FUNCTIONAL TRAINING OF THE BILATERAL ABOVE-KNEE AMPUTEE[1]

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Rehabilitation of the amputee falls into four categories of concentration: postoperative care, fitting of the prosthesis, functional training and vocational re-training. Postoperative care is intended to assuage any psychic trauma, to prevent surgical complications, and to prepare the stump for prosthetic fit. It assists the amputee in attaining some independency before the fitting of the artificial limb as well as in reducing his total dependency on the prosthesis in an emergency when the prosthesis could not be used. Fitting of the prosthesis includes procedures whereby the proper prosthesis is selected and fitted for the individual. Functional training includes instruction and practice in the use of the prosthesis. Vocational re-training covers the preparation of the amputee for the occupation most suitable to his new limitations. It may include psychometric testing and prevocational exploration, vocational training and vocational guidance, schooling, and placement. This paper is concerned primarily with only one of these categories of concentration, namely, functional training of the amputee.

Because functional training of the amputee has much to do with the acquisition of special abilities or the attainment of some forms of manipulative skills in the use of equipment, it is both a medical and an educational process. As such, functional training programs for the amputee should conform to recognized therapeutic procedures as well as to accepted educational principles. In practice a daily activity evaluation is used to determine present positive powers and abilities as well as future needs. Periodic re-evaluations are given to determine the effectiveness of teaching and responses by the patient. General conditioning has as one goal physical fitness for effective living with a prosthetic device. The use of the compensatory musculature of the body offsets the various physiological effects of prolonged bed rest. In addition a program of body reconditioning contributes to the physical and mental well-being of the amputee (1, 2, 3). Training in "fundamentals" includes the development of those specifics of strength, balance, coordination, and endurance basic to the efficient use of the prosthesis. Instruction in functional activities is that part of the functional training program which teaches the amputee how best to use his conditioning and achieved fundamentals in practical day-to-day living.

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The exercises and activities selected for this article are only representative of a great number that might be developed for the bilateral above-knee amputee. They should suggest ideas from which many more exercises may be developed.

Evaluation

At the New York State Rehabilitation Hospital, the Physical Rehabilitation Section determines the actual functional ability of all patients, regardless of type of disability, by administration of a 76-item daily activity test (4) which covers the entire range of essential activities likely to be encountered in day-to-day living. In practice, the test results are used to orient the therapist to the teaching problem before him for each individual patient and to develop a program of instruction for each patient in functional exercises and activities designed to meet his needs. The test results help to establish in the patient a connection between prospective learning and present attainments, all of which can be effectively used by the therapist as a means of motivation. Generally, the patient is interested in learning of his present level of ability and what he can do to improve himself.

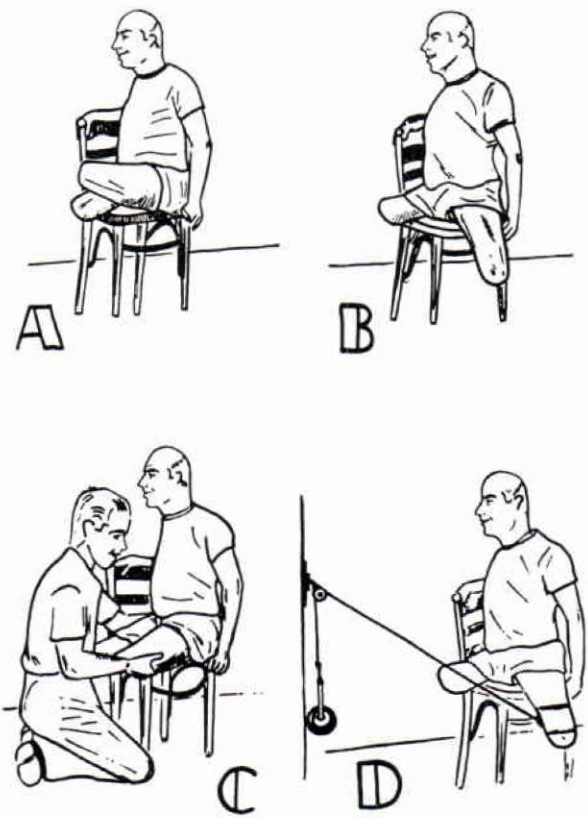

Fig. 1

In the actual instructional phase of functional training, the evaluation procedure is of distinctive value as a teaching device. The test results can be used in determining whether or not the teaching has been effective and when the therapist can go on to the next learning experience. The results disclose what modifications of teaching procedure are needed if the teaching has not fully registered with the patient (5). The entire program for the patient should be continuously reevaluated by physician and therapist on the basis of all examinations and tests recorded for a given patient. Difficulties may not necessarily be due to ineffectual teaching methods or materials or lack of technical ingenuity to cope with motor problems, but rather, to lack of capacity which may or may not be amenable to improvement.

