Height Measures

Evaluating alternatives to standing height in the ambulatory setting

Dianne M. Cirillo, MS, RN-BC, Sarah K. Hart, BSN, RN, Richard R. Reich, PhD, and Tina M. Mason, MSN, ARNP, AOCN®

BACKGROUND: Height measurement is a key clinical component to measure body mass index and body surface area used for patient care, including calculating chemotherapy doses. Some patients cannot feasibly or safely stand for height measurement because of a number of diseases and disabilities. The literature is unclear regarding alternatives to standing height for patients unable to stand.

OBJECTIVES: The purpose of this research study was to test equivalence of a number of measurements to find a reliable alternative to standing height for ambulatory oncology clinic patients who are unable to or cannot safely stand.

METHODS: A repeated-measures design was used to measure the height of 60 volunteer adult participants using a convenience sample of 30 men and 30 women. Standing height was compared to self-reported height, recumbent length, arm span, half-arm span, demispan, and knee height measurements.

FINDINGS: Results indicated that demispan was equivalent to standing height with a mean difference of −0.69. A practice change to use demispan in patients who cannot stand has been proposed and accepted at the authors’ organization. The use of demispan was a feasible alternative to standing height in cost of supply and technique.

KEYWORDS
arm span; body height; demispan; half-arm span; knee height; recumbent height

DIGITAL OBJECT IDENTIFIER
10.1188/18.CJON.529-533
noted, Froehlich-Grobe et al. (2011) found that recumbent length yielded the most accurate height estimate for wheelchair users. Recumbent height was also found to be the most accurate compared to self-reported height and knee height estimate by Frid, Adolfsson, Rosenblad, and Nydahl (2013).

Arm Span
Numerous studies favored the arm span measurement when compared to standing height as an alternative measurement (Manonai, Khanacharoen, Theppisai, & Chittacharoen, 2001; Nygaard, 2008; Quanjer et al., 2014; Villa-Verde-Gutiérrez, Sánchez-López, Ramirez-Rodrigo, & Ocaña-Peinado, 2015). With this measurement, the person is asked to extend arms at 90 degree angles and a measurement is obtained from the tip of one middle finger to the other. Brown et al. (2001) found arm span was an accurate alternative to standing height (test-retest reliability, r = 0.997) compared to reported height in a sample of 409 participants. In contrast, Froehlich-Grobe et al. (2011) found arm span provided the least accurate estimate of height in a comparison with self-report, recumbent height, and knee height.

Half-Arm Span
A half-arm span measurement requires a simple calculation of multiplying the half-arm measurement (mid sternal notch to tip of middle finger along an outstretched arm) by 2. An analysis by Hickson and Frost (2003) found poor agreement between standing height and half-arm span (X difference = 7.04 cm), demispan (X difference = 4.33 cm), and knee height (X difference = -0.6 cm). Lahner, Kassier, and Veldman (2017), in a study of 900 participants (150 per gender) for Caucasian, Black/African, and Indian races in South Africa, found that half-arm span and demispan overestimated height for all race groups and both genders. The half-arm measurement is included in the Nestlé Nutrition Institute (2013) guide to completing the Mini Nutritional Assessment.

Demispan
The demispan measurement (mid-sternal notch to the web between the middle and ring fingers along an outstretched arm) (see Figure 1) requires a calculation from an equation (Nestlé Nutrition Institute, 2013). Hirani and Mindell (2008) measured height and demispan in a study of 3,346 non-institutionalized adults aged 65 years or older in the Health Survey for England. Demispan was determined to be a useful estimate of height when compared to standing height. Measured height underestimated prevalence of being underweight and overestimated prevalence of being overweight in women aged 65 or older. Measured height also overestimated obesity in women aged 70–74 years compared to demispan estimated height.

