Validation of Breast Idea Volume Estimator Application in Transfeminine People

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Background: Accurate estimation of breast volume is important as researchers aim to achieve optimal feminization for transfeminine people. The Breast Idea Volume Estimator (BIVE) application allows estimation of breast volume using two-dimensional (2D) photographs but has not been validated in the chests of people who have undergone testosterone-mediated puberty.

Methods: To estimate breast volume, clinical photographs and 3D scans were collected at baseline and 6 months, as a prespecified secondary outcome of a randomized clinical trial of antiandrogen therapy in transfeminine people commencing hormone therapy. BIVE was used to estimate breast volume by two independent researchers and compared with the gold standard of 3D scan calculated volume at different timepoints. Statistical analysis was performed, including the mean absolute difference, standard error of measurement, and intraclass correlation, to determine accuracy, precision, and interrater agreement.

Results: Clinical photography and 3D scans were collected from 82 breasts of 41 participants. The median (interquartile range) age of participants was 25 (22–28) years, and the median (interquartile range) body mass index was 24.6 (21.2–28.9) kg/m². The BIVE sagittal and transverse algorithms demonstrated robust performance, with mean absolute difference less than 20 mL and intraclass correlation greater than 0.87 indicating clinical reliability with high interrater agreement.

Conclusions: BIVE provided an accurate, precise, and reliable measure of breast volume in the chests of people who have undergone testosterone-mediated puberty, compared with the gold standard of 3D scan. (*Plast Reconstr Surg Glob Open 2024; 12:e6131; doi: 10.1097/GOX.0000000000006131; Published online 3 September 2024.*)

INTRODUCTION

People with a female or nonbinary gender whose sex was recorded as male at birth (herein collectively referred to as transfeminine people) may seek hormone therapy to achieve physical changes aligned with their experienced gender identity. Treatment regimens typically include an estrogen with or without an antiandrogen to decrease the production and/or effects of androgens such as testosterone.[1–3] Typical changes of feminization include gradual breast development, body fat redistribution to gynoid areas, and decreased growth of facial and body hair over months to years.[1]

The degree of breast development observed with feminizing hormone therapy in transfeminine people is typically less than cisgender women: after 3 years of feminizing hormone therapy, the average breast volume was 100 mL and cup size was smaller than an A-cup.[4] The peak rate of change in breast development as measured by the breast chest distance appeared to occur in the first 6 months of hormone therapy,[5] but further longitudinal follow-up showed that estimated breast volume from a three-dimensional (3D) scanner continued to increase despite the breast–chest distance plateauing at 9 months.[4]

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This smaller breast volume, and anatomical differences (such as the increased thoracic length, sternal width, and increased distance between the nipple-areolar complex) observed in those who undergo testosterone-mediated puberty[6] may contribute to high rates of breast dissatisfaction and breast augmentation surgery observed in some studies. For example, in a Dutch cohort of 773 transfeminine people, 40% underwent and an additional 41% considered breast augmentation.[7]

Estimates of breast volume are utilized by plastic and reconstructive surgeons for the purposes of planning aesthetic and reconstructive breast surgery. Recently, there has been interest in measuring breast volume in transfeminine people taking feminizing hormone therapy to identify any factors associated with improved breast development. Reported methods include self or clinician assessment of Tanner stage, breast–chest distance,[5] water displacement techniques, thermoplastic castings, magnetic resonance imaging (MRI), and 3D imaging techniques.[8–10] Several studies have shown that 3D imaging can provide high fidelity estimates of breast volume comparable to the gold standard of MRI.[8–10]

Despite these developments, accessibility and cost of 3D imaging equipment and software remains a barrier for routine clinical use. For example, a commercial 3D scanner may cost US $20,000–$30,000 for procurement plus ongoing costs. In comparison, the Breast Idea Volume Estimator (BIVE) is a freely available web-based application that allows estimation of breast volume using only clinical photographs. To use the BIVE application, users must first upload photographs of the breasts from a frontal, left lateral, and right lateral view including a reference landmark of known length. These photographs can be taken with a standard digital camera or smart phone with appropriate patient consent. The user then identifies key anatomical landmarks which are used by the algorithm to estimate the volume of each breast. (**See figure, Supplemental Digital Content 1**, which displays use of the BIVE application to calculate breast volume. Key landmarks are identified by the user using photographs from a frontal and left/right lateral view. http://links.lww.com/PRSGO/D476.)

User training and experience in identifying key anatomical landmarks is required for reproducible results. This tool has previously been validated in cisgender women[11] but not in transfeminine people. Here, our objective was to assess the performance of a new module on the BIVE application (modified BIVE) to estimate breast volume of transfeminine people who had undergone testosterone-mediated puberty before commencing feminizing hormone therapy, at different stages of breast development, with comparison to a gold-standard measurement of 3D scanning.