General Conditioning

General conditioning exercises are intended to improve the over-all condition of the patient as well as of the stump. Stump exercises, as part of general conditioning procedures, are administered for the same purposes as are therapeutic exercises instituted during the postoperative care program except that the intensity is greatly increased and stump movements are carried out against manual and mechanical resistance. Several typical basic stump exercises are explained in the following paragraphs and illustrated in figures 1 and 2. The aims of such exercises are to prepare the stump for weight bearing, to maintain joint range, and to develop muscle strength.

I. Hip Extension

Hip extension exercises can be performed in the prone and side lying positions, in the sitting position, and in the erect position. One method of performing hip extension in the sitting position is described as follows: *Starting Position:* Erect sitting position on chair or plinth with one leg held in flexion over the edge of the chair and with the hands grasping the sides of the chair for support. *Action:* (fig. 1A) With the trunk held fixed move the stump down and back through the entire range of hip extension holding the contraction at maximal extension for several seconds (fig. 1B) before relaxing and returning the stump to the starting position. *Progression:* An advance of this movement would be to perform hip extension against manual resistance at first (fig. 1C) progressing to mechanical resistance (fig. 1D), whereby a greater exercise load can be used once the patient is able to easily overcome the maximum manual resistance the therapist can offer.

II. Hip Adduction

Hip adduction exercises are best performed in the supine, side lying, and erect positions. One method of performing hip adduction exercises in the supine position is described as follows: *Starting Position:* Supine lying on mat or plinth, with or without a pillow under the head, according to the preference of the patient, with the stumps spread in abduction (fig. 2A). The arms should be relaxed over the abdominal area (if the patient

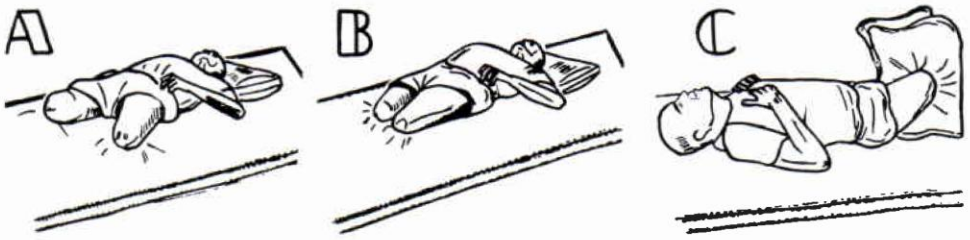

Fig. 2

is permitted to place the arms at the sides, he may substitute by pushing or pulling on the mat or plinth). *Action:* Adduct the stumps, squeezing the limbs together and holding the contraction at maximum adduction for several seconds (fig. 2B) before relaxing and returning the stumps to the starting position. *Progression:* An advance of this exercise would be to have the patient squeeze a folded pillow between the stumps (fig. 2C) progressing to manual and mechanical resistance exercises.

Fundamentals

The "fundamentals" of functional training are: *balance, strength, coordination,* and *endurance.* Fundamentals train the patient in capacities necessary for learning activities of daily living. The introduction of methods of performing higher levels of daily activity skills before the acquisition of the basic fundamentals may require re-teaching later. An easy way to start a lively discussion is to ask the question, "Which of these is most important?" Every worker in functional training probably has a strong opinion on the subject. The position taken here is that all fundamentals are important, but that, if any one were to be singled out for special emphasis, it would be coordination. It is this quality which makes the difference between "muscling through" an activity with brute strength and performing an act skillfully, smoothly and efficiently.

There is an unlimited amount of material in the form of exercises, drills and activities that can be used to develop fundamentals. Any well-trained therapist with a knowledge of kinesiology and therapeutic exercises has at his command a good many of these activities, and he can formulate a large number of movements and exercises closely related to the development of fundamentals which should contain elements of, and duplicate where possible, motions which the amputee will be called upon to do later in performing daily activity skills (6). In addition it should be pointed out that fundamentals are usually stressed at the mat, parallel bar, and crutch management levels of functional training (7-14). Many activities adaptable for use as lead-up exercises at these levels of training can be found in any good reference work. To illustrate the lead-up principle, several lead-up functional parallel bar exercises are explained and illustrated in the following paragraphs.

I. Step Climbing Drill

Aims: To develop the fundamentals of balance (weight shifting, etc.) and coordination (foot placement, knee locking and unlocking, etc.). *Lead-up Values:* A preparatory drill to develop balance and coordination necessary to perform the daily activities of ascending and descending curbs and stairs.

A. Ascending Drill

Starting Position: Parallel bar stance directly facing the apparatus to be ascended at a distance permitting the prosthesis to be lifted from the starting position onto the step (fig. 3A). *Action:* Shift the weight of the body to one side and flex the hip on the opposite side placing the foot on the stool (fig. 3B). Flexion of the stump at the hip causes the prosthesis to rise and the knee of the prosthesis flexes due to gravity. Move the hands forward slightly and shift the body weight forward and over onto the hands. Pushing down on the bars, straighten the elbows and lift the body off the floor. Transfer the weight of the body over onto the leg which has been placed on the step and simultaneously extend the stump forcefully inside the prosthesis (fig. 3C). This is done to lock the knee of the prosthesis by pressure of the posterior portion of the stump against the inner surface

