Short communication

A novel approach to anthropometric assessment for geographically dispersed samples: A pilot study

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Keywords: BMI Height Weight Anthropometric assessments Videoconference-assisted measurement Remote assessment

ABSTRACT

Measurements by trained personnel are the criterion standard for assessments of body mass index (BMI) and obesity. Yet, in-person measurements are less practical for studies of geographically dispersed samples. Recent advances in technology and the success of telehealth suggests that videoconferencing may be promising. We conducted a pilot study to examine the validity of videoconference-assisted measurements (VCAM) relative to in-person measurements by trained staff. We collected height, weight, percent body fat and waist circumference measurements using VCAM and staff measured in a convenience sample of 50 greater Los Angeles participants. We calculated relative standardized differences, and agreement between the two approaches using Pearson correlation and Bland-Altman plots. The small magnitude of differences (effect sizes < 0.03), and high agreement suggested that the two approaches produce similar values. Thus, completing height and weight measurements through videoconference may be a valid and cost-effective approach, especially for geographically dispersed samples.

1. Introduction

Body Mass Index (BMI), a measure of weight relative to height, is most often used to assess overweight and obesity among those ages two years and older (Krebs and Jacobson, 2003; Himes and Dietz, 1994; Institute of Medicine, 2005; World Health Organization, 2000). BMI is preferred because of the ease and lower cost of collecting height and weight data, as well as the documented association with adiposity and future health risks (Himes and Dietz, 1994; Barlow and Dietz, 1998; Krebs et al., 2007). In contrast, gold standard measures such as dual-energy c-ray absorptiometry (DXA) are prohibitively expensive to deploy in field studies and place greater burden on study participants. BMI is collected through self-reports, proxy-reports and/or measurements conducted by trained personnel. Although measurements by trained personnel are more accurate (Voss and Bailey, 1994) than self/proxy-reports (Engstrom et al., 2003; Villanueva, 2001; Black et al., 1998; Jeffery, 1996; Schmidt et al., 1993), it is prohibitively expensive and less practical for geographically dispersed samples to collect in-person measurements (Himes and Dietz, 1994).

With rapid improvements in technology and the demonstrated success of telehealth (Informatics UoTSoB, 2018), especially among underserved and rural populations (Harrison, 2019), we wanted to explore the feasibility of remote BMI measurement. With the potential for lower costs, videoconference-assisted assessment may increase the validity of sensitive measurements (e.g. body weight) by enabling data collection in the participant’s home, thereby increasing participant’s level of comfort. In this study, we present findings from a pilot study of a new video-assisted protocol for anthropometric assessment that may be as accurate as staff measurements, without the need for deployment of trained personnel. This novel approach was used to collect anthropometric data remotely via a videoconference session led by trained study staff. If valid, the VCAM approach offers the opportunity to conduct measurements (instead of or in addition to survey reports) in studies where measurements by trained personnel are not feasible.

2. Materials and methods

2.1. Design

A pilot validation study was conducted by the ongoing Military Teenagers Environments, Exercise, and Nutrition Study (M-TEENS), a longitudinal study of adolescents and parents to assess the impact of exogenous relocation of military families to varied neighborhood environments on obesity (Shier et al., 2016). To collect anthropometric...
data in our mobile, geographically dispersed sample, we compared videoconference-assisted measurements (hereafter, VCAM) with in-person measurements conducted by trained personnel (hereafter, staff measurements). All assessments involved a pair of participants, either an adolescent and his/her parent or two adults. Instead of the trained personnel-study participant combination, the second person can be a co-worker, family member or friend. Each participant pair scheduled a 30-min appointment in their home or at our office with a staff member who provided participants with 3 pieces of equipment: stadiometer, scale, and measuring tape, and then sat in a separate room to guide participants using videoconferencing (e.g. Skype, Google hangout). Also, participants were asked to remove shoes and socks, hats, hair ornaments, and heavy outer garments before beginning the measurements, as is standard. Upon completion of the VCAM assessments, the staff member took a set of measurements, using the same equipment. By conducting both measurements in the same visit, we ensured that differences between the two approaches are attributed to measurement error, rather than natural fluctuations in body weight or other factors (e.g. clothing). Each participant was paid $25 for the pilot study. This study was approved by the University of Southern California’s Institutional Review Board.

2.2. Sample

The pilot study included a convenience sample of parent-child and adult-adult pairs to mimic pairings anticipated in future MTEENS waves; MTEENS adolescents will become adults and will have to transition from pairing with his/her parent to pairing with another adult when implementing the VCAM approach. Between fall 2017 and spring 2018, we recruited 10 parent-child pairs and another 15 adult pairs who may or may not be related (i.e. relatives, friends, coworkers, etc.) from college campuses in the greater Los Angeles area; the total sample size is 50 (25 pairs).