Figure 2 provides a list of alternatives to standing height measurements and calculations for conversion. Accuracy of these equations has been questioned, particularly with older adults because height often changes over time. Using demispan measurements, Hirani and Aresu (2012) developed and tested new equations for predicting height in adults aged 65 years and older. This study validated age and gender-specific equations to estimate height in older persons more accurately than the more commonly used Bassey equation. Weinbrenner, Vioque, Barber, and Asensio (2006) also tested an updated equation using the demispan and age to apply to the older adult Spanish population and suggested it as an acceptable surrogate. Recommendations to consider race/ethnicity, gender, and population-specific equations have been made for arm-associated measurements (Lahner et al., 2017).

Knee Height
A knee height measurement involves the person placing one foot (sans footwear) flat on the floor with a knee bent at a 90 degree angle. Using a caliper, one blade is placed under the heel and the other blade is placed on the anterior surface of the thigh about 3 cm above the patella. Pressure is applied to compress the tissue. The shaft of the caliper is held parallel to the long axis of the lower leg for measurement (Perry, 2007). Knee height and wall height (standing against a wall when a stadiometer is not available) have been found to be an alternative to standing height measurement in older community-dwelling adults when a stadiometer is not available (Gordon et al., 2013). Van Lier, Roy, and Payette (2007) tested equations for measured height, reported height, and knee height in a seated position. They concluded that these equations, including knee height, age, weight, and hip circumference, can be used in frail older adults as predictors of height. As stated, Froehlich-Grobe et al. (2011) found knee height to be a reasonable alternative when a recumbent length measurement cannot be obtained. Ferreira-Melo, Kuerten-de-Salles, Vieira, and Ferreira (2017) found knee height was the only measurement that resulted in underestimation of height in all study groups.

The H. Lee Moffitt Cancer Center and Research Institute had selected the arm span as an alternative to standing height. During the policy’s scheduled review and discussion of the literature with the center’s nursing standards and policies committee, the
arm span measurement, like other alternatives, was questioned. This study's purpose was to determine an accurate alternative to standing height for ambulatory oncology clinic patients who are unable to stand. Alternatives compared to standing height measurements were self-report, lying recumbent, arm span, half-arm span, demispan, and knee height.

**Methods**

**Design and Setting**
A repeated-measures design was used to obtain six measurements and verbal report using three devices with each participant. These height-estimating methods were used to determine the degree of equivalence with standing height. The study was conducted in the ambulatory clinical setting at H. Lee Moffitt Cancer Center and Research Institute, a National Cancer Institute–designated comprehensive cancer center.

**Sample**
A convenience sample of 60 staff members/volunteers from the center (30 men and 30 women) who met the following inclusion criteria were included: able to maintain standing, supine, and sitting positions during data collection safely and comfortably; able to read and understand English; and being aged 18 years or older.

**Instruments**
A data collection tool, designed by investigators, was used to record participants’ age, gender, and height per self-report, stadiometer (standing), tape measure (recumbent, arm span, half-arm span, demispan), and knee caliper (knee height). Self-report, if given in non-metric, was converted to metric, and measurements for half-arm span, demispan, and knee heights were calculated per standard formulas and recorded on the data collection tool.

The investigators used the following existing equipment at the center: Welch Allyn Scale-Tronix® stadiometer and the Seca-201 Ergonomic circumference measuring tape. In addition, the Shorr Knee Height Caliper was purchased with the department’s fund for conducting this study. Training for investigators consisted of reviewing manufacture guidelines and practice sessions prior to data collection.

**Recruitment and Data Collection**
Participants were recruited by the investigative team. An author explained the study to interested participants and provided an informational letter to read. The following measurements were obtained: verbal report, standing height, arm span, half-arm span, demispan, and knee caliper (knee height). Self-report, if given in non-metric, was converted to metric, and measurements for half-arm span, demispan, and knee heights were calculated per standard formulas and recorded on the data collection tool.

The investigators used the following existing equipment at the center: Welch Allyn Scale-Tronix® stadiometer and the Seca-201 Ergonomic circumference measuring tape. In addition, the Shorr Knee Height Caliper was purchased with the department’s fund for conducting this study. Training for investigators consisted of reviewing manufacture guidelines and practice sessions prior to data collection.

**Ethical Considerations**
Regulatory approval was obtained from the center’s nursing research and innovation council, scientific review committee, and institutional review board. No increased risk or burden was placed on the participants. Participation was voluntary.