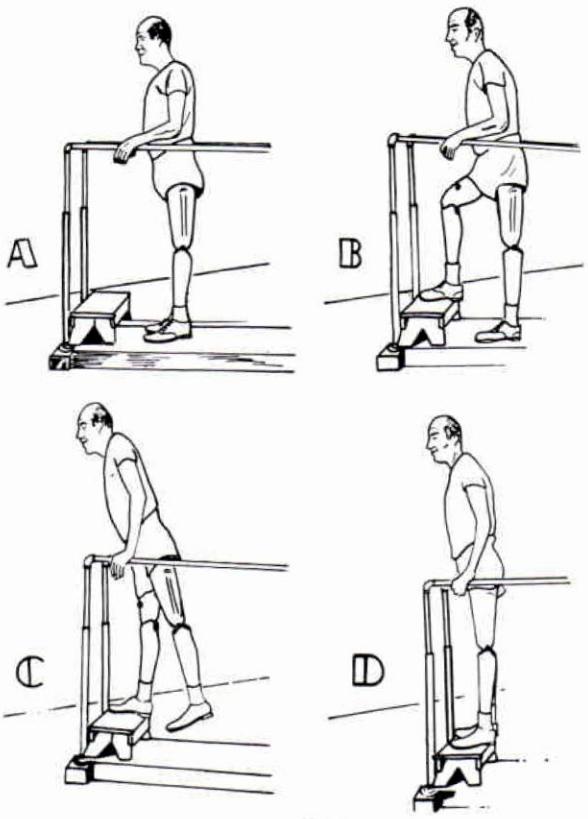

Fig. 3

of the thigh portion of the bucket. Place the other leg on the step and reestablish the balance (fig. 3D). This is accomplished by flexing the stump at the hip high enough to permit the foot to be placed on the step. The knee is locked in the same manner as was described for the other leg, namely, forcefully extending the stump against the prosthesis.

B. Descending Drill

Starting Position: Parallel bar stance on top of the apparatus to be descended with the feet on the step in such a manner that the heels rest on the step with the fore part of each foot over the edge (fig. 4A). *Action:* Shift the weight of the body to either side, hike the hip on the opposite side or flex the stump at the hip and raise the leg forward off the step (fig. 4B). Shift the body weight forward over onto both hands until the leg on the step begins to flex at the knee. Gradually lower the other leg to the floor (fig. 4C). Flexion of the knee is facilitated by gradually relaxing the hip extensors as the weight is transferred to the hands. As the other leg is lowered to the floor, the stump is forcefully extended against the bucket to lock the knee for weight bearing. Flex the stump at the hip, bring the other leg off the step and reestablish the balance (fig. 4D).

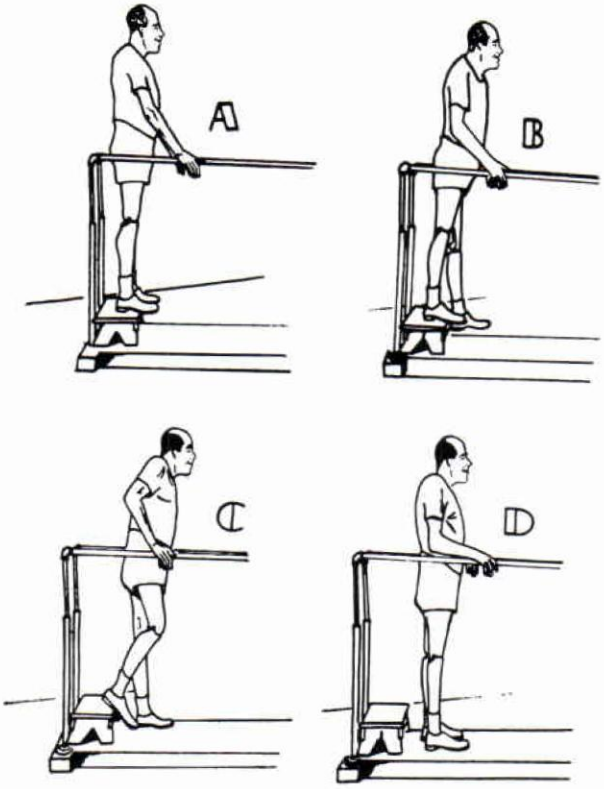

Fig. 4

Functional Activities

This section analyzes some of the basic methods of performing daily activities with the aid of artificial limbs. Much of the training in this area consists of the basic technics used in functional training with braces and crutches, modified to meet the specific kinesiologic demands required of the amputee patient equipped with bilateral above-knee prosthetic devices.

I. Wheelchair Activities

Although it is generally anticipated that a bilateral above-knee amputee will eventually become completely ambulant with prosthetic devices with or without crutches or canes (15), a wheelchair can be considered an aid to locomotion under certain specific conditions. It can answer the problem of getting about during the postoperative treatment phase and during the period of waiting for prosthetic devices. The amputee will also find it convenient to use a wheelchair during the training phase because of lack of endurance. Even after full walking tolerance has been established, use of a wheelchair may be needed in emergency situations, e.g., when one or both stumps have broken down or when the patient cannot bear weight for other reasons. For these reasons, wheelchair activities must be included in the functional training program for the bilateral above-knee leg amputee.