2.3. Measures

These measurements were conducted in the same order during the VCAM and staff measurements.

Height: Height was measured using a Charder HM200P Portstad Portable Stadiometer. Participants stood on the stadiometer with heels touching the back of the stadiometer and looked straight ahead. Participants were instructed to take a deep breath and release, while the person measuring them lowered the headpiece and read out the measurement to the nearest 0.1 cm. Each participant in the pair was measured twice, with a third measurement needed if the difference was more than 0.5 cm. The average of the two closest measurements was recorded as height. Height was measured first as it is the least intrusive and needed as input for the next measurement.

Weight, body fat percentage: Body weight and body fat percentage were measured next using a Tanita UM-081 scale. They followed height due to their sensitive nature, relative to height. Participants were instructed to enter their age, gender, and height into the scale. Weight was recorded to the nearest 0.1 kg and body fat percentage was recorded to the nearest 0.1%. Each participant in the pair was measured twice, with a third measurement necessary if the difference in weight (waist circumference) measurements was greater than 0.2 kg (0.5%). The average of the two closest measurements was recorded as weight. Body mass index (BMI) was computed as weight (kilograms) divided by height squared (meters).

Waist circumference: Waist circumference was assessed using a DiCUNO measuring tape. Participants were instructed to measure the waist below the belly button and on the skin. The measurement was taken at the end of a normal exhalation and recorded to the nearest 0.1 cm. If the difference between two measurements was greater than 1 cm, a third measurement was taken. The average of the two closest measurements was used to determine waist circumference. Abdominal waist circumference was assessed last as it is the most intrusive.

2.4. Analysis

Mean values and standard deviation of height, weight, BMI, body fat percentage and waist circumference were computed for each approach, VCAM or staff measured. Next, we computed within-person differences between VCAM and staff measurements; the average within-person difference, along with its effect size (i.e. difference in standard deviation units) are reported. Agreement was investigated by computing Pearson correlation and Bland-Altman plots (Martin Bland and Altman, 1986) of differences versus staff measurement with 95% limits of agreement (LOA). The Bland Altman test is a statistically robust method of assessing reliability and agreement (Giavarina, 2015). We also computed sensitivity and specificity to assess classification ability. Analyses were conducted in SAS 9.4.

3. Results

3.1. Sample characteristics

The sample is diverse in terms of age (mean of 26 years; range: 13–58 years), sex (60% female), racial-ethnic composition (26% white, 24% Hispanic, 6% black, 44% multi-ethnic), and anthropometrics (16% overweight or obese).

3.2. Differences between VCAM and staff measurements

Table 1 shows the mean and standard deviations for the two approaches (columns 2–3). Weight, BMI and body fat percentage have the smallest mean (raw) difference of 0.04 lbs, −0.07 units and −0.03%, respectively, corresponding to a very small effect size. Mean differences for height and waist circumference were only slightly larger, corresponding to a small effect size (ES = 0.03). The standard deviations across the two approaches were similar.

3.3. Agreement between VCAM and staff measurements

The Bland Altman plots and LOA provide an indication of bias and discrepancy in VCAM, relative to staff measurements (Fig. 1). The mean differences for height and waist circumference indicated slight over and under estimation, respectively, by VCAM; mean difference for others

Table 1

Comparison of VCAM vs. Staff Measurement.

| Anthropometrics | VCAM, Mean (SD) | Staff-Measured, Mean (SD) | Mean Difference (SD)a | Effect Sizeb |
|-----------------|----------------|--------------------------|----------------------|-------------|
| Weight (lbs)    | 150.9 (32.4)   | 150.8 (32.5)             | 0.04 (0.9)           | 0.00        |
| Height (inches) | 66.7 (3.9)     | 66.6 (3.8)               | 0.11 (0.2)           | 0.03        |
| Body mass index (BMI) | 23.8 (4.5)   | 23.8 (4.5)               | −0.07 (0.02)         | −0.02       |
| Body fat percentage | 24.2 (10.4)  | 24.2 (10.4)              | −0.03 (2.0)          | 0.00        |
| Waist circumference (inch) | 32.9 (4.6) | 33.1 (4.8)               | −0.14 (0.9)          | −0.03       |

a Difference = VCAM - Staff measured.

b Average difference divided by standard deviation; SD = standard deviation.
are around zero implying no bias. The 95% LOAs are: 1.83 and −1.74 lbs for weight, 0.41 and −0.20 in. for height, 3.93% and −3.98% for body fat percentage, 1.54 and −1.83 in. for waist circumference, and 0.27 and −0.41 units for BMI. There was no visible relationship between bias (y-axis) and magnitude of staff measurements (x-axis). The Pearson correlation coefficients were: 0.99 for weight (p-value < 0.0001), 0.99 for height (p-value < 0.0001), 0.98 (p-value < 0.0001) for body fat percentage, 0.98 (p-value < 0.0001) for waist circumference and 0.99 (p-value < 0.0001) for BMI. The sensitivity for overweight, obesity and combined overweight/obesity status was
90.0%, 71.4% and 94.1%, respectively. The specificity for overweight, obesity and combined overweight/obesity status was 95.0%, 100% and 100%, respectively.

