



New Methods for the Objective Measurement of Bra Fit

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Introduction: The fit of a bra is critical, not only from a comfort and support perspective but it can significantly impact on the health and well-being of the wearer (Chan *et al.* 2001). Bra fitting is particularly important for adolescent females as it can affect the size, shape, and composition of their bones and breasts during this growth period (Strasburger 2006). Wood *et al.* (2008) found that 80% of young women, aged 18-26, that they investigated, wore the wrong-sized bras.

Bra fitting is still an inherently subjective process. It relies on the experience of a professional bra fitter to assess the fit against a checklist of fitting criteria. More accurate fitting could be achieved if the process was made more objective.

This paper presents the results of a study to objectively measure the fit of crop-top bras. Crop top bras are currently very popular because they are highly extensible, body hugging garments that are comfortable to wear, imperceptible under clothing and protective. Furthermore they have no supporting wires to cause excessive skin pressure which may inhibit body growth (Ashby 2005). However a critical feature of these bras is that they can cause breast deformation which detracts from their other beneficial features. This study specifically addresses these effects of breast deformation and defines new, objectively measurable parameters to quantify it, through a series of wearer trials and the analysis of 3D body scans conducted for a range of commercial crop top bras and newly developed bras with increased cup volumes designed to reduce the effects of breast deformation.

Methods: To evaluate both the newly designed and commercial crop-top bras, 25 college females aged 20.8 ± 1.47 and with a BMI of 20.22 ± 2.15 participated in a wearer trial. Each participant was asked to rate their breast shape using magnitude scaling whilst wearing, in turn, a newly designed crop top bra with increased bust volume and the best fitting crop top bra selected from a range of commercial bras. The scores rated were normalized to equal scales ranging from 0 (worst) to 10 (best) prior to data analysis. To determine the effects of breast deformation, all the wearers were subsequently scanned both nude and wearing both the bras using a VOXELAN 3D laser body scanner to generate a set of 3D image data. Body data was processed and extracted using Rapidform™ software.

Findings: To evaluate and compare the effects of breast deformation of the commercial bras and the new design, three parameters - the bust radius of curvature, bust angle and bust depth-height ratio were measured for each participant from side-view vertical sections through the scanned images. Figure 1 illustrates these measurements. The ratio of each of the three parameters for both the nude body and the body when wearing the bras gives a measure of the breast deformation. The ideal ratio is 1, implying no deformation. A value less than 1 implies bust compression; a value greater than 1 implies bust uplift and enhancement. Figure 2 shows graphs of the ratios plotted against the subjects' score for their breast shape wearing the different bras.

The three indices of fit: the bust radius of curvature ratio ($r=0.44$), bust angles ratio ($r=0.58$) and bust depth-height ratio ($r=-0.57$) were significantly ($p<0.01$) correlated with the subjective ratings of breast shape. The graphs also clearly indicate the subjects higher scoring for (and hence preference for) the breast shaping for the new design compared to the commercial bras. These findings imply that the three parameters can be confidently applied to, indicate and objectively measure deformation in breast shape and, hence, the fit of bras.

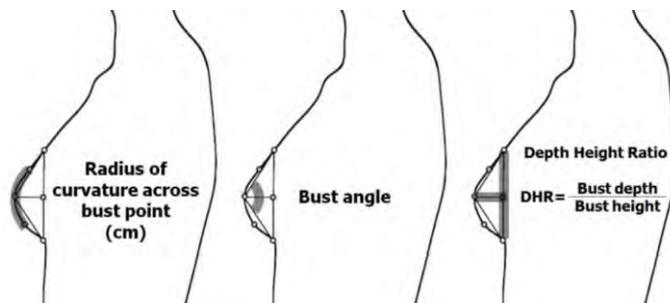


Figure 1. Bust indices of fit for quantifying the bust compression

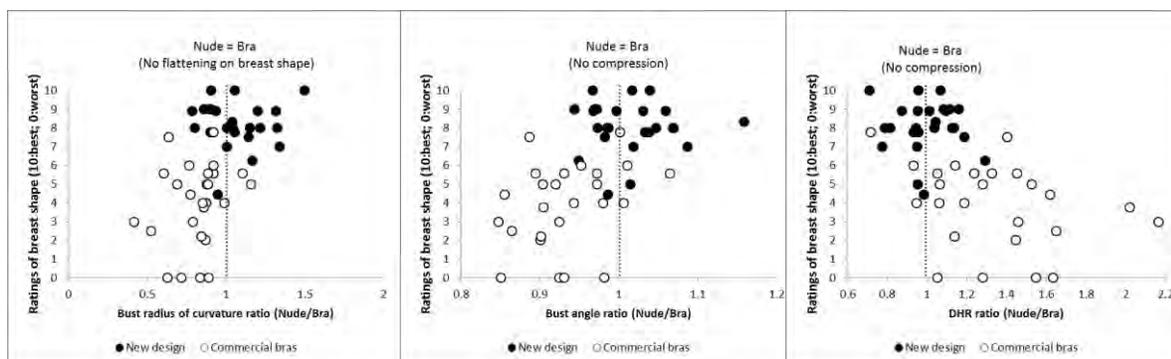


Figure 2. Subjective breast shape rating scores vs. three parameters (Nude/Bra)

Conclusion: Three key indices of fit - bust radius of curvature ratio, bust angle ratio and bust depth-height ratios have been newly defined to quantify the fit of bras with respect to their effects of breast deformation. The ideal ratio for each parameter is 1, which implies no breast compression, good fit and good shaping for crop top bras. This shape ratio concept can be applied to other stretch-to-fit types of apparel products, e.g. compression garments, swimwear and intimate apparel.

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