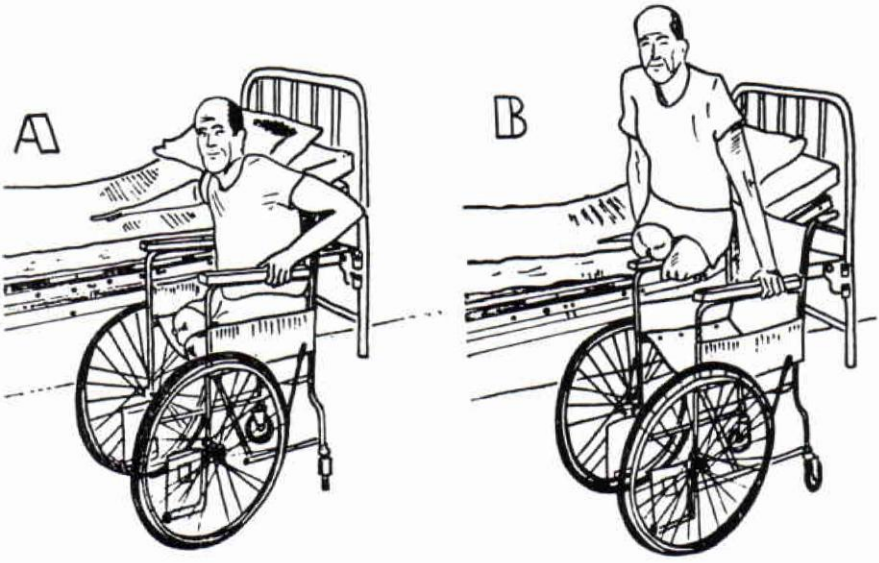

Fig. 5

A. Wheelchair to Bed and Return

Starting Position: Position wheelchair so that it is parallel to the side of the bed. Lock the brakes. Place the hand nearest the bed on the bed and grasp armrest with the other hand (fig. 5A). *Action:* Push down with both hands, straighten both elbows and raise the body to above the level of the armrests. With lateral pressure from the hand on the armrest shift the body weight over onto the hand and arm on the bed and transfer the hips to the bed (fig. 5B). Remove the hand from the armrest and adjust to a comfortable position on the bed sitting or lying.

The procedure for returning to the wheel chair is the reverse of the above-mentioned method. Move to the edge of the bed and with the hand nearest the chair, grasp the armrest farthest from the bed (fig. 5B). Push down on both hands, extend the elbows and lift the buttocks off the bed, transferring the body between the armrests. From this position gradually lower the hips to the wheelchair assuming the sitting position (fig. 5A).

B. Wheelchair to Straight Chair and Return

Starting Position: Position wheelchair so that it faces toward the side of the straight chair. Lock the brakes. Draw straight chair in as close as possible toward the wheelchair. *Action:* Position body forward in the wheelchair so as to allow room for hand to be placed behind hips, and place the other hand on the outer edge of the straight chair (fig. 6A). With the elbows locked shift the weight over onto the hand on the straight chair. Push down on both hands and lift the hips from the wheelchair

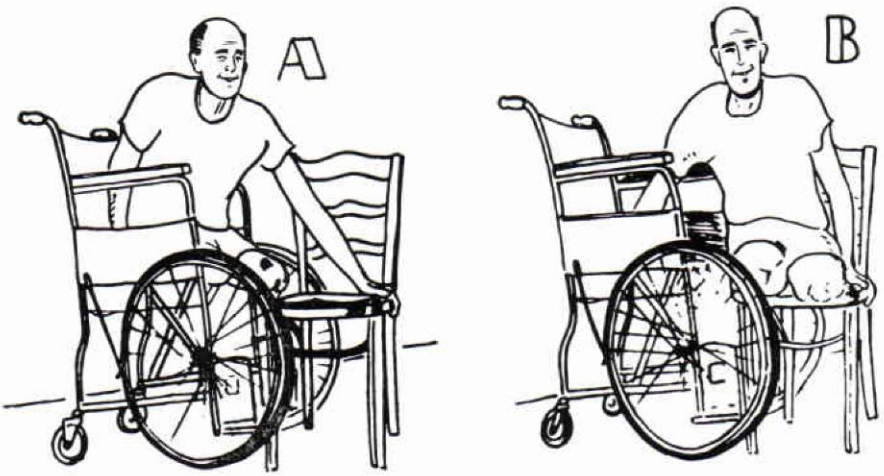

Fig. 6

and transfer the body to the straight chair (fig. 6B). Adjustment of position on straight chair can be accomplished by pushups, buttock walking or both.

The procedure for returning to wheelchair from straight chair is the reverse of the above method. Place hand nearest wheelchair on seat (fig. 6B). Shift the body weight over onto the hand on the wheelchair seat. Push down on both hands extending the elbows and lifting the buttocks from straight chair to wheelchair (fig. 6A). Reposition body in wheelchair.

