

# Comparative Analysis of Predetermined Axillary Crutch Length Settings to Individualized Fittings

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Axillary crutches are the most common assistive devices given to individuals with musculoskeletal injuries in an acute care setting. Nurses are frequently the care provider fitting injured individuals with crutches. This study compared the crutch length determined by the crutch manufacturer's height setting with the crutch length attained after applying a standard clinical protocol for crutch fitting. A total of 116 adults with lower extremity injuries were enrolled. Self-reported height was documented as well as initial crutch length as indicated by the numbers on the push-button feature of the crutches. Subject height with and without shoes was measured. Proper crutch length was then determined using the method described by Bauer et al. (1991). No change between the initial and adjusted crutch settings was made in 43% of the subjects. Change was made in 57% of the subjects: lengthening in 40% and shortening in 17% of subjects. This study revealed the predetermined crutch settings are unreliable and should simply be used as a starting point during a personalized fitting.

## Background

Axillary crutches are the most common assistive devices given to individuals with musculoskeletal injuries in an acute care setting—emergency departments or urgent care facilities. Nurses are frequently the care provider fitting injured individuals with crutches. A review of three databases identified several studies that addressed injuries related to ill-fitting crutches or poor crutch usage (Konishi et al., 2009; Pringle, 2001; Veerendrakumar et al., 2001). However, there was only one recent study that addressed the sizing of crutches (Bauer et al., 1991). Improper sizing is one mechanism that may contribute to concomitant injury (Borrelli & Haslach, 2013). Bauer et al. (1991) explored seven different methods for fitting an individual with crutches:

1. Axillary fold to heel in supine;
2. Olecranon to opposite third fingertip;
3. Olecranon to opposite fifth fingertip;
4. 77% of height;
5. Height minus 16 in. (40.6 cm);
6. 77% of arm span; and

7. Arm span minus 16 in. (40.6 cm).

Most crutches are typically manufactured from tubular aluminum alloy with a push-button telescoping feature that allows for quick length adjustment (see Figure 1). These buttons are labeled in 1-in. increments to serve as predetermined patient height settings. Typically, the setting is a quick and definitive way to adjust crutch height and bypass the need for a time-consuming individualized fitting. Yet, clinical observation revealed great variation between the labeled setting and the actual fitted crutch length. Many patients present with improperly fitted crutches despite selecting the setting corresponding to their reported height.

## Purpose

The objective of this study was to compare the crutch length determined by the crutch manufacturer's height setting with the crutch length attained after applying a standard clinical protocol for crutch fitting.

## Methods

### SUBJECTS

After consenting to participate in this study, 116 adults presenting with crutches to a multicenter foot and ankle

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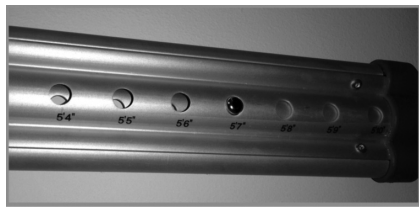


FIGURE 1. Push-button telescoping feature.

practice with a lower extremity injury were enrolled. Inclusion criteria accepted all adult patients (>18 years of age) who presented to our institution for care and were fitted with axillary crutches postinjury at a prior institution (emergency department or urgent care facility). Exclusion criteria eliminated minors, individuals who could not stand upright, individuals who had upper or lower extremity amputation, and those who had cognitive impairments.

### PROCEDURE

Self-reported height was documented as well as initial crutch length as indicated by the numbers on the push-button feature of the crutches. Subject height with and without shoes was measured using a telescoping ruler attached to a medical-grade scale. Proper crutch length was then determined using the method described by Bauer et al. (1991):

Subjects were asked to stand in their normal base and angle of gait. The tip of the crutch was positioned on the floor 6 inches (15.24 cm) anterolateral to the fifth toe. In this position, the axillary pad of the crutch was adjusted to allow 2 to 3 finger breaths distance (1.5-2.0"; 3.8-5.1 cm) between the pad and the anterior axillary fold (p. 296).

The corresponding push-button value on the crutch was recorded. The crutch handle was then adjusted to allow for a 20° elbow flexion; however, this adjustment was not included in the analysis. The crutch manufacturer and the model number were also recorded.

