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# Ambulatory Devices: Assessment and Prescription

*Daniel Olufemi Odebiyi and Caleb Adewumi Adeagbo*

## Abstract

Injuries or disabilities associated with the lower extremities and aging frequently result in ambulation difficulty and this usually necessitates the prescription of ambulatory assistive device (e.g., cane, crutch and walker) in an attempt to restore locomotory function. Ambulatory devices are orthotic devices that provide support, stability and balance for users to able to move from one point to another. Users can progress or retrogress from one ambulatory device to another while some are permanently fit on a particular device throughout lifetime. The progression is dependent on the medical condition, user's abilities, user's anthropometric and environment. Physiotherapist prescribes ambulatory device to users and helps with the fitting and proper use of the ambulatory device. A correct prescription and well fitted ambulatory device minimize functional limitation and promote functional ability and improve quality of life. Incorrect prescription, fitting and use of ambulatory device may result in early fatigue, frustration, fall and damage to blood vessels, muscles or nerves.

**Keywords:** ambulatory devices, walker, crutches, cane

## 1. Introduction

Ambulatory devices are mobility devices that assist in transfer of user from one point to another. Ambulatory devices require active participation of users during mobilization while mobility devices requires passive participation of users. Mobility devices are stretchers and wheelchairs [37].

Ambulatory devices are used by people with musculoskeletal impairments, neurological deficit and older people in order to be independent or decrease dependency on care-givers and health care practitioners. Ambulatory devices are orthotic devices used for support (i.e., augmentation of muscle action and/or reduction of weight-bearing load), maintaining stability and balance with the aim of transferring individual with ambulatory difficulty from one point to another due to injury or disability [13].

Many factors predispose an individual to use ambulatory devices. These factors may be aging, congenital, medical or traumatic. Congenital factors include structural deformities that are present at birth, while traumatic factors are as a result of accident. Medical factors are as a result of diseases which can lead to amputation, limb discrepancies, muscle weakness and loss of balance. Users can progress or retrogress from one ambulatory device to another while some are permanently fit on a particular device throughout lifetime.

There are many ambulatory devices developed to suit diverse presentations from difference medical or surgical conditions and these include parallel bar, walker, crutches and cane. Each of the ambulatory device has advantages and disadvantages that enhance their prescription and usage. Therefore, clinicians need to have a good understanding of these ambulatory devices to be able to recommend the ideal ambulatory device for the user [3, 10].

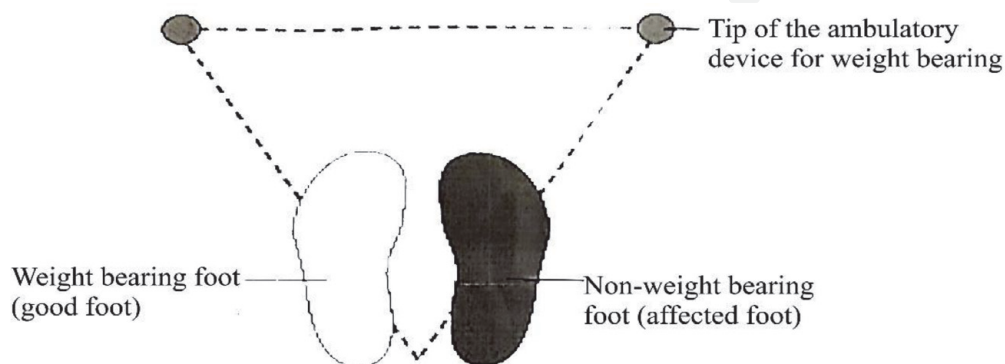
Prescription of ambulatory device is determined by the user's anthropometric parameters (body weight, height and body mass index), user's abilities (skill), user's needs and environment. Other factors that influence the prescription of ambulatory devices include; weight bearing status, the degree of support or assistance the device can offer, the coordination of the user, range of motion available at the involved joints, balance, stability, strength, and general condition of the user.

There are also body functions involved in determining user's capacity to use an ambulatory device, these are cognitive function, judgment, vision, vestibular function, upper body strength, physical endurance. Depending on severity, impairments in any of these functions could make it impossible for a user to safely use a device.

The prescription of any ambulatory device should specify the device most likely to maximize the user's function; the individual's goals and personal preferences must also be considered. Physiotherapists are licensed and help with the fitting and proper use of ambulatory device while other health practitioners can also recommend ambulatory devices. All ambulatory devices are made in different height and so user must be fitted in order to obtain the correct ambulatory device height [6].

The functions of ambulatory devices when properly use includes the following:

- Provides assist forward, backward and lateral movements: users of an ambulatory device can walk in any direction with and within the device.
- Helps to increase balance, stability and coordination of the users: there is increase balance due to the increase in the base of support provided by the ambulatory devices (**Figure 1**).
- Helps to reduce weight bearing on the affected lower limb: use of ambulatory devices result in the upper limbs sharing weight bearing with the affected lower limbs, thereby reducing the weight of the body of user being borne on the affected lower limbs.
- Helps to increase confidence of the users: the user can move independently without or with little manual assistance.



**Figure 1.**  
*Increase of the base of support for a user of ambulatory device (crutches).*

- Helps to correct poor posture: the support provided by ambulatory devices creates a platform that enhances good posture habit among users when the right ambulatory device is selected and properly fit.
- Helps to reduce risk of fall: assumption of good posture arising from increased supporting base of users help to reduce the risk of fall among users.
- Helps to reduce pain on the affected limb: the use of ambulatory support encourages body weight of the users to transferred to the ambulatory devices.
- Helps to augment muscular strength of the trunk and of the affected lower limbs [21].

## 2. Ambulatory devices

Ambulatory devices are aids made of durable and non-malleable materials for assistance during walking and standing. The main function of ambulatory device is to reduce the amount of weight bearing on the weak (or affected) lower limb or totally eliminate weight from the lower limb by transmitting the body weight from the upper limb to the floor through the ambulatory device [8]. Weight bearing status of ambulatory device user is the amount of weight the user put on the weak (or affected) lower limb during ambulation. The weight bearing status can be measured in grades or percentages. The amount of weight bearing on the weak (or affected) lower limb is determined by the user medical history, weight bearing capacity as can be tolerated and functional ability of the weak (or affected) lower limb [11]. The weight bearing status available among ambulatory device users (apart from cane) are as described below:

*Non-weight bearing (NWB)*: the affected lower limb will not touch the floor during ambulation (i.e., no weight is borne on the affected lower limb) [11]. The percentage of body weight transmitted to the floor, through the affected lower limb is zero (0)% (**Figure 2**).

*Touch down weight bearing (TDWB)*: this is also known as toe touch weight bearing (TTWB). Here, the foot or the toes touch the floor but no weight is transmitted to the floor through the affected lower limb involved. Thus, the percentage of body weight transmitted to the floor, through the affected lower limb is also zero (0)% (**Figure 3**).

*Partial weight bearing (PWB)*: here, a little amount of weight is transmitted to the floor through the affected lower limb. The percentage of body weight transmitted to the floor can range between 1 and 50% [11]. During the training stage, two body weighing machines/apparatus can be used to accurately determine the percentage body that may borne on the affected lower limb (**Figure 4**).

*Weight bearing as tolerated (WBT)*: the user of the ambulatory device determines the amount of weight to bear on the affected/involved lower limb. The weight bearing status is totally dependent on the individual ambulatory device user and the percentage of body weight transmitted to the floor can range from 50 to 100% [11].

*Full weight bearing (FWB)*: the affected/involved lower limb can bear the total weight of the body. The percentage of body weight transmitted to the floor through the affected lower limb can be 100% [11]. This type of weight bearing status is used to build confidence with the ambulatory device user.