C. Wheelchair to Tub and Return

The method of transferring from wheelchair to straight chair and return can be utilized in the following way to transfer from wheelchair to tub and return. *Starting Position:* Position the wheelchair parallel with the tub and place straight chair or bathroom bench next to tub in front of wheelchair. *Action:* Transfer to straight chair or bench (fig. 7A) in manner previously described in moving from wheelchair to straight chair and return (see Wheelchair to Straight Chair, figs. 6A and 6B). Facing the tub

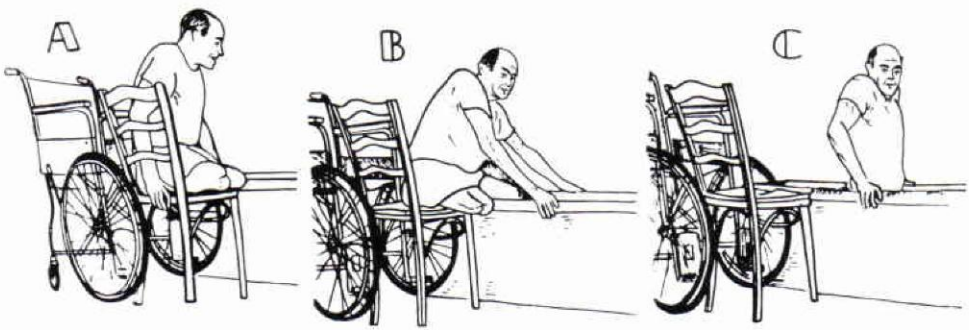

Fig. 7

at an obtuse angle place hand, on same side as the tub, on the edge of the tub (fig. 7B). Transfer the hips so as to straddle the tub edge. Reach forward and place the hands on each tub rail (fig. 7B). Shift the body weight over onto the arms, lifting the hips from the edge of the tub and gradually lower the body into the tub (fig. 7C). The above method of getting from wheelchair to tub can be used in reverse sequence in order to get from tub to wheelchair (fig. 7C-7A).

D. Wheelchair to Floor and Return

Starting Position: Sitting in wheelchair with the wheels of the chair in the locked position. *Action:* Position the body to the front edge of the chair. With one hand firmly grasping the armrest on the same side[6], bend forward and reach down for the floor placing the other hand on the floor (fig. 8A). With the elbow locked, shift most of the body weight over onto the hand and arm on the floor. Push down on both hands lifting the hips off the chair; lower the body to the floor (fig. 8B). The procedure for returning to the wheelchair is the reverse of the above method with the exception that the hand is placed on the seat instead of the armrest.

II. Activities with Prostheses and Crutches

Whether or not a bilateral above-knee amputee will become completely ambulant with or without crutches or canes depends upon many factors. Among the most important are the age of the patient and his general health and fitness, the condition of the stumps, and the patient's capacity for training. The ultimate goal of independent living without the aid of crutches or canes may never be fully realized. In such a case, a lesser goal with crutches or canes may have to be accepted. Forearm crutches are preferred as they offer more support than canes and, in most instances, the amputee may not require the complete support afforded by full length underarm crutches. If an amputee can get along with canes or if underarm crutches

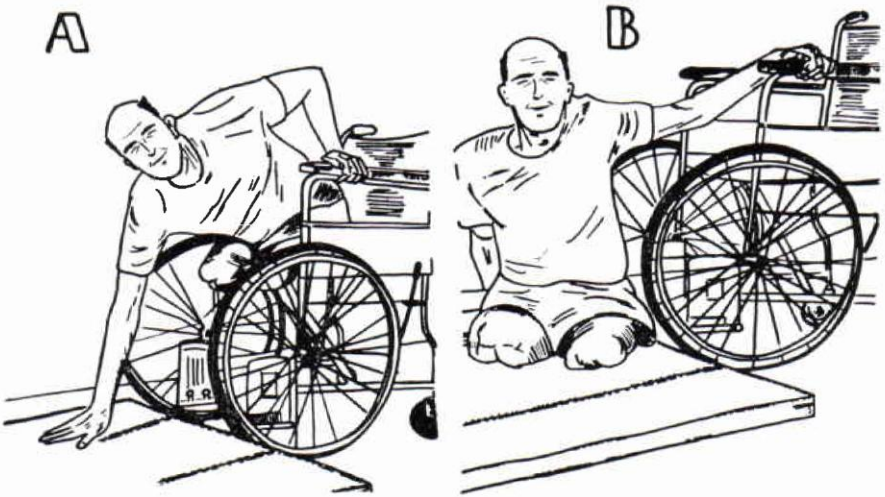

Fig. 8

[6] The hand may be placed on the seat of the wheelchair in preference to the armrest. By so doing the angle of the lean and the distance the body must be suspended and lowered are decreased.

are required, it is simple to modify the methods described below to meet the differences among the three types of support.

