Analysis of Method of Axillary Crutch Measurement

Augustine Amaeze Amaeze[1], Ngozi F. Amaeze[2], Emmanuel Ifeanyi Obeagu[3,4*],
Charles I. Ezema[5], Chukwudi Uchenna Onwudiwe[6], Clementina N. Eze[7]
and Chukwuenyegom Joseph Egbumike[1]

[1]*Department of Physiotherapy, Evangel University, Akaeze, Ebonyi State, Nigeria.*
[2]*Department of Public Health Education, Faculty of Education, Gregory University, Uturu, Abia State,*
Nigeria.
[3]*Department of Medical Laboratory Science, Imo State University, Owerri, Imo State, Nigeria.*
[4]*Department of Medical Laboratory Science, Evangel University, Akaeze, Ebonyi State, Nigeria.*
[5]*Department of Medical Rehabilitation, College of Medicine, University of Nigeria, Enugu Campus,*
Enugu State, Nigeria.
[6]*Physiotherapy, Alex Ekwueme Federal University Teaching Hospital, Abakaliki, Ebonyi State,*
Nigeria.
[7]*School of Basic Midwifery, Alex Ekwueme Federal University Teaching Hospital, Abakaliki, Ebonyi*
State, Nigeria.

Authors' contributions

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ABSTRACT

The purpose of this study was to determine which of the 3 methods axillary measurement best predict ideal crutch length. Ideal crutch length is defined as the length of the crutch, including accessories, obtained during stance when the crutch tip is 15.2cm lateral and 15.2cm anterior to fifth toe and the axillary pad is 6.4cm below the axillary fold. Two hundred and twenty-four (224) volunteers were measured for crutches using each of the following methods: 77% of actual height;

Corresponding author: E-mail: emmanuelobeagu@yahoo.com;

actual height minus 40.6cm and anterior axillary fold to heel in supine position with arm adducted. The result of the calculation were statistically significant (p<0.01). However, 77% of actual height and actual height minus 40.6cm had the strongest relationship to the ideal crutch length r (person Product Moment Correlation Coefficient) = 0.941; r^2 (linear regression correlation coefficient) = 0.89; p<0.01. Axillary fold heel method had r =0.917: r^2= 0.84; P<0.01.

Keywords: Method; axillary crutch; measurement.

1. INTRODUCTION

Crutches, in one form or another, have been used for 5,000 years (Epstein, 1937). From the fallen tree branches used to assist balance and ambulation, they have evolved into their present configurations of underarm and forearm crutches. The materials have changed but the overall design of the crutch is largely the same. They are basically sticks with hand and underarm or forearm supports [1].

Crutches are wooden or metal objects used to support the body. These should be adjustable both in handgrip to ground length and in axilla to hand grip [2]. Axillary crutches possess axillary pads, hand pieces and crutch tips with rubber ferrule. Crutches are used when normal walking is compromised by mechanical or neurological disability and the lower limbs are incapable of withstanding the issued on a short-term basis to overcome temporary immobility resulting from trauma, but some are prescribed long term for those with lasting disability. The use of crutches to assist walking is not a new concept as studies of Egyptain tombs (2830 BC) have shown single-strutted crutches not dissimilar from current designs (Hall and Clarke, 1991.). The design of crutches and walking sticks to assist the disabled has not varied much since their original conception, some 500 years ago. From an engineering viewpoint, one must consider crutches and walking sticks as dynamic mechanical system which alleviate a disability; they may act as support, help the user to recover from feet from ground, an action not provided by artificial ankle joint (Nava and Laura 1985) Current crutch designs present some problems for user:

➢ High-energy expenditure [3]: It takes about twice as muchenergy to ambulate with swing-through crutch gait as it does for normal ambulation. This is due both to the upper body's reaction to both to upper body's reaction to the shock of impact and to the vertical movement needed to clear the feet in swing phase by users wearing knee-ankle-footorthoses with locked knees. The user essentially is doing a body push-up with every step.

➢ Injuries caused by repetitive loads on the hands, wrists and arms during ambulation [4], (Malkan, 1992) [5,6]. These injuries affect many users and are simply stress injuries to the upper limb caused by constant use of crutches. If users have arthritis or other condition affecting condition affecting the upper limb, then the effect is compound.

➢ Problems created by not standing and walking [7]; (Axelson, Gurski and Lesko-Harvill, 1987) [8]. If people do not use crutches because they tire easily or acquire hand/arm problems, there are possible consequences. There are many reasons physiological and psychological- why it is good to stand and walk rather than sit and use wheeled mobility. These reasons include improved bone growth, improved blood circulation, reduced bladder infection, reduced pressure sores and prevention of contractures.