**Figure 2.**  
*Non-weight bearing (NWB) on the right lower limb. The non-weight bearing limb is not touching the floor.*



**Figure 3.**  
*Touch down weight bearing (TDWB) on the right lower limb. The reference lower limb is only touching the floor but not bearing weight.*



**Figure 4.**  
*Partial weight bearing (PWB) or weight bearing as tolerated (WBT) on the right lower limb. The weight the reference lower limb bear is decided by the amount of weight that can be tolerated.*

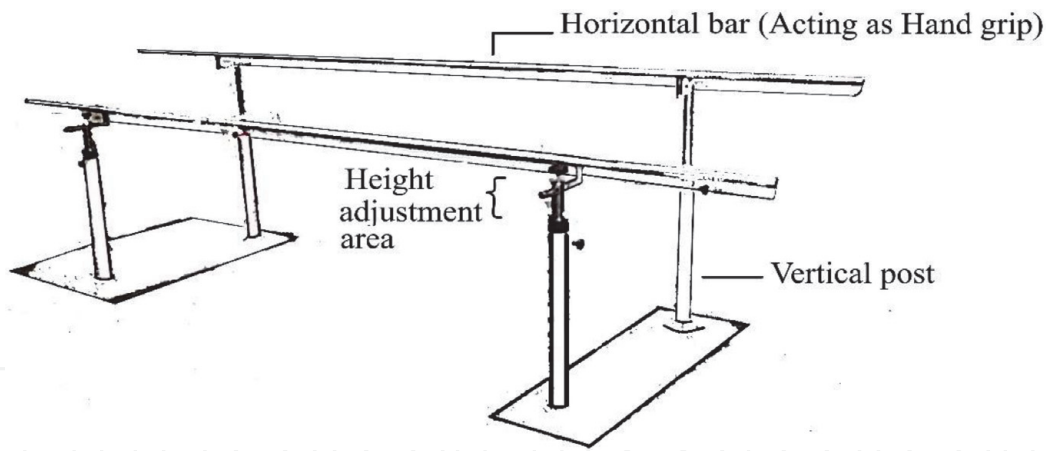
### 3. Categories of ambulatory device

Ambulatory devices can be group into categories depending on the basic design. When arranged in the level of stability of the ambulatory device the progression is parallel bar, walker, crutches and cane. Each of the categories of the ambulatory device is then redesign and modify to different styles and types to specifically meet the needs of the user.

### 4. Parallel bar

#### 4.1 Description and components of parallel bar

Parallel bar are fixed apparatus with a pair of horizontal bars on vertical posts used for standing and ambulatory training (**Figure 5**). It is a medical ambulatory device with two parallel horizontal bars on fixed four legs; the user holds the horizontal bars at wrist height and move forward, backward and sideways, usually



**Figure 5.**  
Parallel bar fixed together for stability. There are knobs on the vertical poles for adjusting the height.

in front of a standing mirror. Each of the horizontal bars is mounted on two adjustable vertical posts to allow for easy adjustment of height of the parallel in accordance with the anthropometric parameters of the users. The entire horizontal bars form the handgrip for the users. The vertical posts are fixed to the floor or joined together for stability of the parallel bar. The horizontal bars are about 18 inches apart; and are set at the same height by the vertical posts which are about 11 feet (340 cm) long. Pediatric parallel bars are also available with adjustable height. The horizontal bars are usually made of wood; while the vertical posts are made of different materials such as stainless steel, aluminum steel or iron. The material used to manufacture the parallel bar determines the weight, durability, cost, strength, comfort and safety.

#### 4.2 Advantages of parallel bar

1. It provides maximum stability: the fact that users (patients) are positioned between the two parallel bars gives room for further stability in addition to the presence of the therapists at either side of users.
2. It requires the least amount of coordination: the present of the two parallel bars also makes coordination a lot easier; as users holds onto the bars as he/she moves along.
3. It is the best ambulatory device to practice ambulation, particularly at the onset of ambulatory training. As it creates confidence in the patient and also reduce the fear of falling in the patient.
4. It can be used to determine other ambulatory device the user will use because the patient performance within the parallel bar will indicate the ability to use other type of ambulatory devices.

#### 4.3 Disadvantages of parallel bar

1. User's ambulation is limited within and between the parallel bar, although guided by the mirror positioned at the other end of the parallel bars.
2. It is stationary (usually not moveable): parallel bars are usually permanently positioned at a particular place in the treatment room or medical gymnasium. The patient has to be moved (usually on wheelchair) to the parallel bars.



3. It is expensive compared to other ambulatory devices: it is not readily made available for home use because the financial implication involved in building it. Thus, its usage usually requires moving the patient (users) to the facility (i.e., hospital).

#### **4.4 Fitting of parallel bar**

Parallel bars are usually adjustable, the heights of the bars are adjusted to fit the user. The adjustment is estimated base on the user's height. The bars should be at the level of the greater trochanter of the user and the elbow joint should be able to flex to about 20 or 30 degrees when the user grips the horizontal bars. Further adjustment of the heights of the bars is made, with the view to fit the parallel bars to the user's height, immediately the user is position in standing position, where there is need. Usually the adjustment of the parallel bar is fixed at two- and half-inch interval or less depending on the manufacturer and the user (adult or pediatric).

#### **4.5 Instruction on the use of parallel bar**

Prior to ambulation using the parallel bar, the following safety and precautions should be checked.

- The stability of the parallel bar should be checked. All the vertical posts (limbs) of the parallel bar should be fixed, stabilized and immovable.
- All the push buttons for height adjustment should be visible and at the same height level.
- The handgrips on the horizontal bars should be attached sturdily and not move when pressure applied.
- There should be no loose component (screw, nuts or bolt) in the parallel bar.
- No dents, cracks or any irregularities on the parallel bar.

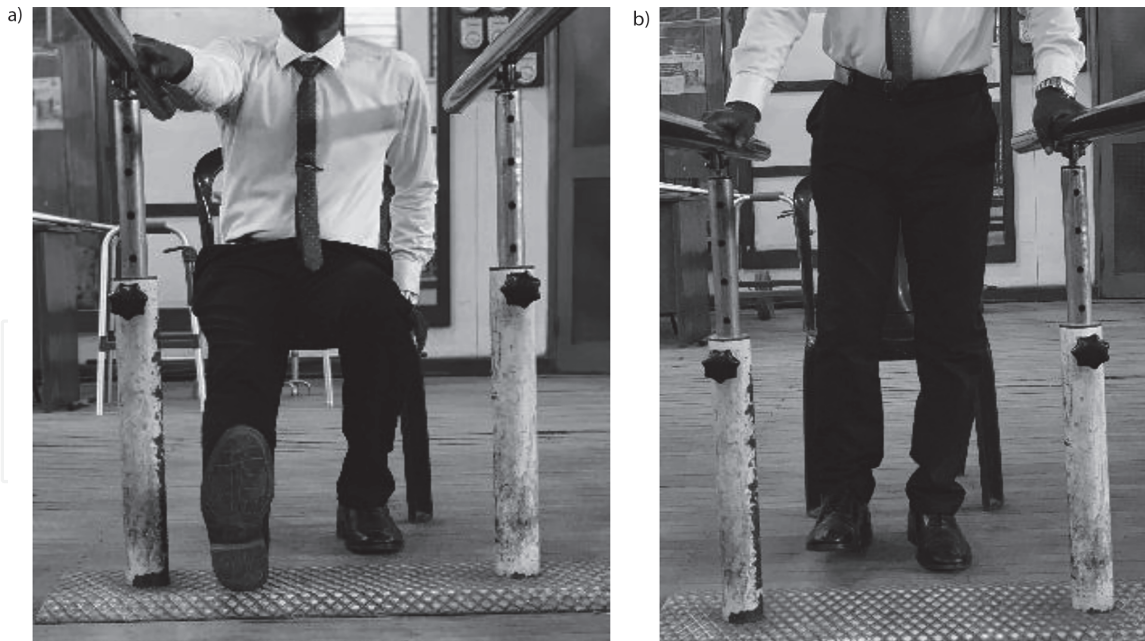
Also, the following instructions should be given to the users before they are positioned between the parallel bars:

- Users should maintain good posture (hyper flexion of the head, neck and trunk should be avoided).
- Users should hold the horizontal bars firmly.