Wheelchair to Standing and Return

Starting Position: Sitting in the wheelchair with the brakes locked. Grasp crutches in the usual manner and place them on the floor in the vertical position (fig. 9A). *Action:* Forcibly extend the elbows and push-up to an erect position (fig. 9B). Simultaneously with the push-up extend the stumps at the hips bringing pressure on the inner posterior surface of the prostheses. This will not only help in assuming the erect position but help to insure the locking of the knee joints. After the knee joints have been held in full extension, advance the crutches and assume the crutch balance stance preparatory to ambulating away from the chair. The above method of getting from wheelchair to standing can be used in reverse sequence in order to get from standing to wheelchair (figs. 9B-9A).

Note: Other authors have described a method of getting from wheelchair and return which is very similar to that used by some bilateral long leg brace-wearers. In this variation the patient lifts the body out of the chair with a half turn of the body in the direction of the chair and pivoting on the extended legs (16). Although this is probably the safest method of getting up from a chair, the present authors feel that it is a slow and laborious technic which should be used only when a patient has difficulty with learning the straight forward method.

III. Curb Climbing

A. Ascending Curbs

Starting Position: Crutch balance stance facing the curb. *Action:* Balance on the prosthesis and place both crutches onto the curb simultaneously or alternately depending on the patient's ability. Shift the weight of the body to one side and flex the hip on the opposite side placing the foot on the

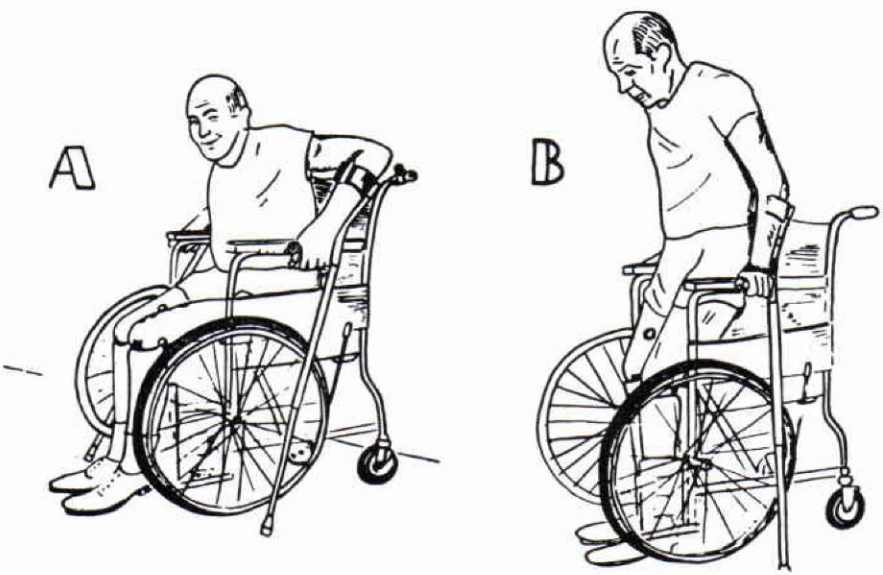

Fig. 9

curb (fig. 10A). Flexion of the stump at the hip causes the prosthesis to rise and the knee of the prosthesis flexes due to gravity. Shift the body weight forward and over onto the hands and simultaneously straighten the elbows lifting the body off the street level onto the curb (fig. 10B). As the body is raised from the street level, the stump of the leg which has just been placed on the curb is forcefully extended inside the prosthesis. This is done to lock the knee of the prosthesis by pressure of the posterior portion of the stump against the inner surface of the thigh portion of the bucket.

B. Descending Curbs

Starting Position: Crutch balance stance facing the street. *Action:* Move the feet alternately to the edge of the curb so that both feet are overlapping. After this has been done, lower the crutches to the street. Shift the weight to one side, hike the hip on the opposite side or flex the stump at the hip, raising the leg forward and off the step (fig. 10C). Shift the weight of the body forward onto the hands until the leg on the curb begins to flex at the knee. Gradually lower the other leg to the street (fig. 10D). Flexion of the knee is facilitated by gradually relaxing the hip extensors as the weight is transferred to the hands. As the other leg is lowered to the street the stump of the first leg is forcefully extended against the bucket to keep the knee locked for weight bearing.

