INVESTIGATION OF GENDER-SPECIFIC RISKS OF SKIN FOLDING AFTER BARIATRIC SURGERY: A COMPUTATIONAL APPROACH

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Introduction

Obese individuals who experience significant weight loss after bariatric surgery may have difficulty with excess skin that cannot adjust to their new body size [1]. Excess skin can lead to skin folding, which can be a source of dissatisfaction for many, with ~80% of women complaining about excess skin in the abdomen region and desiring body contouring surgery. About 20% of men also have problems with redundant skin, mainly in the abdomen [2]. The abdomen comprises organs and adipose tissue composed of visceral adipose tissue (VAT) and subcutaneous adipose tissue (SAT). The distribution of fat within these layers differs between men and women, with a relatively higher content of SAT in women and a higher content of VAT in men [3]. Using a computational model, we investigated if these differences in local fat distribution and reduction during weight loss can (partly) explain the differential risk of skin folding in women and men. We hypothesized that women are more likely to develop skin folding due to the relatively high reduction of SAT volume compared to men, while reducing VAT volume in men leads to less significant skin folding [4].

Methods

We developed a finite element model to simulate fat loss with a kinematic growth model implemented in Abaqus/Explicit via a user-defined subroutine (VUMAT). The fat loss starts at an initial state of extreme obesity with a Body Mass Index (BMI) of 60 kg/m^2, and we simulated a 75% fat reduction to reach a BMI of 30 kg/m^2. We mimicked the fat loss in a simplified 3D belly geometry, which consisted of four layers: organs in the core, VAT, SAT, and skin, all modeled as a compressible Neo Hookean materials. We based the fat distribution ratio h_{VAT}/h_{SAT} and the local fat loss ratio VAT_{loss}/SAT_{loss} for females and males on literature data (Table 1) [3], [4].

	Women	Men
h_{VAT}/h_{SAT}	2.4	3
VAT_{loss}/SAT_{loss}	0.33-4	0.33-4

Table 1: VAT and SAT thickness ratio (h_{VAT}/h_{SAT}) based on ultrasound measurements of fat thickness [3], and local fat loss ratio (VAT_{loss}/SAT_{loss}) in women and men.

Results

We evaluated differences in skin folding patterns using the radius distribution in the abdomen (Fig. 1). In the female case, reducing SAT (VAT_{loss}/SAT_{loss} >1) led to multiple and prominent folds (Fig.1) compared to the male situation, where a reduction in VAT volume (VAT_{loss}/SAT_{loss} <1) resulted in fewer skinfolds (Fig.1). Interestingly, men's skinfold patterns were similar for high ratios, with a more uniform radius distribution. This suggested a tendency towards changes in waist circumference instead of skinfold formation.

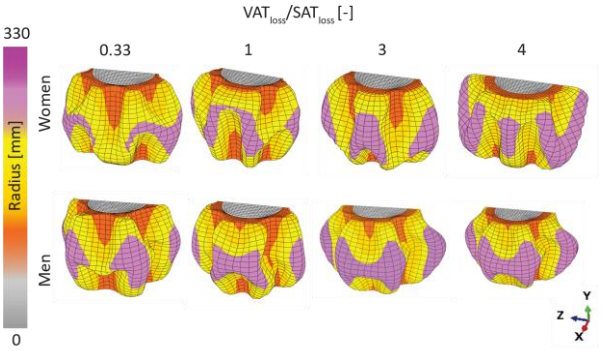

Figure 1: Skinfold patterns with increasing VAT_{loss}/SAT_{loss} ratios (from left to right) in women (top) and men (bottom). The colorbar represents the distance from the center of the abdomen.

Discussion

Our simulations showed that the sex-specific fat distribution and local differences in fat reduction can affect the skinfold patterns in women and men, and support our hypothesis that women have an increased risk of skinfold formation after bariatric surgery.

In future research, we aim to incorporate gravity and skin-rib connections to improve the accuracy of skinfold predictions. Such an improved model may help in identifying individuals with a high risk of skin folding prior to the weight loss.

References

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