Users of parallel bars first need to learn how to stand using the parallel bar. The user uses one of the upper limbs to hold one bars of the parallel bar (for stability and balance) and the other upper limb to assist in standing by pushing up on the seat (**Figure 6A**). Clinicians can assist the user into standing position from sitting by assisting the user from the axilla region. Immediately the user is almost standing user change the position of the upper limb that was on the seat to the other bar of the parallel bars (**Figure 6B**). User stands upright within the walker, adjusting the upper limb and lower limb till the user is balance.

When siting from standing using the parallel bar, the user follow the reverse pattern of standing. From upright standing within the parallel bar, the user place





**Figure 6.**  
*Positioning for learning how to use the parallel bars: (a) learning how to stand when using the parallel bar, (b) moving the hand on the seat to the horizontal pole of the parallel bar to maintain stability.*

one hand (i.e., upper limb) on the seat to control the speed and bear weight of sitting. Then the user sits gradually, using the other upper limb on the bar to control the movement back to seating.

#### 4.6 Weight bearing status possible with parallel bar

The following weight bearing status can be used with parallel bar: non-weight bearing (NWB), touch down weight bearing (TDWB), partial weight bearing (PWB), weight bearing as tolerated (WBT), full weight bearing (FWB).

#### 4.7 Non-weight bearing (NWB)

The user slides the upper limbs on the horizontal bars forward to an arm's length (weight of the body is on unaffected lower limb and the affected lower limb is not touching the ground). The user shared his/her body weight between the unaffected lower limb and parallel bar by putting body weight on the parallel bar using the upper limbs. The user then moves the affects/involved lower limb (freely without bearing weight, i.e., NWB) forward and finally moves his/her body (weight), by propelling himself/herself forward (hopping) using the upper limbs to complete the cycle. The user is made to repeat this cycle in order to continue to move forward.

#### 4.8 Touch-down weight bearing (TDWB)

The user slides the upper limbs on the horizontal bars forward to an arm's length distance, with the body weight borne on unaffected lower limb while allowing the foot or toes of the affected lower limb to touch the ground without bearing any weight. Then the user put body weight on the parallel bar using the upper limbs and moves himself/herself forward, completing the cycle. This way the user finally moves forward. The user is made to repeat this cycle in order to continue to move forward.

#### 4.9 Partial weight bearing (PWB)

The user slides the upper limbs on the horizontal bars forward to an arm's length distance. Then the user puts weight on the parallel bar using the upper limbs and moves the affected/involved lower limb forward (bearing less than 50% of body weight on the affected/involved lower limb). And the other 50% body weight is shared between unaffected lower limb and the horizontal bars. The user finally moves forward to complete the cycle. The user is made to repeat this cycle in order to continue to move forward.

#### 4.10 Weight bearing as tolerated (WBT)

While standing and sharing the body weight on the unaffected lower limb and the horizontal bars, the user slides the upper limbs on the horizontal bars forward to an arm's length distance. Then the user moves forward by taking the affected/involved lower limb forward, bearing body weight that the lower limb can tolerate on the affected/involved lower limb, and finally moves the weight bearing lower limb. This cycle is then repeated. User can learn normal walking by putting one leg ahead of the other during ambulation.

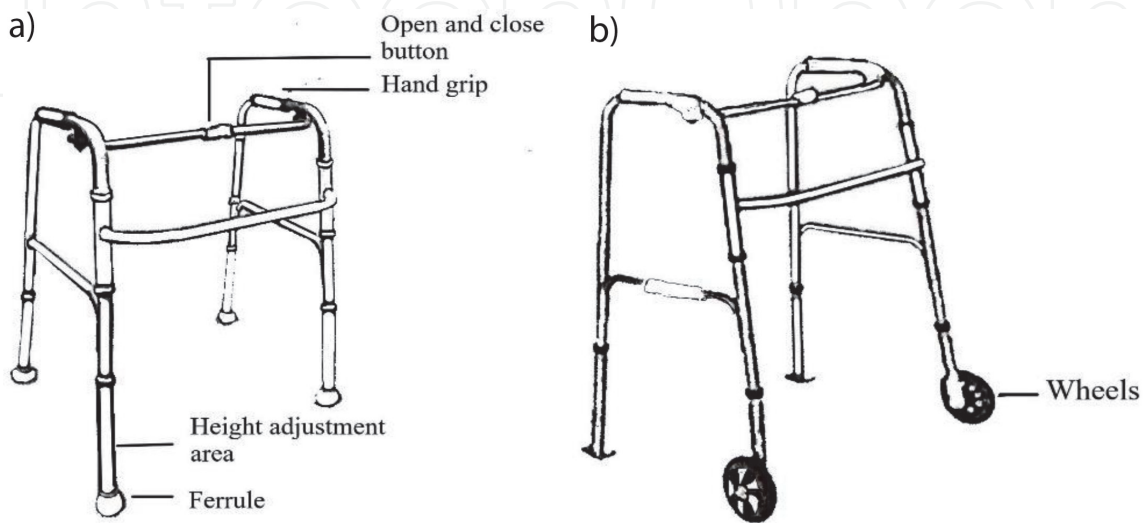
#### 4.11 Full weight bearing (FWB)

The user slides the upper limbs on the horizontal bars forward to an arm's length distance. Then the user hold the parallel bar using the upper limbs and moves the affected/involved lower limb forward (bearing full body weight on the lower limb) and finally moves the weight bearing lower limb forward (same or different level as the FWB lower limb). Then cycle is then repeated.

### 5. Walker

#### 5.1 Description and components

Walker is also known as walking frame or called zimmer frame. It is a modified and mobile version of the parallel bar (**Figure 7**). It is a medical ambulatory device



**Figure 7.**  
*Two types of walkers (walking frame); (a) with four rubber ferrules and (b) two rubber ferrules behind and two wheel rollers in front.*

with about four legs or less in which the user holds the handle bars at wrist height and place the device in front during movement (**Figure 7**). It has horizontal bars on vertical posts for adjustment and folding. It has a permanent hand grip and rubber ferrules. The horizontal bars are about 18 inches apart to fit the body of the user while the height can be adjusted by the vertical posts. Adult walker height is between 32 and 37 inches (81–92 cm). Pediatric walkers are also available with adjustable height [16].

The parts that formed the walker include handgrip, ferrule (or wheels), open and close button (for folding or collapsing the walker), push buttons (for adjustment of the height of the walker). The horizontal bars and vertical posts are made of different materials such as wood, hard plastic, stainless steel, aluminum steel and iron. The material used to manufacture the walker determines the weight, durability, cost, strength, comfort and safety.

## 5.2 Advantages of walker

1. It is good for users with poor balance and coordination.
2. It can be used to decrease weight bearing to both lower extremities.
3. It is the best to prescribe to the elderly.
4. It is the best to prescribe to the obese.
5. It is the best to prescribe to for long distance without getting fatigue in user that lack endurance.
6. It can be used to train endurance.

## 5.3 Disadvantages of walker

1. It cannot be used in crowded environment or cluttered setting.
2. It cannot be used for stair climbing.
3. It is not appropriate for rough terrain.

## 5.4 Types of walkers

*Standard walker*: has four legs with ferrule (no mobile base) (**Figure 7A**). The user requires strength and grip power to lift the entire frame forward during ambulation.

*Wheeled walker*: the design is similar to the standard walker but the ferrules are replaced by wheels (**Figure 7B**). The number of wheels depends on the strength and stability of the user. The user only needs strength tilt the ambulatory device move forward. The wheeled walker can be 2-wheeled walker or 4-wheeled walker. Some design can come in with three legs instead of four and the three legs will be wheeled. Some walkers are design with hand brake for stability. The wheeled walker is better than the standard walker because the user require less energy to move the device forward. However, it is better prescribed for stable users, who can control the walker reasonably. Another disadvantage of 2-wheeled and standard walker is that they cannot be swivel by user when turning, they need to be carried but the 4-wheeled walker and 3-wheeled walker can be swivel. There are two different

folding styles for walkers. The folding help for easy transportation and storage of the device

1. Hinged front legs: the folding mechanism is activated by pulling a ball mounted on a piece of string. When the ball is pulled towards the user, the brace bar situated around the bottom of the frame slides up. At the same time the front section moves inwards until the front and back legs meet. This mechanism offers the user the choice of reducing the size of the walker.
2. Side folding frame: the locking motion on the walker is activated by the user pressing on the close and open button on the front horizontal bar of the frame. This therefore allows each side to be folded in to meet the front section. Once fully retracted, this type of frame becomes completely flat and more space efficient.