### Results

Data analysis included five measurements: initial crutch length, reported height with and without shoes, measured height with shoes, and properly adjusted crutch length while wearing shoes. No change between initial and adjusted crutch setting was made in 43% (50/116) of the subjects, whereas a change was made in 57% (66/116) of the subjects. Lengthening was required in 40% of subjects (46/116) with an average increase of 1.6 in. (4.06 cm). The range was 1-4 in. (2.54-10.16 cm). Shortening was required in 17% of subjects (20/116), with an average reduction of 1.4 in. (3.55 cm) and a range of 1-5 in. (2.54-12.7 cm). These data are displayed in Figure 2.

Referencing *reported height*, the adjusted crutch setting with shoes was longer in 66% of subjects with an average of 1.76 in. (4.47 cm) and shorter in 11% of subjects with an average of 1.35 in. (3.44 cm). The adjusted crutch setting height corresponded to the reported height in only 23% (27/116) of subjects (see Figure 3).

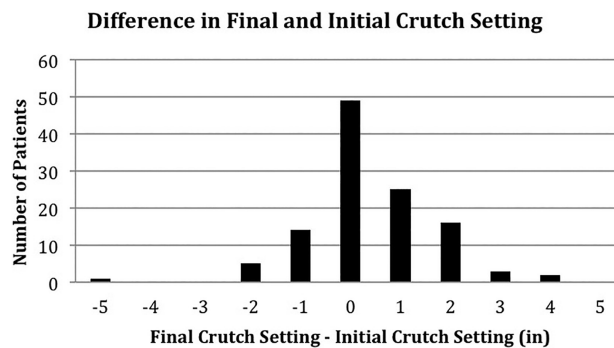


FIGURE 2. Difference in crutch settings.

When referencing *measured height with shoes*, the adjusted crutch setting with shoes was longer in 46% of subjects with an average of 1.52 in. (3.86 cm) and shorter in 39% of subjects with an average of 1.30 in. (3.3 cm). In only 15% of subjects (17/116), measured height with shoes matched the labeled settings, that is, no change was needed (see Figure 4).

Six different manufacturers were found among 90% (104/116) of subjects; 10% (12/116) had no manufacturer label. There was less than 50% accuracy of the labeled setting to the adjusted setting (no change needed) across all manufacturers (see Figure 5). Regression analysis comparing initial crutch length with properly adjusted crutch length showed the coefficient of determination ( $R^2$ ) equaled .863. Comparing reported height with adjusted crutch length revealed an  $R^2$  of .899. Measured height with shoes compared with corrected crutch length revealed an  $R^2$  of .881.

### Conclusions

The data showed inaccuracy of the labeled settings for the majority of subjects. Crutch length estimation techniques vary widely. Many of the clinical techniques have not been validated. Beckwith (1965) reported the equation with the least error was 72% of the person's actual height plus 2 in. (5.2 cm). The second equation with the most clinical accuracy used 68% of self-reported height plus 4.8 in. (12.3 cm). These equations can both have value to healthcare providers. In some scenarios, time does not permit obtaining an actual measure of height

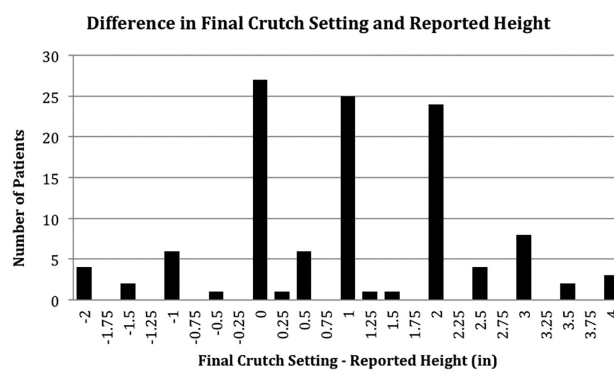


FIGURE 3. Comparison of crutch setting with reported height.