METHODS

We recruited transfeminine people older than 18 years of age and newly commencing feminizing hormone therapy as part of a randomized clinical trial of antiandrogen therapy (Australia and New Zealand Clinical Trials Registry ID 12620000339954).

Measurement of breast volume via clinical photography and 3D scanning was a prespecified secondary endpoint of this trial and was performed at baseline and 6 months. The 3D models were obtained using a low-grade 3D scanner (Kinect for Windows v2; Microsoft, Redmond, Wash.) to take 32 scans in a 180-degree arc. These meshes were then combined using dedicated software (KScan 3D, LMI Technologies, Vancouver, British Columbia, Canada). Clinical photography was performed using a digital camera in a standard clinic environment, with frontal, left lateral, and right lateral views. Three pieces of blue tape with a known width of 28 mm were placed horizontally below the clavicle and vertically on the left and right anterior axillary lines, respectively, to allow translation of known distances to pixel distances in the BIVE application (**Supplemental Digital Content 1**, http://links.lww.com/PRSGO/D476).

The BIVE application was used independently by two researchers of varying expertise in breast measurement (A.K.T. is a plastic surgeon and M.M. was a medical student) to estimate breast volume. All measurements were performed using the standard algorithm (validated for chests of cisgender women) and a modified algorithm to account for anatomical differences for those who have undergone testosterone-mediated puberty. Breast volumes calculated from 3D scan models were estimated by one researcher (M.M.).

Statistical analysis was performed using MedCalc (MedCalc Software Ltd, Ostend, Belgium). The mean absolute difference was used to measure accuracy, that is, the degree of relation between the volumes of the scanned breasts and the volumes measured in BIVE. Intraclass correlation coefficients were used to present both absolute reliability and relative reliability (measurement precision). A clinically oriented intraclass correlation should be greater than 0.87 to demonstrate reasonable reliability.[12]

Ethics and governance approvals were obtained from Austin Health (HREC/44503/Austin-2018) and LGBT community-controlled organization Thorne Harbour Health Community Research Endorsement Panel (THH/CREP 20-002). Participants provided written informed consent, and the procedures followed were in accordance with institutional guidelines.

Takeaways

Question: Given sex differences in chest anatomy that occur during puberty, is the Breast Idea Volume Estimator (BIVE) module accurate and reliable for estimating breast volume in people who have undergone testosterone-mediated puberty?

Findings: In 41 transfeminine people assessed in the first 6 months of feminizing hormone therapy, breast volume was estimated using the BIVE module and compared with the gold standard three-dimensional scan. BIVE sagittal and transverse algorithms performed well, with high clinical reliability and interrater agreement.

Meaning: The BIVE application has been validated to estimate breast volume in chests of transfeminine people and provides a free and accessible tool for clinicians and researchers.

Table 1. Participant Demographics

N = 41	
Age, y	25 (22, 28)
Body mass index, kg/m²	24.6 (21.2, 28.9)
Race	
White	40 (98)
Black	1 (3)
Asian	2 (5)
Mixed	2 (5)
Country of birth	
Australia	37 (90)
New Zealand	2 (5)
Other	2 (5)

Categorical values presented as N (%). Continuous variables presented as median (IQR). Participants self-nominated race and were able to choose multiple categories.

RESULTS

Participant Characteristics

The volumes of 82 breasts from 41 participants were calculated using the BIVE application and compared with the gold standard 3D scan. Participant demographics are detailed in Table 1. The median [interquartile range (IQR)] age of participants was 25 years (22–28 y), and the median (IQR) body mass index was 24.6 kg/m² (21.2–28.9 kg/m²). The majority of participants were White (n = 40, 98%) and born in Australia (n = 37, 90%).

Performance of BIVE Application Compared with Gold Standard

The accuracy and precision of measurement using the BIVE application are presented in Tables 2 and 3 for the transverse algorithm and sagittal algorithm, respectively. The transverse and sagittal algorithms performed well compared with the gold standard, with a mean absolute difference less than 20 mL, and intraclass correlation greater than 0.87 indicating clinical reliability and high interrater agreement. The "closest match" algorithm, whereby the sagittal algorithm was chosen for participants with typical feminine pendulous breasts and the transverse algorithm was chosen for participants with flatter breasts, and further improved accuracy and reliability (Table 4).