*Other forms of walkers are:*

*Forearm walker:* this type of walker is basically the same as the standard walking frame but with forearm support rather than handgrips. This allows the user to transfer their weight through their forearms rather than their hands. This is particularly helpful to those who have arthritic hands and find gripping the frame challenging.

*Reciprocal walker:* a reciprocal walker operates with a pivot mechanism for each side. This provides the user with the option of lifting the frame up and moving around one step at a time. Many users prefer this movement as it is more intuitive to how one naturally walks. However, consideration needs to be given to how much weight is being placed on one side of the body, specifically arms. It is advisable to consult a physiotherapist or other health practitioner about the suitability of this frame.

## 5.5 Fitting a walker

Walkers are usually adjustable; the height of the walker is adjusted to fit the user. The adjustment is estimated base on the user's height. The height of the walker should be at the level of the greater trochanter of the user and the elbow joint should be able to flex to about 20 or 30 degrees when user hold the hand grip of the frame in an upright position. Immediately the user stand and the horizontal bars are too short or too tall for the user the user is allow to sit and the horizontal bars are adjusted to fit the user height.

## 5.6 Safety and precautionary measures when using a walker

Prior to ambulation using a walker, the following safety and precautions should be checked.

- The stability of the walker should be checked. All the vertical posts (limbs) of the walker should touch the floor.
- The open and close button should be in open position.
- All the push button should be visible and same level.
- The ferrules or wheels are not loose or worn out.



- The handgrips are attached sturdily and not move when pressure is applied.
- No component should be found loosen in the walker.
- There should be no dents, cracks or any irregularities on the walker.

### 5.7 Instruction on how to use a walker

The following instructions should be given to the user before use:

- User should maintain good posture (hyper flexion of the head, neck and trunk should be avoided).
- User should avoid moving too close to the front horizontal bars.
- User should avoid staying too far away from the walker.
- Users should not use walker for stair climbing.

### 5.8 Weight bearing status used with walkers

The following weight bearing status can be used with walkers: non-weight bearing (NWB), touch down weight bearing (TDWB), partial weight bearing (PWB), weight bearing as tolerated (WBT), full weight bearing (FWB).

The user first need to learn how to stand using the walker. The user uses one of the upper limb to hold the walker (for stability and balance) and the other upper limb to assist in standing (pushing on the seat). Clinicians can assist the user into standing position from sitting by assisting the user from the axilla region. Immediately the user is almost standing user change the position of the upper limb that was on the seat to the walker. User stands upright within the walker, adjusting the upper limb and lower limb till the user is balance. User will sit by following the opposite procedure of standing. User first make sure the lower limbs are touching the seat then use one upper limb to hold the seat and user gradually sit on the seat and remove the other upper limb to adjust the position on the chair.

### 5.9 Non-weight bearing (NWB)

The user moves the walker forward to about an arm's length distance, with the weight of the body is on the unaffected/involved lower limb (i.e., weight bearing lower limb) and the affected lower limb is not touching the ground. Then the user put his/her weight on the walker using the upper limbs and moves the affected/involved (i.e., NWB lower limb) forward towards the walker and finally moves the weight bearing lower limb towards the walker (to the same level as the NWB lower limb). Then cycle is then repeated.

### 5.10 touch down weight bearing (TDWB)

The user moves the walker forward to an arm's length distance, with weight of the body is on unaffected lower limb and the affected lower limb foot or toes is touching the ground but not bearing weight. Then the user put the weight on the walker using the upper limbs and moves the affected/involved lower limb (i.e., TDWB lower limb) forward towards the walker (the foot or toes touching the ground but not bearing

weight) and finally moves the weight bearing lower limb towards the walker (to the same level as the TDWB lower limb). The cycle is then repeated.

### 5.11 Partial weight bearing (PWB)

The user moves the walker forward to an arm's length distance. Then the user put the weight on the walker using the upper limbs and moves the affected/involved (i.e., PWB) lower limb forward towards the walker, bearing less than 50% of body weight on the PWB lower limb and finally moves the weight bearing lower limb towards the walker (to the same level as the PWB lower limb). The cycle is then repeated.

### 5.12 Weight bearing as tolerated (WBT)

The user moves the walker forward to an arm's length distance. Then the user put the weight on the walker using the upper limbs and moves the affected/involved (i.e., WBT) lower limb forward towards the walker, bearing body weight that the lower limb can tolerate on the WBT lower limb. The user finally moves the weight bearing lower limb towards the walker (to the same level as the WBT lower limb). The cycle is then repeated.

### 5.13 Full weight bearing (FWB)

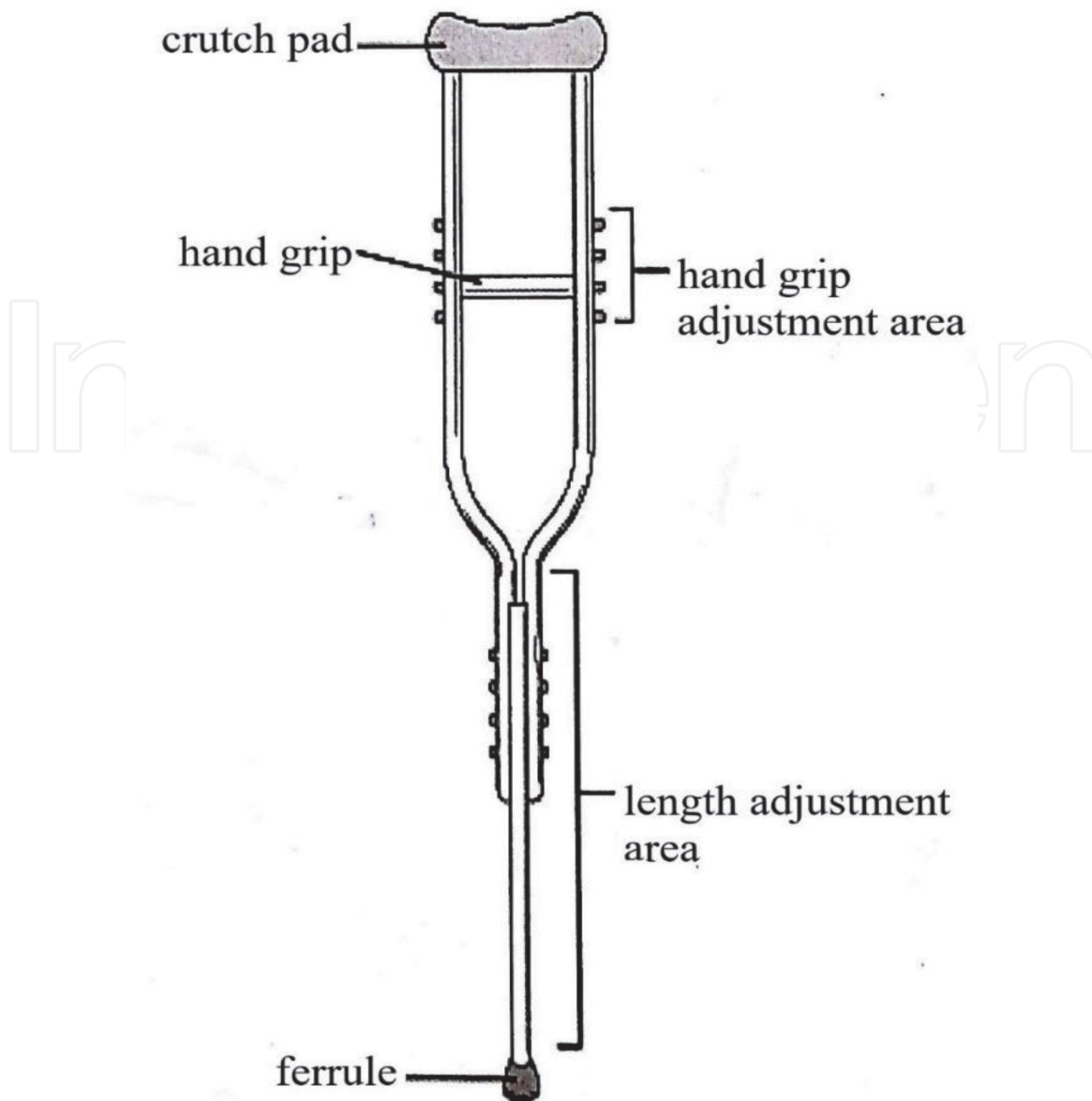
The user moves the walker forward to an arm's length distance. Then the user put the weight on the walker using the upper limbs and moves the affected/involved (i.e., FWB) lower limb forward towards the walker (bearing total of body weight on the FWB lower limb) while moving the unaffected lower limb, i.e., the weight bearing lower limb towards the walker (to the same level as the FWB lower limb). Then cycle is then repeated.