4. Discussion

This study is the first to provide preliminary findings on the feasibility of collecting anthropometric measurements through video-conference. Both adolescent and adult M-TEENS participants were guided by study staff remotely via live video to take measurements, which were comparable to staff measurements. For BMI, the LOAs were acceptable (0.27 and –0.41 units) and less than clinically meaningful differences. For comparison, we found studies reporting LOAs of differences between self-reported and staff-measured BMI; those LOAs were much wider, suggesting that VCAM has greater agreement with staff measurements than self-reports (Davies et al., 2019; Yoong et al., 2013; Pursey et al., 2014). Instead, the LOAs for waist circumference and body fat percentage suggest less precision compared to BMI. We compared our results to another study comparing accuracy of anthropometric measurements by school staff (physical education instructors or nurses) versus trained study personnel; the mean differences for the two for weight (lbs.), height (in.) and BMI were 0.2 (4.2), –0.12 (6.3) and 0.1 (0.9), which are slightly larger with less precision than our estimates in Table 1 (Thompson et al., 2019).

An important benefit of VCAM is greater flexibility and simpler logistics of scheduling measurements. The M-TEENS has a large, geographically dispersed sample across the U.S., so that site visits to conduct measurements occur over a short window (e.g. two days or a weekend); this may also require participants to travel some distance to the nearest measurement site. People in difficult-to-access (e.g. rural) areas who may be excluded due to the difficulty of conducting in-home measurements, may now be easier to assess with the option to use VCAM. Another potential benefit of VCAM is cost savings by reducing (e.g. staff travel time) or eliminating (e.g. airfare) certain costs associated with in-person measurements, which are especially high for dispersed samples. Also, the sample representativeness and validity of sensitive measurements (e.g. waist circumference) may improve if in-home data collection by VCAM translates into a reduction in stigma. In fact, we may see many of the same benefits as encountered by tele-health studies (Hjelm, 2005).

As with most benefits, there are trade-offs. Conducting VCAM measurements requires internet service. Each VCAM assessment involves two people, and two incentives per measurement. There are several logistical considerations, too. Providing study participants with equipment means larger quantities of these, coordinating shipping and equipment return (which may add to participant burden), with associated monetary costs. These demands are in lieu of coordination of site visits, travel by study staff and scheduling participants at measurement sites. Thus, there is a cost-benefit consideration for each study. Cost effectiveness should be explored.

Although these findings are promising, several limitations are worth noting. One limitation is that participants knew they would be measured by a staff member before they did the VCAM, which may have improved the accuracy of their VCAM assessment. In practice, we would use VCAM instead of staff measurements. However, one study that compared self-reported height and weight to staff measurements found that knowledge of being measured did not change accuracy of self-reports (Yoong et al., 2013). A second limitation is that we used a convenience sample with small sample size; also, the percent overweight and obese in the pilot study sample is 16% which does not reflect the U.S. population. Therefore, our study findings need to be replicated with a large, population-representative sample. Also, the small sample of study participants with overweight or obese status means that the sensitivity and specificity estimates need to be re-computed with studies with larger sample size. Despite limitations, the demonstrated validity of VCAM and its ability to capture participants’ measurements from any location, makes it a promising approach to conduct anthropometric assessments.

5. Conclusion

In-person measurements by trained personnel are the current standard for collecting accurate BMI measurements over other methods such as self- or proxy-reports. However, in-person measurements can be costly and limit participation (due to scheduling or other logistics), especially in studies that involve a geographically-dispersed or difficult-to-access samples. Completing height and weight measurements through videoconference may be a cost-effective, valid alternative for body composition measurements.

CRediT authorship contribution statement

Madhumita Ghosh-Dastidar: Methodology, Writing - original draft. Nancy Nicosia: Conceptualization, Writing - review & editing. Ashlesha Datar: Conceptualization, Writing - review & editing, Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

We gratefully acknowledge pilot study participants, Sarah White for data collection assistance for this pilot study, and Ingrid Maples for manuscript formatting.

Funding

This research was supported by National Institute of Child Health and Human Development (grant no. R01HD067536) and National Institute of Diabetes and Digestive and Kidney Diseases (grant no. 1R01DK111169).

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