DISCUSSION

In this study, use of the BIVE application to estimate breast volume in transfeminine people before and 6 months after commencing feminizing hormone therapy

Table 2. Accuracy, Precision, and Interrater Agreement of the Transverse Algorithm

Transverse Algorithm	Observer 1 (A.K.K.-T.)	Observer 2 (M.M.)
Accuracy		
Mean absolute difference (SD), mL	8.27 (8.01)	9.58 (12.78)
Precision (relative reliability)		
Intraclass correlation (95% CI)	0.9930 (0.9891–0.9955)	0.9486 (0.9203–0.9669)
Standard error of measurement, mL	0.20	0.93
Interrater agreement (absolute reliability)		
Intraclass correlation (95% CI)	0.9801 (0.9692–0.9872)	
Standard error of measurement, mL	0.4087	

CI, confidence interval.

Table 3. Accuracy, Precision, and Interrater Agreement of the Sagittal Algorithm

Sagittal Algorithm	Observer 1 (A.K.K.-T.)	Observer 2 (M.M.)
Accuracy		
Mean absolute difference (SD), mL	15.38 (23.18)	9.55 (9.63)
Precision (relative reliability)		
Intraclass correlation (95% CI)	0.9974 (0.9974–0.9983)	0.9892 (0.9833–0.9930)
Standard error of measurement, mL	0.57	0.23
Interrater agreement (absolute reliability)		
Intraclass correlation (95% CI)	0.9637 (0.9438–0.9766)	
Standard error of measurement, mL	0.3047	

CI, confidence interval.

Table 4. Accuracy, Precision, and Interrater Agreement of the Closest Match Algorithm

Closest Match Algorithm	Observer 1 (A.K.K.-T.)	Observer 2 (M.M.)
Accuracy		
Mean absolute difference (SD), mL	7.22 (7.40)	6.47 (6.19)
Precision (relative reliability)		
Standard error of measurement, mL	0.19	0.15
Interrater agreement (absolute reliability)		
Intraclass correlation (95% CI)	0.9850 (0.9753–0.9907)	
Standard error of measurement, mL	0.19	

CI, confidence interval.

was highly reliable when compared with the gold standard 3D scan.

Although breast tissue of both sexes is identical at birth, testosterone-mediated puberty causes involution and atrophy of ducts, resulting in breast tissue largely composed of subcutaneous fat, stromal elements, and a small nipple-areolar complex with absence of the Cooper ligament.[13] In contrast, estradiol-mediated puberty typically results in ductal proliferation, branching, and growth, with maturation of the terminal ductal-lobular unit attributed to the effects of progesterone.[14] Compared with cisgender women, transfeminine people who have previously undergone testosterone-mediated puberty before commencing hormone therapy typically have the following differences: a wider sternum, larger distance between nipple-areolar complexes, shorter nipple-inframammary fold distance, broader shoulders, and more prominent pectoral muscles.[6] As such, conventional techniques used to estimate breast volume may not have been validated for transfeminine people.

The BIVE application has two available algorithms: (1) sagittal, which emphasizes the lateral profile of the breasts and (2) transverse, which emphasizes the frontal curvature of the breast. Use of the standard algorithm was more suitable for typical pendulous breasts because it was easier to demarcate the lateral outline of the breast with volume mostly below the nipple. The development of a modified BIVE algorithm to account for anatomical differences in those who had undergone testosterone-mediated puberty resulted in improved reliability in those in which the breast volume is mostly under the areola.

Compared with other available methods (eg, MRI, 3D scanning), use of clinical photography and the BIVE application provides an efficient, free, and accessible alternative to estimate breast volume with an acceptable degree of error in the clinic setting. This is particularly useful in settings where financial resources and/or physical space are scarce. This tool has now been validated in a sample of participants with heterogenous chest shapes. Use of the BIVE application has numerous potential applications in medical, surgical, and research settings. To date, we have used BIVE to estimate breast volume in a randomized clinical trial comparing different feminizing hormone regimens in transfeminine people and are currently evaluating the utility of BIVE in assisting with the selection of implants for surgical planning compared with clinical judgment alone. In transfeminine people taking hormone therapy, serial measurement of breast volume may inform treatment decisions (eg, change of therapy or recommendation for surgery) if breast growth seems to have plateaued and patients are dissatisfied, or be used for patient education.

Limitations of this study include the user training required to become proficient in estimating breast volume using the BIVE application, and that the participants included were predominantly White, which may limit generalizability of findings.

CONCLUSIONS

Use of the BIVE application to estimate the breast volume in transfeminine people commencing feminizing hormone therapy was accurate and reliable compared with the gold standard of 3D scanning. The BIVE application provides a free, accessible, and efficient tool for clinicians and researchers to document breast volume and has a number of potential clinical and research applications, especially in settings with limited financial resources and/or physical space.

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