## 6. Crutches

Crutches are the most common prescribed ambulatory devices. They are used in pair. Crutches have two contacts with the body (hand and elbow or hand and axilla) which make it a better ambulatory device for stabilization of the user. They are types of orthosis that provide support from the floor to the upper limb. There are two different types of crutches: axillary crutch and elbow crutch [16].

*Axillary crutch:* this is also known as the standard crutch. It has the following components: axillary bar covered with an axillary pad, a hand grip, and double uprights vertical posts joined distally by a single vertical post (allow height adjustment) covered with a ferrule (**Figure 8**). The adjustment of the handgrip is performed by adjusting the handgrip in predrilled holes in the double upright bars using screws and wing bolts. The vertical posts and short horizontal bars are made of different materials such as wood, hard plastic, stainless steel, aluminum steel and iron.

Adjustment of height of the axillary crutch and the handgrip is standardized in an inch distance (2.54 cm). Adult axillary crutch range from 48 to 60 inches (122–153 cm). It is available in Pediatric, youth, adult and tall adult sizes (**Figure 10** and **Table 1**).



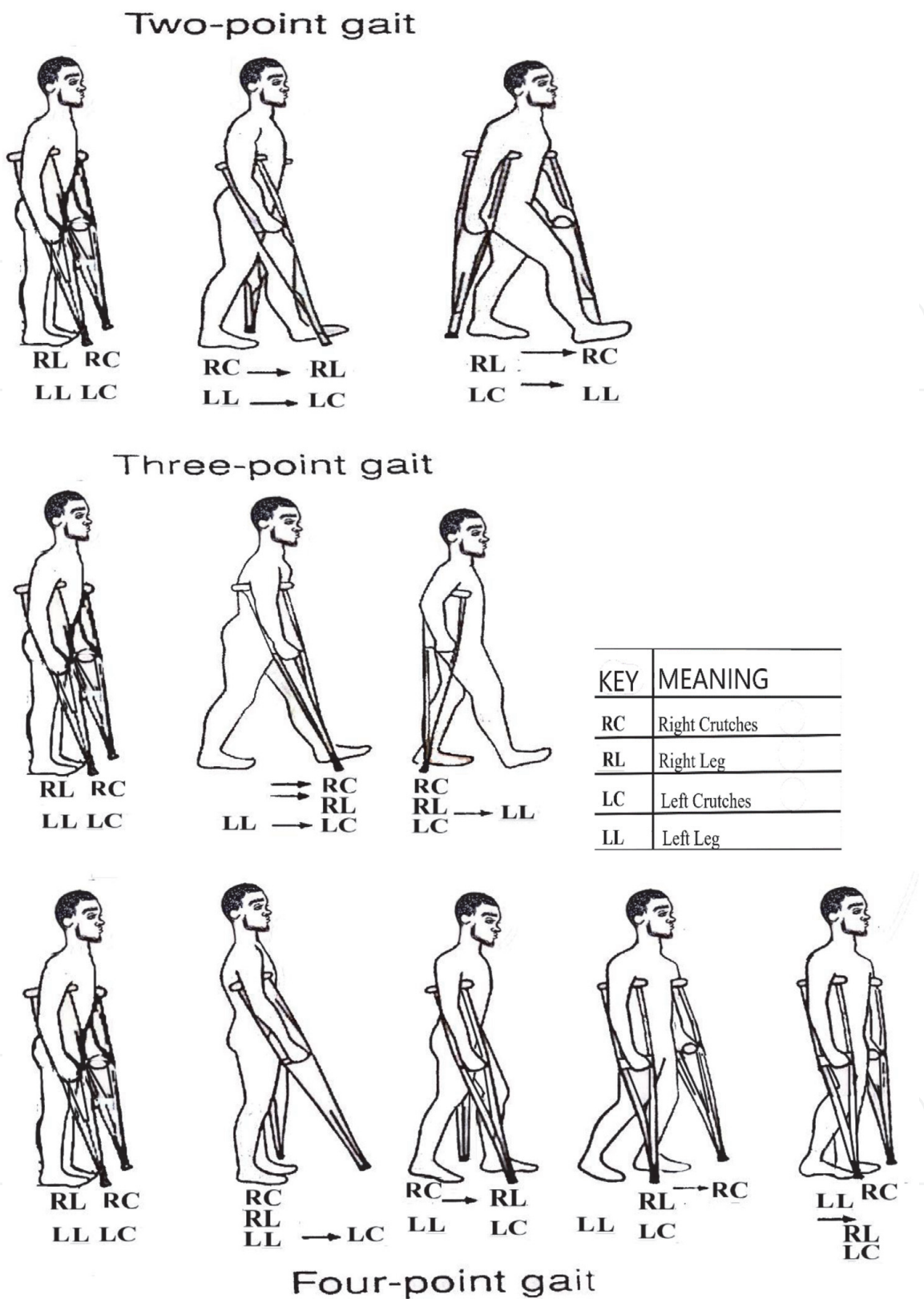
**Figure 8.**  
*Axillary crutch and its features.*

### 6.1 Advantages

1. It is used to reduce weight bearing on one lower limb.
2. It is used to improve balance.
3. It is used to improve lateral stability.
4. It can be used for stair climbing.