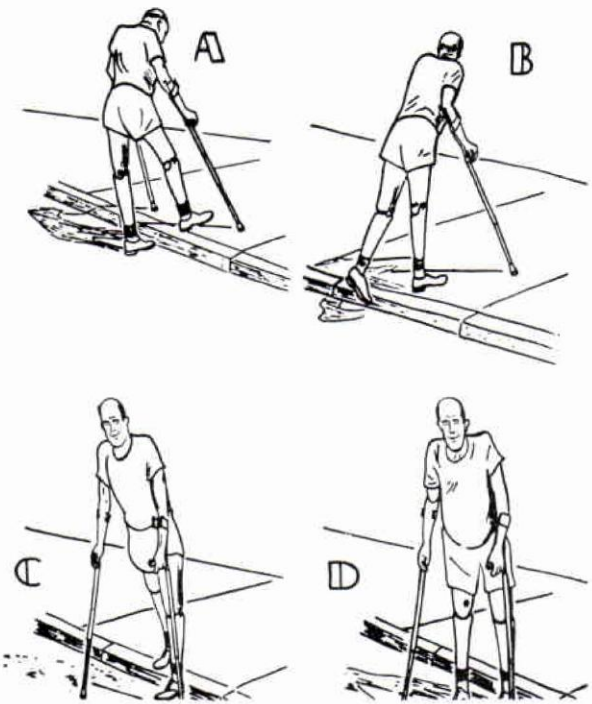

Fig. 10

IV. Stair Elevations

A. Ascending Stairs with Handrail

Starting Position: Crutch balance stance facing the stairs and near the handrail. *Action:* Maintain balance on the crutch farthest from the handrail, remove the opposite arm from the forearm cuff, and hold both crutches in the manner deemed most convenient. Grasp the handrail with the free hand preparatory to ascending the steps (fig. 11A). Shift the weight of the body to the arm on the handrail and the leg of that side. Flex the hip on the opposite side and raise the foot onto the step (fig. 11B). Flexion of the stump at the hip raises the prosthesis, permitting the knee to flex due to gravity. Advance the crutches two steps above the starting position (fig. 11C). Shift the body weight forward and over onto the hands and simultaneously straighten the elbows lifting the other leg onto the step (fig. 11D). Readjust stance and complete the movements for the remaining steps. As the body is raised to the step, the stump of the leg just placed on the step is forcefully extended inside the prosthesis (fig. 11D). This is done to lock the knee of the prosthesis by pressure of the posterior portion of the stump against the inner surface of the thigh portion of the bucket.

B. Descending Stairs with Handrail

Starting Position: Crutch balance stance near the handrail at the top of the staircase directly facing the steps. *Action:* Maintain balance on the crutch farthest from the handrail, remove the opposite arm from the forearm cuff, and hold both crutches in the manner deemed most convenient.

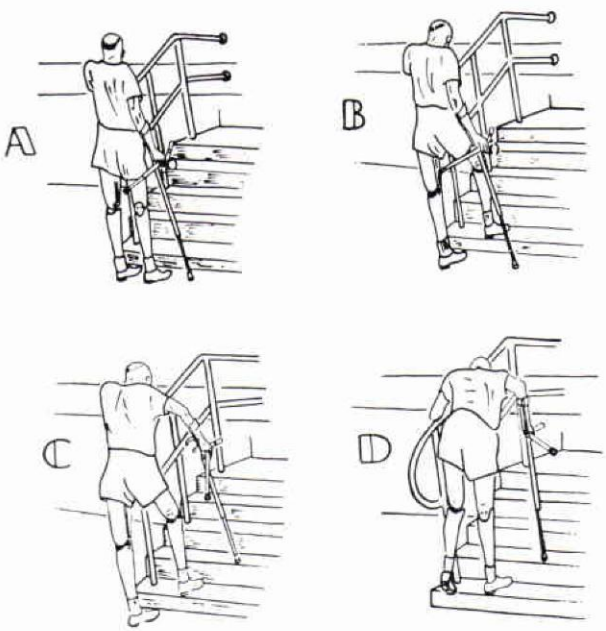

Fig. 11

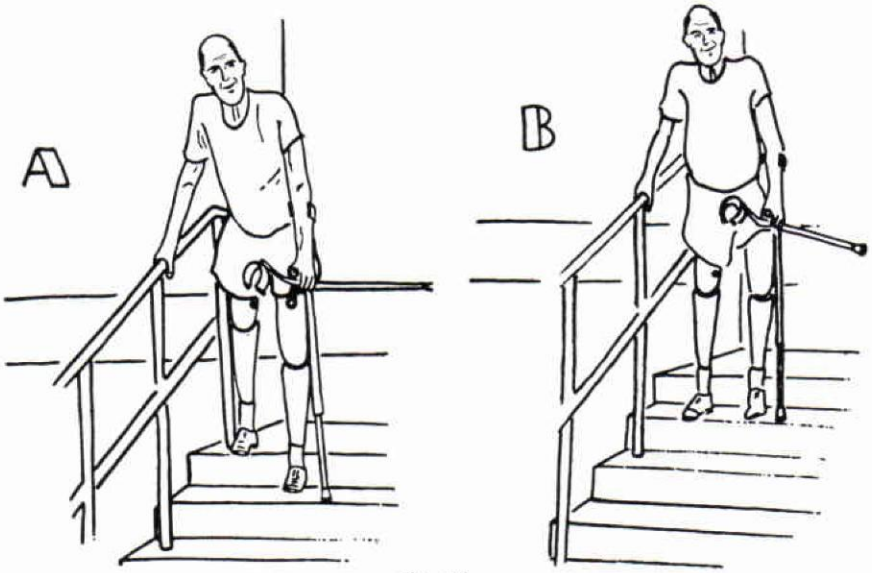

Fig. 12

Grasp the handrail with the free hand preparatory to descending the steps. Move the feet alternately to the edge of the step so that both feet are overlapping. After this has been done, lower the crutches to the step below. Shift the weight of the body to the arm on the handrail and the