### Difference in Final Crutch Setting and Measured Height + Shoe Height

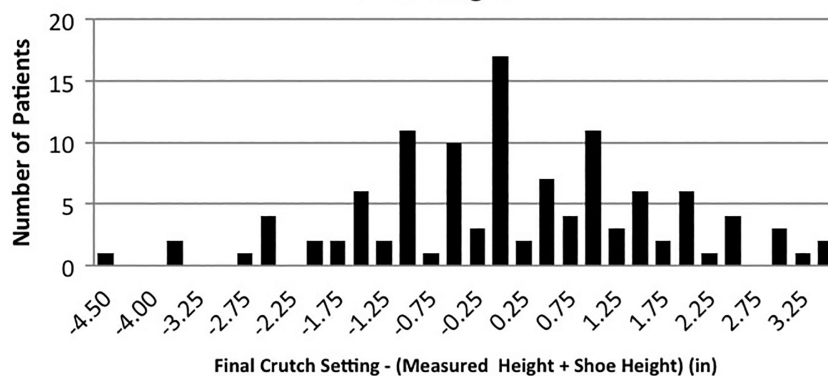


FIGURE 4. Comparison of crutch setting with measured height (with shoes).

and there are challenges measuring individuals in a hospital bed as well as those who are unable to stand. If the actual height can be assessed, one needs to consider whether the measure is to be taken with or without footwear. Again, this can be a challenge if a person's footwear heel height varies on the basis of shoe choice. Heel height variation as little as 1 in. (2.54 cm) can influence the crutch fit.

Bauer et al. (1991) ranked their estimation of ideal crutch length as follows (most to least accurate):

1. 77% of reported height;
2. Reported height minus 16 in. (40.6 cm);
3. 77% of actual height;
4. Actual height minus 16 in. (40.6 cm);
5. Olecranon to tip of contralateral fifth finger;
6. Olecranon to tip of contralateral third finger;
7. 77% of arm span;
8. Arm span minus 16 in. (40.6 cm); and
9. Axillary fold to heel.

In the current study, regression analyses revealed all measurement techniques had minor degrees of variance. No one measurement approach (i.e., using

reported height, reported height with shoes, measured height, or measured height with shoes) was found to be significantly superior. This most likely reflects the fact that multiple variables exist when measuring height. With crutch fitting, functional height is from the axilla to the ground. However, both reported and measured heights included the head and neck. Because there is variation within the population among head and neck size, this confounds the measurement from a crutch length perspective. Shoe height, erroneous self-reporting of height, and measurement margin of error are additional variables confounding height assessment. Based on prior literature and the results of this study, there is no universal standard to predict crutch length based on height. Thus, it is understandable how the predetermined crutch settings are not reliable.

### Clinical Relevance

Maladjustment of crutches can result in improper axillary loading and poor biomechanics (Borrelli & Haslach, 2013). This can compound the effects of an already existing injury. This study revealed the predetermined

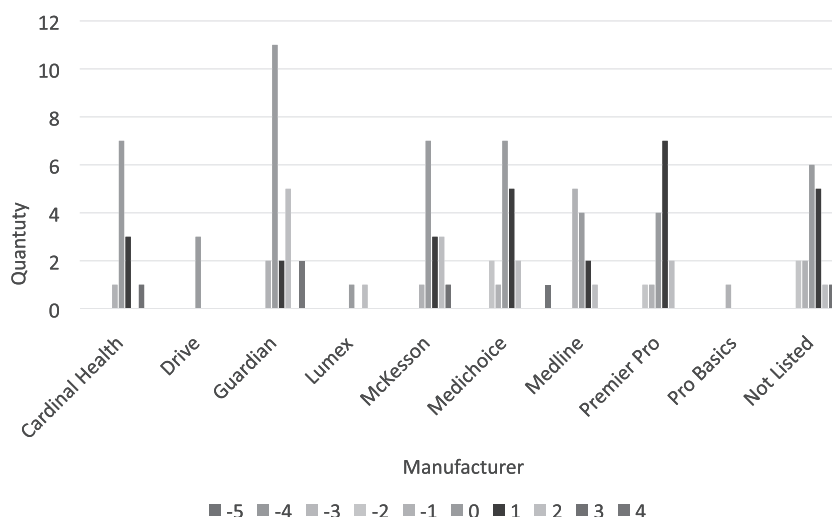


FIGURE 5. Comparison of final crutch setting by manufacturers. The color version of this figure is available in the online issue at <https://journals.lww.com/orthopaedicnursing>.

crutch settings are unreliable and should simply be used as a starting point during a personalized fitting. Whether one uses the predetermined crutch setting or selects one of the calculations identified, one should always repeat the fit when the patient is wearing street shoes. Healthcare providers should also watch the person ambulate with the crutches to not only check the fit but also confirm proper clinical usage. Failure to properly fit crutches to the appropriate length exposes patients to injury risk and impedes safe, efficient ambulation.

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