### 6.2 Disadvantages

1. It need upper limb strength and coordination.
2. It need some trunk support.
3. It need good trunk stability.

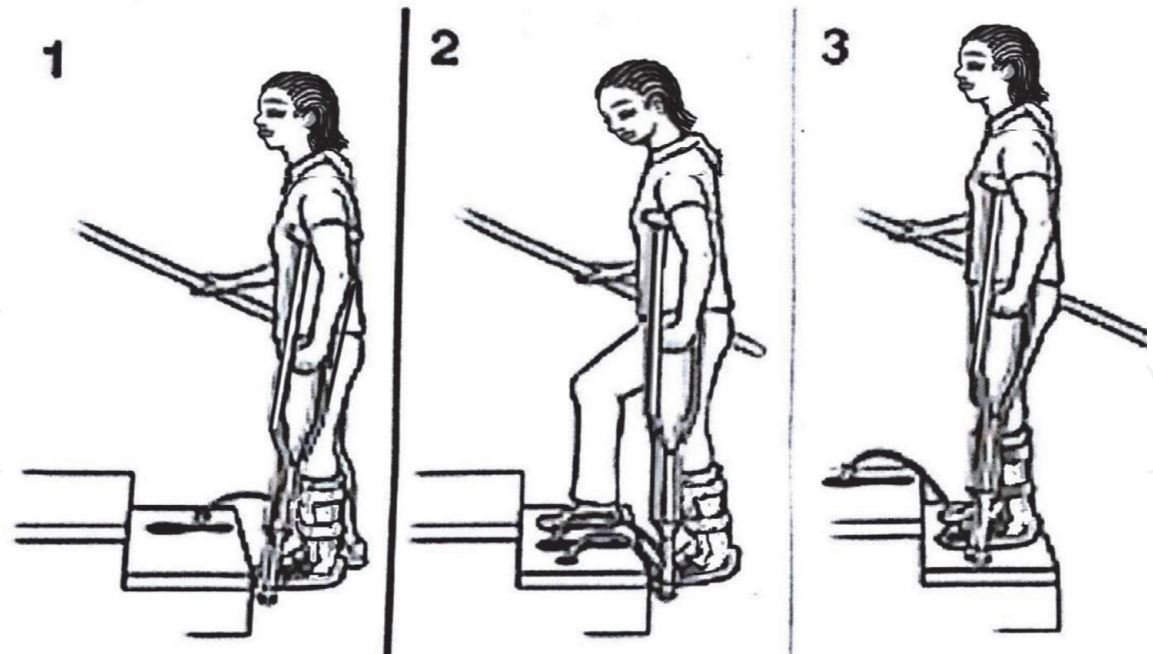


**Figure 9.**  
*Diagram of different axillary crutch walking.*

### 6.3 Measurement for axillary crutches

There are several techniques of estimating and predicting axillary crutch length for users. The following techniques can be used: foot-head linear techniques, arm span techniques and foot-anterior axillary fold linear techniques [1, 2, 4, 5, 32].





**Figure 10.**  
*Crutch placement (to support the affected limb) during stair case climbing using axillary crutches.*

Axillary crutch	Height range
Pediatric	4'0"–4'6"
Youth	4'6"–5'2"
Adult	5'2"–5'10"
Tall adult	5'10"–6'6"

**Table 1.**  
*Available standard crutch length.*

**6.4 Foot-head linear techniques**

- 77% of height of user is estimated to predict axillary crutch length.
- 75% of height of user is estimated to predict axillary crutch length.
- Height of user minus 16 inches (40.6 cm) is estimated to predict axillary crutch length.
- 77% of height of user plus footwear (2.54 cm) is estimated to predict axillary crutch length.
- 75% of height of user plus footwear (2.54 cm) is estimated to predict axillary crutch length.
- Height of user with FW minus 16 inches (40.6 cm) is estimated to predict axillary crutch length.

**6.5 Arm-span techniques**

- 77% of arm span of user is estimated to predict axillary crutch length.

- 75% of arm span of user is estimated to predict axillary crutch length.
- Arm span minus 16 inches (40.6 cm) of user is estimated to predict axillary crutch length.
- Olecranon to Middle Finger of other hand of user is estimated to predict axillary crutch length.

6.6 Foot-anterior axillary fold linear techniques

- Anterior axillary fold to heel of foot of user is estimated to predict axillary crutch length.
- AAF to heel of footwear (2.54 cm) of user is estimated to predict axillary crutch length.
- AAF to 15.2 cm lateral to heel of user is estimated to predict axillary crutch length.
- AAF to 15.2 cm lateral to footwear (2.54 cm) of user is estimated to predict axillary crutch length (Table 2).

	Correlation coefficient		
	<i>r</i>	<i>r</i> <sup>2</sup>	<i>P</i>
Ideal ACL			
77% of height	0.951	0.904	0.00
75% of height	0.951	0.904	0.00
Height, 40.6 cm	0.951	0.904	0.00
77% of height + FW	0.951	0.904	0.00
75% of height + FW	0.951	0.904	0.00
Height + FW, 40.6 cm	0.951	0.904	0.00
77% of arm span	0.848	0.719	0.00
75% of arm span	0.848	0.719	0.00
Arm span, 40.6 cm	0.848	0.719	0.00
Olecranon to MF of other hand	0.835	0.697	0.00
AAF to heel of foot	0.967	0.935	0.00
AAF to heel of FW	0.967	0.935	0.00
AAF to 15.2 cm lateral to heel	0.967	0.935	0.00
AAF to 15.2 cm lateral to FW	0.968	0.937	0.00
ACL, axillary crutch length; FW, footwear; MF, middle finger; AAF, anterior axillary fold.			

Table 2.  
Prediction of axillary crutch length (courtesy [32]).

Elbow crutch	Height range
Youth	4'5"-5'5"
Adult	5'3"-6'2"

**Table 3.**  
*Available elbow crutch length.*

The measurement of ideal axillary crutch length is measured in standing position. Potential user assumes a relax position (posture), measurement of a distance of 1.5–2 inches (3.8–5.1 cm) is made below the anterior axillary fold of the shoulder to a point 4–6 inches (10.2–15.2 cm) anterior and lateral to fifth toe of the ipsilateral limb.

*Elbow crutch:* this is also known as Lofstrand and Canadian crutch. It has the following components a single fore arm cuff (vinyl-coated, leather, plastic or rubber), a hand grip, and a single uprights vertical post (allow height adjustment) covered with a ferrule distally. The adjustment of the handgrip and upright bar are by using push button mechanism. The vertical bar is made of different materials such as wood, hard plastic, stainless steel, aluminum steel and iron.

Adjustment of height of the elbow crutch and the handgrip is standardized in an inch distance (2.54 cm). Adult elbow crutch range from 29 to 35 inches (74–89 cm). Only available in youth and adult range (**Table 3**).

**6.7 Advantages**

- 1. It is used to reduce weight bearing on one lower limb.
- 2. It is used to improve balance.
- 3. It is used to improve lateral stability.
- 4. It can be used for stair climbing.

**6.8 Disadvantages**

- 1. It need upper limb strength and coordination.
- 2. It need some trunk support.
- 3. It need good trunk stability.

**6.9 Measurement for elbow crutches**

The best position to estimate elbow crutches length is standing position. The measurement is from the tip of the elbow crutch at 4–6 inches (10.2–15.2 cm) anterior and lateral to fifth toe of the ipsilateral limb to the greater trochanter. The elbow crutches hand grip can be adjusted to allow elbow flexion of 20–30°. The forearm cuff is adjusted and positioned close to the elbow joint distally (proximal one third of the forearm).

**6.10 Ambulation with crutches**

The walking style a user of crutch will adopt is dependent on the medical condition, trunk control, balance, coordination, muscle strength, endurance, weight

bearing status, functional capacity and learning ability. Prior to ambulation using crutches, the following safety and precautions should be checked:

- All the push button should be made visible and at same level.
- The ferrules should not be loose or worn out.
- The handgrips should be attached sturdily and not move when pressure applied.
- None of the component in the crutch should be loose.
- There should be no dents, cracks or any irregularities on the crutch.

The following instructions should be given to the users before usage:

- Users should maintain good posture (hyper flexion of the head, neck and trunk should be avoided).
- Users should avoid resting (i.e., bearing body weight) on the axillary pad.
- Users should avoid moving the crutches too far away during ambulation. The distance the crutch should be move should be within arm length.
- Axillary pads should be close to chest wall to improve lateral stability.
- Users should avoid pivoting when turning around, rather short circle movement should be used.

The following weight bearing status can be used with walkers: non-weight bearing (NWB), touch down weight bearing (TDWB), partial weight bearing (PWB), weight bearing as tolerated (WBT), full weight bearing (FWB) (**Table 4**).

Progression of axillary crutch walking is from non-weight bearing to partial weight bearing. Three-point gait first followed by four-point gait then two-point gait (**Figure 11**).

### **6.11 Standing from lying position with crutches**

When in bed, the user first moves to a sitting position and maintain balance. The user then inches forward to the edge of the bed or the chair (users can also first transfer to an armless chair). The user picks up the crutches with upper limb of the affected side. Both axillary crutches are then placed upright and same side of the injured side. Using the armrest of the chair and the crutches handgrips as support, the user slowly moves the injured leg forward, moving out of the chair and rising up on the uninjured leg and the crutches. The user then position the crutches properly and then balances up in preparation to move, using any of the available weight bearing status that can be accommodated based on the user's condition.