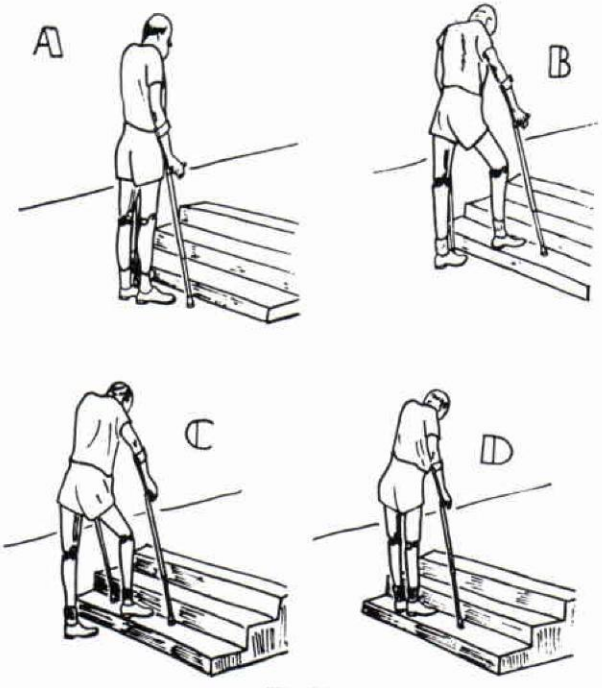

Fig. 13

leg of that side. Hike the hip on the opposite side or flex the stump at the hip raising the leg forward and off the step (fig. 12A). Shift the body weight forward over onto the hands until the leg on the step begins to flex at the knee. Gradually lower the other leg to the step (fig. 12B). Readjust stance and complete the movements for the remaining steps. Flexion of the knee is facilitated by gradually relaxing the hip extensors as the weight is transferred to the hands. As the other leg is lowered to the step below, the stump of the other leg is forcefully extended against the bucket to keep the knee locked for weight bearing.

C. Ascending Stairs without Handrail

Starting Position: Crutch balance stance facing the stairs (fig. 13A). *Action:* Advance one crutch to the step above. Shift the weight of the body to one side and advance the leg on the same side as the advanced crutch (fig. 13B). Reestablish balance and advance the other crutch so that both crutches are now on the same step (fig. 13C). Shift the body weight forward and onto the hands and simultaneously straighten the elbows lifting the body up onto the step. Place the other leg on the step and reestablish balance (fig. 13D). This is accomplished by flexing the stump at the hip high enough to permit the foot to be placed on the step. The knee is locked in the same manner as was described for the other leg, namely, forcefully extending the stump against the prosthesis. This procedure is repeated until the flight of stairs is completed.

D. Descending Stairs without Handrail

Starting Position: Crutch balance stance at the top of the staircase directly facing the stairs (fig. 14A). *Action:* Move the feet alternately to

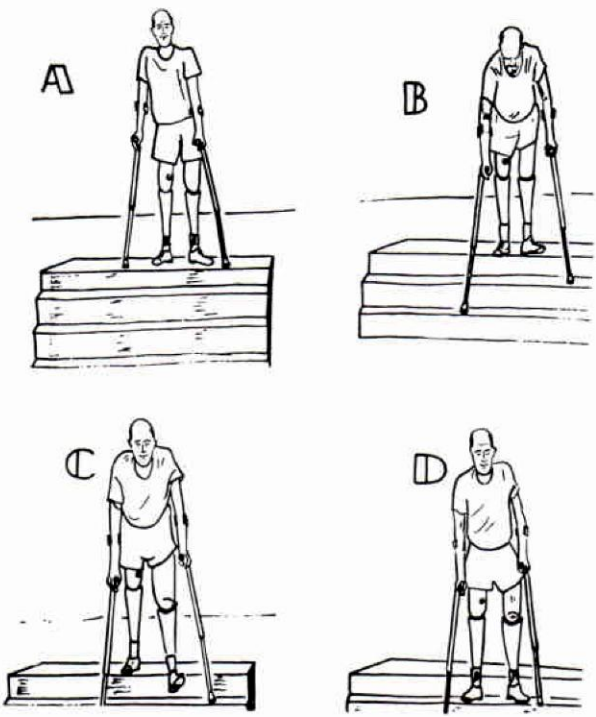

Fig. 14

the edge of the step so that both feet are overlapping the step. Advance one crutch to the step below: the other crutch is placed two steps below (fig. 14B). Shift the weight of the body to one side, hike the hip on the opposite side or flex the stump at the hip and raise the leg forward and off the step (fig. 14C). Shift the body weight forward over onto the hands until the other leg begins to flex at the knee. Gradually lower the other leg to the step (fig. 14D). This procedure is repeated until the flight of stairs has been descended.

Summary

One phase of rehabilitation of the bilateral above-knee amputee, namely, functional training, has been discussed. An attempt has been made to show that the fundamental approach to functional training with prosthetic devices is the same as with braces and crutches. Proper evaluation is followed by general conditioning, including pre-prosthetic stump exercises, and training in fundamentals, prior to actual instruction in functional activities. Four qualities have been emphasized as the bases of training. These are strength, balance, coordination and endurance. Of these, coordination has been considered as the most essential.

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