Just as the sportsman must practice to acquire skill in using the tennis racquet, goof club or skis, so the disabled person must acquire skill in his wooden or metal crutches. The ability to use crutches efficiently requires systematic programmes with competent instruction. This programme should include:

1. The proper selection of the crutches and correct measurement.
2. A muscle test to judge the subjects joint movement and strength.
3. Exercise to develop the muscle groups needed for crutch management.
4. Determine of the crutch gaits must best suited to meet the patient's need [9].

The axillary crutch is commonly prescribed as an ambulatory aid to patient with temporary or permanent disability in the lower extremity. When fitting the axillary crutch, it is important that the user be instructed not to bear excessive weight

on axillary bar. Excessive weight bearing on the axillary bar can result in asevenfold increase in the reaction force under the armpit. This force may be a contributory factor to crutch paralysis or thrombosis of axillobrachial artery (Anget et al., 1989). Axillary crutches should be used when weight must be relieved from one leg and can be used to train partial weight bearing before progressing to sticks. The correct length is important as the axillary pad must not push up into the axilla but arm must be high enough to allow it to be held between the upper arm and the chest wall when weight is put on the crutch [2].

Correct crutch length is necessary to prevent injury and minimize energy expenditure during crutch ambulation. Patients may obtain crutches form physicians, pharmacists, emergency departments, Physical Therapist, Family members, friends and even garage sales. Crutch fitting is often done on a trial and error basis utilizing many different methods [1].

2. MATERIALS AND METHODS

2.1 Subjects

Two-hundred and twenty-four normal volunteer (104 male, 120 females) who were student in the college of Medicine, University of Nigeria Enugu, Student nurses, Staff nurses of the University Teaching Hospital (UNTH) Enugu workers and residents of U.N.T.H. Participated in this study. The subjects had a mean age of 26.15 years. Female students had a mean age of 26.61 years. Height ranged from 150cm-189cm. All subjects were informed to the experimental protocol beforehand, and each willingly volunteered before participating in the study. All subject had no measurable limb length discrepancies after scrutiny.

2.2 Equipment

2.2.1 Standiometer

This was a standard physical (wooden) examination scale, made locally, and calibrated in centimeter used for height measurement.

2.3 Metal Metre Rule

This was simple piece of calibrated metal rule for determining the subjects' height level while standing upright against the standiometer.

2.4 Crutches

A pair of old adjustable standard wooden axillary crutches with rubber tip and axillary padding was used for the arm-rest length and crutch fitting of all the subjects. A pair of new adjustable standard wooden axillary crutches was made out from a subject's data and their suitability was confirmed by swing-through and four-point crutch gaits. The new adjustable standard wooden axillary crutches made weighed 1 kilogramme.

2.5 Goniometer

This was a simple locally made transparent plastic with protractor and two arm (one fixed, other moveable) for the adjustment of the angle of elbow flexion to be 30^0 as subject placed his/her hands on the hand rest (arm rest) as recommended by [10].

Methods: *Axillary-crutch-length techniques*

2.6 Estimated

In this study, estimation of subjects' ideal crutch length was carried out making use of the following techniques:

1) 77% of the Actual length
2) Actual height minus 40.6cm
3) Anterior axillary fold to the heel of the foot

2.7 Procedure

During the study, the subjects were asked of their ages, and their actual heights were measured. Height was measured with the subjects barefooted.

The position for the crutch hand bar (or arm rest bar) was determined by instructing the patient to rest the elbow which flexed to 90 degrees on the hand bar. The arm length in that was taken with tape rule with patient thumb touching the bottom of the axillary support [11]. This was done in sitting position.

The subject assumed a supine position in hand and he distances from the anterior axillary fold to the heel of the foot were measured.

Finally, an ideal crutch length value of each individual in a stationary position was determined. Subjects were asked to stand with their feet a comfortable distance of 10cm apart

and their shoulders relaxed. The hand bars were adjusted when the subject was standing erect with goniometer so that the elbows are bent at an angle of 40 degrees [10].

The crutch tips were placed 15.2cm laterally and 15.2 cm anteriorly form the fifth toe using a measured template; and the top of the foam-rubber axillary pad was placed a 6.4cm below the axillary fold also using a measured template [1]. Subjects were then permitted to leave at this point, and values for the remaining techniques were determined. The actual height recorded were used in techniques were determined. The actual heights recorded were used in the calculations. Seventy-seven percent of the actual height of each subject was determined. In another calculation 40.6cm was subtracted from each subject's actual height. All these resulted into two different methods of crutch length estimation arising from the actual height.