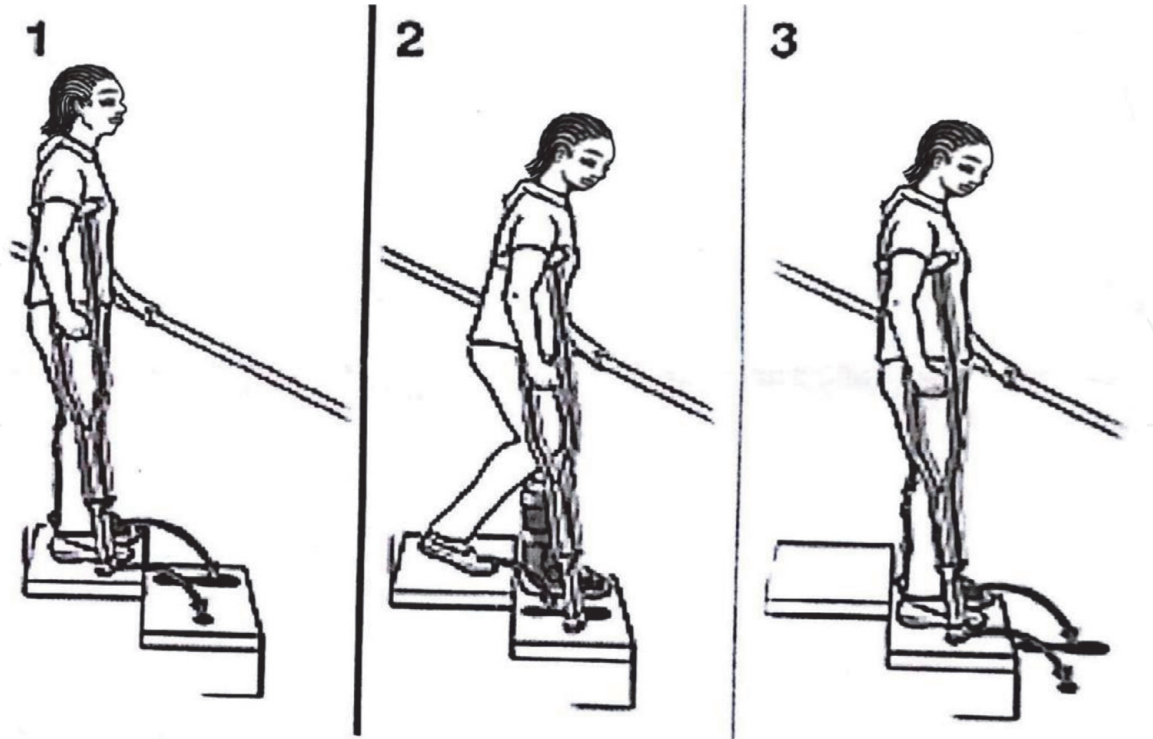
### **6.12 Sitting with crutches**

On getting to the chair, the user is instructed to turn and back up against the chair, moving backward until the back of the legs touches the chair. While bearing weight on the uninjured leg, and the crutches on either side of the user, the injured



	Non-weight bearing (NWB) and touch down weight bearing (TDWB)	Partial weight bearing (PWB), weight bearing as tolerated (WBT) and full weight bearing (FWB)	
	Three point axillary crutch gait	Four point axillary crutch gait	Two point axillary crutch gait
Pattern sequence	First move both axillary crutches forward and then weaker lower limb forward. Then bear all the weight down through the axillary crutches, and move the stronger or unaffected lower limb forward ( <b>Figure 9</b> )	Left axillary crutch, then right foot, followed by right axillary crutch, and then left foot ( <b>Figure 9</b> )	Left axillary crutch and right foot together, then the right axillary crutch and left foot together ( <b>Figure 9</b> )
Advantage	Eliminates all weight bearing on the affected leg	Provides excellent stability as there are always three points in contact with the ground	Faster than the four point gait
Disadvantage	Good balance and coordination is required	Slow walking speed and difficult to learn	Can be difficult to learn the pattern
Progression	As the user becomes confident he may progress from a swing to gait to a swing through gait, where the unaffected leg is placed ahead of the crutches		

**Table 4.**  
*Ambulation with crutches [19].*



**Figure 11.**  
*Crutch placement (to support the affected limb) when descending stair case using axillary crutches.*

leg is advanced slightly forward. Both crutches are rolled out of the axilla and held by the hand grip. Then, the crutches on the unaffected side is then moved across and on the outer border of the crutch on the affected side, such that both crutches

are placed side by side on the injured side, and held at the hand grips. The user holds both handgrips together with the hand of the affected side and reaches back for the armrest of the chair with the other hand. Using the armrest of the chair and the crutch handgrips as support, the user slowly moves the injured leg forward and lowers himself into the chair. The axillary crutches are placed nearby. Standing them on the axillary pads, when possible, makes it less likely that they will tip over and fall away from the user.

### **6.13 Climbing upstairs with crutches**

Climbing stairs with axillary crutches requires strength and flexibility. If the user is unsure of his strength, he should be instructed to turn around and sit on the stairs and scoot himself up one stair at a time using his uninjured leg to propel himself.

Where strength is available, the user is instructed to keep the axillary crutches in one hand and bring them up with him/her. When climbing stairs with axillary crutches, the user leads with the uninjured leg and brings the injured leg and axillary crutches up behind him (**Figure 10**). If the stairway has a handrail, the user should place both axillary crutches under the arm opposite the handrail and grip the handgrips together in one hand. The user places his weight on the handrail and the handgrips, leans slightly forward, and brings his uninjured leg up one step. He then brings the axillary crutches and the injured leg up the step and advances his hand up the handrail. Once the user has regained his balance, the process is repeated. The user should be instructed to take his time and rest halfway up the stairs if necessary. To climb stairs with no handrail, the user leans slightly forward and puts his weight on the handgrips of the axillary crutches. The user moves the uninjured leg up the step. He then shifts his weight to the uninjured leg and brings the axillary crutches and injured leg up the step. His foot and axillary crutch tips are kept in the middle of the step, away from the edge to avoid slipping. The user is instructed to take his time, rest as needed, and ask for help if necessary. Going up the stairs with axillary crutches stay with the affected leg behind and the uninjured leg goes up first.

Note that someone should always be at the back of the user learning to climb the stair with axillary crutches.

### **6.14 Going down stairs with crutches**

Going down stairs with axillary crutches also requires strength and flexibility. If the user is unsure of his/her strength, he should sit down and scoot down the stairs one at a time, bracing himself with the unaffected leg. The user should keep the axillary crutches in one hand and take it along on the way down.

When going down stairs with axillary crutches, the user should lead with the affected/involved lower limb and the axillary crutches (the unaffected limb carries the whole body at this period) and then bring the unaffected lower limb down from behind (**Figure 11**) and then bring the unaffected lower limb down behind.

If the stairway has a handrail, the user should hold both axillary crutches at the hand grips and opposite the hand on the handrail. With the user's weight on the unaffected/uninvolved lower limb, the user moves the axillary crutches and the affected/involved lower limb down the stairs; with the user bearing weight on the handrail and the handgrips of the crutches and brings the unaffected/uninvolved lower limb down the stairs. The user should take time to regain balance. The process is repeated as the user moves forward. The users are given a prior instruction that they can rest when the need arises as they move down the stairs.

To go down the stairs with no handrail, the user bearing weight on the unaffected/uninvolved lower limb and the handgrips of the axillary crutches, moves the axillary crutches and the affected/involved lower limb forward down the stairs. The user keeps the foot and the tips of the axillary crutch at the middle of the step, away from the edge to avoid slipping. Are given a prior instruction that they can rest when the need arises as they move down the stairs. For safety reasons, someone (i.e., therapist) can walk in front of the users as they move down the stairs. This person can assist the user into a sitting position if users become fatigued. Going down the stairs with axillary crutches stay with the affected leg behind.

