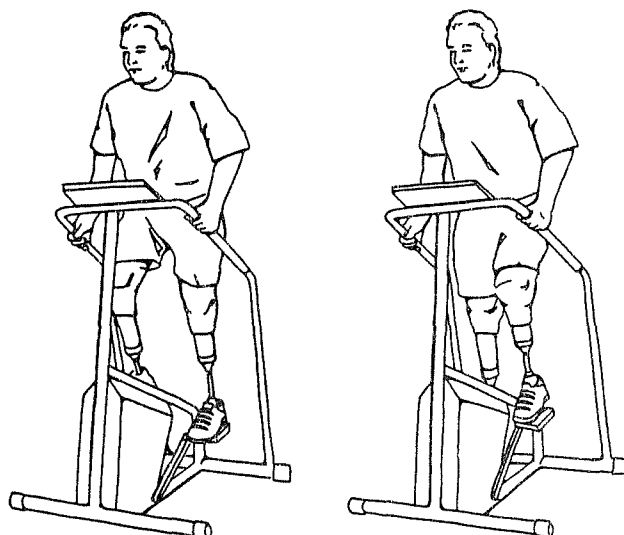
Retro walking is an excellent method of training for below knee amputees to 1) develop hamstring and gluteal response time, 2) reverse weight transfer over the prosthetic foot, and 3) increase prosthetic familiarity, coordination and agility. Above knee amputees may find retro walking awkward and frustrating because of the inability to actively flex the knee and the need for constant hip hiking.



5. Stair Climbing Machine

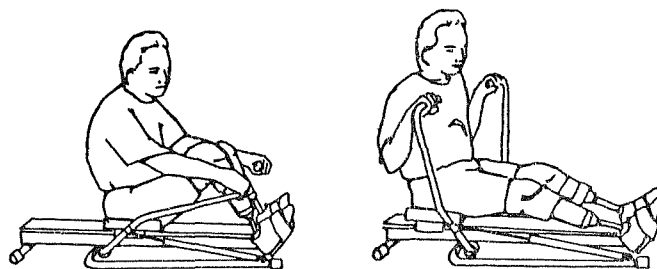
Modern stair climbing machines offer several advantages over climbing real stairs: (1) The resistance can be graded to less than that of actual body weight and, (2) grab bars are available with most models which reduce weight-bearing through the prosthesis if needed, as well as provide safety.

For aerobic fitness and increasing weight bearing within the prosthesis, these machines are an excellent tool, but must be considered an advanced exercise for most amputees.



6. Rowing Machine

Rowing machines have proven to be one of the few aerobic machines that provide both upper and lower body conditioning. In most instances, a strap is required around the foot plate of the prosthetic foot. The ROM available at the knee and hip of the prosthetic limb determine the degree of sliding motion possible.



7. Swimming

Swimming is one of the most popular and relaxing of all aerobic activities. This is an excellent exercise to continue in a maintenance program after discharge from rehabilitation. To ensure that the residual limb is strengthened during swimming, the amputee must initially concentrate on kicking the residual limb and not let it passively move through the water.

The selection of the stroke is up to the individual.

The walking log below may be duplicated for patient use.

Walking log of:

Date	Walk Time	Walk Distance	Rest Time	Comments	Totals
					T =
					D =
					R =
					T =
					D =
					R =
					T =
					D =
					R =