2.8 Analysis of Data

Descriptive statistics in the form of mans and standard deviations were obtained for all crutch measurement variable. Then, Pearson Product-moment correlation coefficient ® among the ideal crutch length and the other measure were calculated to determine the degree to which each of variables was associated with the ideal length criterion linear and multiple regression equation were developed for the best predictive variables. All crutch-length-estimation technique in this study and the regression equations were then assessed for accuracy against the ideal crutch length.

Mean squared error (MSE) indices were computed for all techniques as the average of the squared deviation or errors, between the technique measurement and the ideal crutch lengths (Levin, Rubin and Stinson, 1986). The MSE methods were chosen over a simple difference methods because in squaring errors, more weight was given to large errors.

3. RESULTS

The results of the study are shown in Table 1. Means and standard deviation for the actual height, minus 40.6cm, 77% height and axillary fold to heel measure are also presented in Table 1. Analysing actual height consistency index for measurement reliability had an alpha coefficient of 0.95.

Table 2 contains the resultant Pearson product moment correlation coefficient and linear values.

Actual height x 77% and actual height minus 40.6cm had the strongest relationship with the ideal crutch length values. Table 2 also showed a good display of height x 77/% (r= 0941, P <0.01, r^2= 0.89). The actual height minus 40.6cm measure showed the same with r (Pearson product moment correlation coefficient) = 0.941, and linear regression coefficient, r^2 = 0.89, P < 0.01. Anterior axillary fold to heel measure on the other was different r = 0.917, r^2 = 0.84; P<0.01.

A simple linear regression equation was computed by regression of ideal crutch length values on the actual height. The resultant slope and y intercept were 0.70 and 8.9cm respectively.

Table 3 contains the value of Pearson product moment coefficient (r) and linear regression value for best three method of technique (MSE) mean squared error analysis was conducted. The result produced the least amount of error because of the nature of the least squared solutions. Comparison among the three techniques height tallied with that obtained from actual height minus 40.6cm.

The MSE value obtained by taking the measurement from axillary fold to heel was (5.9609). The MSE value obtained from actual height x 77% (4.2603) was the actual height minus a 40.6cm (4.2603). This was 1.7006 less than that from axillary fold to heel measures.

Of all the experiment; for crutch length estimated. 77% of actual height and actual height minus 40.6cm tailed at least MSE (4.2603) respectively and the axillary fold to heel (AFH) had the greatest MSE (5, 9609) amongst the best three methods in this study. This is a difference of 1, 7006 units in MSE.

A crutch length includes crutch tip and axillary pad Metric formula

0.70 X Actual height + 8.9cm

3.1 Hypothesis Testing

In carrying studying, the main hypothesis was that there is no relationship between the ideal crutch length and the independent variables namely. Actual height minus 40.6cm 77%of height. Axillary fold to hell and age.

Test:

R^2 = 0.81
Multiplier R = 0898
F = 119.65
 Sig f=0.000

Table 1. Descriptive statistics for subject and measurement

Variable	X	SD
Age (x)		
Male subjects (n=104)	26.15	6.71
Female subjects (n=120)	26.61	8.23
Measurement (cm)		
Actual height	162.56	8.47
Height x 77%	132.10	5.22
Actual height minus 40.6cm	130.96	6.77
Auxiliary fold to heel (AFH)	139.35	6.15
Arm rest measurement(ARMR)	41.66	2.00
Ideal crutch length (Female)	122.30	6.41
Ideal crutch length (male)	129.24	6.08
Ideal crutch length (for all)	125.52	7.14

Table 2. Pearson product moment correlation coefficient ® and linear regression correlation coefficient (r^2) correlation with ideal crutch length (a) (overall)

N=224		
Variable	**r**	**r^{2h}**
Actual height	0.941	0.89
Height minus 40.6cm	0.941	0.89
Axillary fold to heel (AFH)	0.917	0.84

Ideal crutch length is defined as the length of the crutch, including accessories, obtained during stance when the crutch tip is 15.cm lateral and 15.2cm anterior to the fifth toe and the axillary pad is 6.4cm below the axillary fold [1]; All correction were statistically significant ($p<0.1$)

Table 3. Mean squared errors (MSES) associated with equation and crutch-length-estimation techniques