## 7. Cane

### 7.1 Description and components

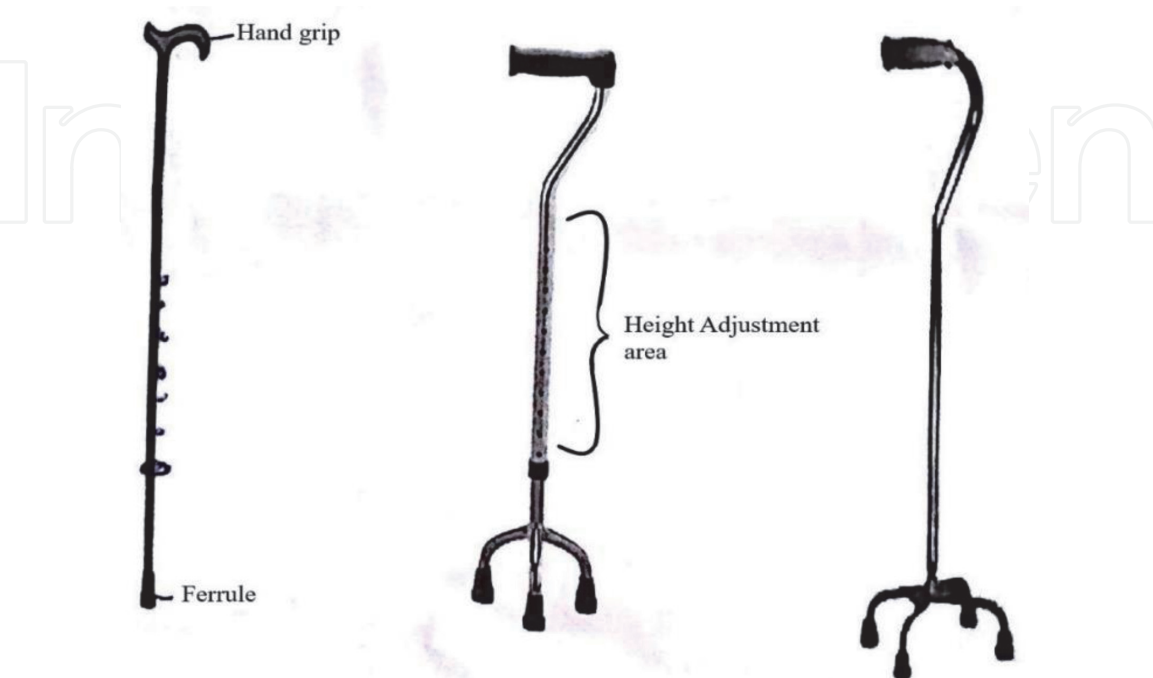
Cane is also known as walking stick. It is a horizontal bar with a crook or T shape hand grip at one end and the tip (tips) covered by ferrule at the other end (**Figure 12**). The vertical bar is adjustable to fit the user. The vertical bar is made of different materials such as wood, acrylic, stainless steel, aluminum and iron. Most canes are usually between 25 and 40 inches long. Cane is typically used when minimal stability is needed and can support up to 25% of a user's weight [16].

### 7.2 Types

*Standard cane:* this is a single point straight cane with a crook or T-shaped handle.

*Offset cane:* this is similar to the standard cane but the proximal component of the horizontal shaft is offset anteriorly thereby creating a straight offset handle.

*Quadripod:* this is also similar to the standard cane, it however has a broad base of support with four point of support for floor contact. Others can come in form of a tripod.



**Figure 12.**  
*Illustration of different types of cane—single point and multiple points.*

*Hemi cane*: this also has four point of support for floor contact but the legs are angled from the shaft to increase stability of the cane.

### 7.3 Advantages

1. Cane is inexpensive.
2. Fit easily on every environment including stairs.
3. Use more for support than weight bearing.

### 7.4 Disadvantages

1. Not a good weight bearing ambulatory device.
2. Cannot be used by fearful user.

### 7.5 Fitting of cane for ambulation

The ideal cane measurement is obtained by placing the centre of the cane base at 6 inches lateral and anterior to the border of the fifth toe. Then the proximal part



**Figure 13.**  
*Standing using the cane (full weight bearing).*



(hand grip) at the level of the greater trochanter when the user is in an upright position. The user should have about 20–30° flexion of the elbow at this position (**Figure 13**).

## 7.6 Instruction on use of cans

It is usually advised to have the cane at the contralateral limb (i.e., opposite hemisphere of the user for additional confidence). The user can perform 3-point or 2-point gait pattern with a cane:

*3-point gait:* the user first move the cane forward followed by the contralateral limb and finally the ipsilateral limb.

*2-point gait:* the user moves the cane and the contralateral limb together forward then the ipsilateral limb.

## 7.7 Maintenance of cane as an ambulatory device

1. The screw bolts and nut wings of the ambulatory device should be checked daily to be sure they are securely tightened.
2. Ferrules and wheels that become worn or tear should be replaced as the need arises.
3. Rubber handgrips that are torn or worn should be replaced promptly to prevent blisters on the hands or slipping of the hands.
4. Worn or torn rubber padding should be replaced to prevent pressure injuries.

## 7.8 Precautions when ambulating with ambulatory device

The following precautions are to be noted when ambulating with an ambulatory devices:

1. Items that may cause the user to trip and fall, such as scatter rugs or extension cords, should be removed.
2. Spilled liquids should be wiped up to avoid slipping.
3. Items the user needs with him can be carried in a fanny pack, apron with pockets, or knapsack to keep hands free to grip the ambulatory device.
4. A non-skid bath mat should be used in the shower or tub for users of ambulatory devices.
5. A tennis shoe or other flat, rubber-soled shoe should be worn on the user's uninjured foot to avoid slipping.
6. The user should be careful when going through doorways to be sure that the door does not shut on the ambulatory devices. The user should seek help to hold the door if necessary.
7. The user should avoid walking through water or on icy surfaces with an ambulatory devices.

## **7.9 Rules for safety and comfort when using ambulatory devices**

The clinician needs to observe and check the followings:

1. Before issuing an ambulatory device the clinician should check that the ferrules (rubber tips) and wheels are not worn to the point where no tread is showing or not align. The ferrules and wheels are to act as friction and if they are worn out there is minimal friction and this is a potential risk factor for fall.
2. Ambulatory devices support areas are properly padded. This is important to avoid damage to soft tissues and provide comfort to the user.
3. Ambulatory devices pair is a matching pair. Clinician should not issue a mismatched pair. Uneven ambulatory device will lead to poor posture which can result into musculoskeletal disorder.
4. Ambulatory devices are not cracked, warped or damaged to prevent break of the ambulatory device and also prevent fall.
5. Ambulatory devices nuts and bolts are tight. This is important to avoid fall when the device is in use.

Users need to take note of the following rules:

1. User should not look down but always look straight ahead. This helps the user to maintain a good posture and prevent musculoskeletal disorders.
2. User should not use ambulatory devices when feeling dizzy or drowsy to prevent fall.
3. User should not walk on slippery surfaces to prevent fall.
4. User should avoid snowy, icy, or rainy conditions.
5. User should not put any weight on the affected foot if not advised.
6. User should make sure the ferrules (rubber tips) and wheels are present in ambulatory devices.
7. User should wear well-fitting, low-heel footwear.

## **8. Conclusion**

Ambulatory devices are safe and promote users ability to function in activities of daily living when the right ambulatory device is prescribed and accurate measurements of users obtained prior to usage. It also reduces the burden of care and burden on caregivers. Trial and error method of prescribing and assessment should be avoided to prevent injury to the users.

Safety precautions should be observed by users and clinicians should always educate users on guidelines in ambulating with the devices and care of the devices.

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### **Author details**

Daniel Olufemi Odebiyi\* and Caleb Adewumi Adeagbo  
Department of Physiotherapy, College of Medicine of the University of Lagos,  
Lagos, Nigeria

\*Address all correspondence to: femiodebiyi@yahoo.com

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