**Results**
Means and standard deviations were calculated for each height measurement method. Equivalence was tested using the two one-sided tests (TOST) method (Borman, Chatfield, Damjanov, & Jackson, 2009). This method entails calculating the difference between each height estimation method and the standing height standard. These differences were used to calculate a

---

**FIGURE 2.**
**ALTERNATIVE MEASUREMENT METHODS FOR STANDING HEIGHT AND CALCULATIONS FOR CONVERSION**

**VERBAL REPORT**
- If stated in inches, multiply by 2.54.

**HALF-ARM SPAN**
- Measurement (cm) multiplied by 2

**DEMISPAN**
- Women: Height in cm = (1.35 x demispan [cm]) + 60.1
- Men: Height in cm = (1.4 x demispan [cm]) + 57.8

**KNEE HEIGHT**
- Women: Height in cm = (1.83 x knee height [cm]) – (0.24 x age years) + 84.88
- Men: Height in cm = (2.02 x knee height [cm]) – (0.04 x age years) + 64.19

Note. Conversion formulas were not available for arm span and recumbent measurements.

Note. Based on information from Nestlé Nutrition Institute, 2013; Perry, 2007.
90% confidence interval (CI) for the difference between paired samples. Acceptance criterion for the 90% CI was set at a 2 cm difference from the standing height method. The 2 cm (0.79 inches) difference was chosen because it has little appreciable influence on BMI calculation. The standard deviations observed in previous height measurement studies suggested that 60 participants would be sufficient to test equivalence of 2 cm at greater than 90% power. The TOST option within the PROC TTEST statement of SAS, version 9.4, was used for equivalence testing.

The mean age of the sample was 42.98 years (range = 18–71). Of the six alternates to standing height, demispan was the only method whose difference was within the criterion of 2 cm. The difference was −0.69 cm and the 90% CI (−1.48 cm, 0.11 cm) did not exceed the criterion (p = 0.003). Each of the other alternative height measurements overestimated height at levels that were beyond the acceptance criterion. The results for each method are summarized in Table 1.

Although the study was powered to assess height alternatives for all participants together, the authors also explored the validity of measurements when separated by gender. For women, demispan was the most accurate, with a 0.46 cm difference from standing height (90% CI [−0.69 cm, 1.61 cm]) (p = 0.02). The mean difference for self-reported height also was within the 2 cm criterion (1.84 cm), but the upper limit of the 90% CI (2.39) exceeded it (p = 0.31). For males, the demispan mean difference (−1.83 cm) was within the acceptance criterion, but the lower limit of the 90% CI (−2.86) exceeded it (p = 0.39). Demispan was the second most accurate alternative for males. Knee height was the most accurate for males, with a mean difference of −0.02 cm (90% CI [−0.96 cm, 0.91 cm]) (p = 0.0006).

**TABLE 1.**

HEIGHT METHOD COMPARISONS (N = 60)

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>X (cm)</th>
<th>X DIFF</th>
<th>90% CI</th>
<th>SD</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standing</td>
<td>167.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-report</td>
<td>170.7</td>
<td>2.8</td>
<td>[2.35, 3.24]</td>
<td>2.06</td>
<td>0.99</td>
</tr>
<tr>
<td>Recumbent</td>
<td>170.37</td>
<td>2.47</td>
<td>[2.14, 2.8]</td>
<td>1.55</td>
<td>0.99</td>
</tr>
<tr>
<td>Arm span</td>
<td>173.79</td>
<td>5.89</td>
<td>[5.03, 6.75]</td>
<td>3.97</td>
<td>1</td>
</tr>
<tr>
<td>Half-arm span</td>
<td>173.74</td>
<td>5.84</td>
<td>[4.88, 6.8]</td>
<td>4.45</td>
<td>1</td>
</tr>
<tr>
<td>Demispan</td>
<td>167.21</td>
<td>−0.69</td>
<td>[−1.14, 0.11]</td>
<td>3.67</td>
<td>0.005</td>
</tr>
<tr>
<td>Knee height</td>
<td>170.76</td>
<td>2.86</td>
<td>[1.74, 3.99]</td>
<td>5.24</td>
<td>0.9</td>
</tr>
</tbody>
</table>