Estimation	MSE(cm^2)
Equation a	
Y=0.7x+8.9cm	2.0933
Technique	4.2603
Actual height X 77%	4.2603
Actual height -40.6cm	5.9609

Difference 1.7006; ax = Actual height; y =Crutch length; 0.7 cm =Slope; 8.9 cm = Intercept at y-axis

Table 4. Calculated ideal crutch length (cm)[a]

Actual Height	Crutch length
152	115.3
155	117.4
156	118.1
157	118.8
160	120.9
163	123.7
164	123.7
170	127.9
174	130.7
175	131.4
176	132.5
178	133.5
184	137.7

The result of analysis above shows the data fitted well into a regression model. The contribution of the independent variables to the dependent shows high positive relationships between the dependent variable and independent variables.

The result leads to a rejection of the null hypothesis and the acceptance of the alternate hypothesis.

4. DISSCUSSION AND CONCLUSION

The purpose of this study was to determine which of several axillary crutch length estimation techniques most accurately predicts ideal crutch length. Bauer et al. [1] worked on seven methods. Beckwith [12] concentrated on five. The study centered on the best three methods that featured in the work of Bauer et al. [1] and Beckwith [12]. It is also find out whether there is an acceptable technique among those several crutch fitting alternatives. In reviewing the literature, it was evident that crutch-length-estimation technique varies widely. Virtually, all technique derived by clinical experience have not been scientifically validated in this our locality. This study provides statistical insight into crutch-length-fitting techniques. The result of this study confirmed the fact that one or more of the estimation technique would be significantly predictive of ideal crutch length. Specifically, fairly strong evidence for the use of height measures emerged followed by evidence for the use height measures. The was so since many other methods found in Bauer et al and Beckwith research were eliminated in this study because they were too far from the ideal crutch length.

The results of this study are consistent with the work conducted previously by Bauer et al. [1] and Okoye [13]. Bauer et al. [1] concluded the 77% of height methods yielded the least difference firm the ideal crutch length and that height minus 40.6cm methods was the next most accurate method. The result of this present study showed that 77% of height and height minus 40,6cm yielded the least and the same difference form ideal crutch length and least error. This was followed closely with axilla to heel. Bauer *et al.* [1] had a peculiar population of military officer's predominantly male and utilized self-reported height as their strongest point, which yielded the best result. This did not portray a clinical setting where the calibers of patient were mixed up, literates and illiterates, children and adults, and so forth. It also certain that even the elderly [14, 15]. This, coupled with the depressed state of the patient will make self-reported height unreliable and inaccurate, and a misleading guess work.

Okoye [13] reviewed the methods of Bauer et al. [1] but with actual heights of subjects in complete setting. The same results as in Bauer et al. [1] was produced. The only common occurrence in the works already mentioned was the predominance of male subjects more than the female. In the study of Bauer et al. [1] and Beck with [12] there was no mention of female subjects. Okoye, [13] involved 71 male, and 39 female.

Beckwith [12], Bauer et al. [1] and Okoye, [13] revealed that the most accurate methods were those involving mathematical manipulations of height, specifically actual height or self-reported height 77% of height methods and methods 2 through 5 listed earlier. Fifteen subjects participated in Beckwith's study, and each subject measured each of the other 14 subjects using all five methods to obtain a total of 210 measurements for each method. These measurements were compared calculated. Beckwith found that height minus 40.6cm yielded the least difference from the ideal crutch length. The next most accurate methods according to Beckwith were 77%-of-height methods. Beckwith study lacked statistical cre4dence and was prone to multiple errors. The numbers of subject were too inadequate for any conclusion to be reached.

In this study, only actual height measures were used in all mathematical manipulations involving height. This was because the researcher believed that in a complete clinical atmosphere that self-reported heights will be ridiculous and unreasonable. Self-reported height will only be reliable if the patient was current with his/her height measurement. This was peculiar in the work of Bauer et al. [1].

In addition, through regression analysis of the data, an equation was derived for crutch-length estimation. This equation multiples was derived for crutch-length estimation. This equation multiples the subjects actual height by 70% and then adds 8.9cm. This equation can allow a health care provider to fit a patient for crutches prior to standing. Table 4 shows the example of such crutch-length-estimation. This could be easily and conveniently applied in the setting.

As this study has shown, a more accurate measurement could be obtained by simple

application of the calculated ideal crutch length (Table 4).

CONSENT

As per international standard or university standard, patients' written consent has been collected and preserved by the author(s).

ETHICAL APPROVAL

As per international standard or university standard written ethical approval has been collected and preserved by the author(s).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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