CI—confidence interval; diff—difference

**Note.** All differences are compared to standing height. Limits were set to 2 cm difference.

**IMPLICATIONS FOR PRACTICE**

- Understand that not all patients can safely or comfortably stand to obtain a height measurement.
- Educate healthcare providers that accurate height measurement is required for body mass index and body surface area measurements.
- Consider using demispan, which has been shown to be a viable alternative to standing height measurement.

**Discussion**

Study findings indicated that the currently used alternative measurement of arm span is not equivalent to standing height. This was noted in other investigations as being poor or having a greater difference than other alternatives (Froehlich-Grobe et al., 2011; Hickson & Frost, 2003). Hickson and Frost (2003) differed in the findings of demispan, which could be attributed to the population used, which had a median age of 82 and acutely ill older adults. This population would have a greater difference between the maximum height versus current height because of decreased height over time, which can occur more rapidly after age 70 (Martin, 2016).

For patients who are not able to stand or safely stand for a height measurement, the findings of this study supported demispan as an equivalent alternative. Demispan was also found to be equivalent in other studies (Hirani & Aresu, 2012; Hirani & Mindell, 2008). This is an alternative height measurement that is feasible in its technique and is cost effective, based on the supplies used. The results of this study have led the H. Lee Moffitt Cancer Center and Research Institute to approve a practice change to use demispan as the alternative to standing height. The knee height measurement was equivalent for men; however, it requires a more expensive supply item, a caliper, which would be needed in a large quantity across the organization. The demispan was equivalent for both men and women, enabling standard education of the method to staff. Competencies are being developed as part of staff education and training to ensure skill and proper documentation.

**Limitations**

Various limitations occurred within the study. Shorter participants may have had difficulty forming a right angle at the knee while sitting without using something to elevate the feet. This occurred in 50% of women and 10% of men participants during the knee height measurement. Also noted was a potential limitation with obtaining recumbent height in the ambulatory setting. This setting has short examination tables, which are slightly angled, and would not be optimal for recumbent height. A stretcher was used for the recumbent height measures in this study, which is not feasible for all ambulatory settings at the organization. The measurement of demispan requires mathematical calculations, which are planned to be built into the electronic health record to avoid potential error. This is particularly important because calculations of BSA and BMI are used frequently in the oncology setting. The demispan requires two people to perform the measurement, which may be challenging in small practice settings.
addition, because of a diverse patient population at the authors’ center, race and ethnicity were not separated for this study. The mean age of participants in this study was 42.08 years, with the oldest participant being aged 71 years. Results may not be generalizable to older adults.

Implications for Nursing and Conclusion
An equivalent alternative measurement for standing height was unclear after a review of the literature. Many ambulatory clinical settings struggle to determine the equivalent alternative measurement for clinical practice. This research study confirms demispan as an equivalent alternative measurement in men and women. The results of this study support the use of demispan as an alternative height measurement in adults that can be applied in many healthcare settings. Findings contribute to the quality of care for patients who are unable to stand or safely stand for accurate height measurements.

Dianne M. Cirillo, MS, RN-BC, is a nursing education specialist in the Nursing Professional Development Department. Sarah K. Hart, BSN, RN, is an RN III in the genitourinary clinic. Richard R. Reich, PhD, is a core facility manager, and Tina M. Mason, MSN, ARNP, AOCN®, AOCNS®, is a nurse researcher in the Department of Nursing Research, all at the H. Lee Moffitt Cancer Center and Research Institute in Tampa, FL. Cirillo can be reached at dianne.cirillo@moffitt.org, with copy to editor at CJONEditor@ons.org. (Submitted February 2018. Accepted April 1, 2018.)

The authors take full responsibility for this content and did not receive honoraria or disclose any relevant financial relationships. The article has been reviewed by independent peer reviewers to ensure that it is objective and free from bias.

REFERENCES