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Calculating the Thickness of the Superficial Fatty Layer of the Body Using Age, Gender, and Body Mass Index

Sebastian Cotofana MD PhD,[a,b] Doris Hexsel MD,[c] Luiz E.T. Avelar MD,[d] Christine G. Munia MD,[e] Mariana Muniz MD,[f] Gabriela Casabona MD,[g] Thilo L. Schenck MD PhD,[h] Jeremy B. Green MD,[i] Nirusha Lachman PhD,[j] Konstantin Frank MD[h]

[a]Division of Anatomy, Department of Medical Education, Albany Medical College, Albany, NY
[b]Division of Plastic Surgery, Department of Surgery, Albany Medical Center, Albany, NY
[c]Brazilian Centre for Studies in Dermatology, Porto Alegre, Brazil
[d]Private Practice, Belo Horizonte, Brazil
[e]Private Practice, Sao Paolo, Brazil
[f]Private Practice, Sao Paolo, Brazil
[g]Ocean Clinic, Marbella, Spain
[h]Department for Hand, Plastic and Aesthetic Surgery, Ludwig – Ludwig Maximilians University of Munich, Germany
[i]Skin Associates of South Florida, Coral Gables, FL
[j]Mayo Clinic College of Medicine and Science, Mayo Clinic, Rochester, MN

ABSTRACT

Background: Injections of biostimulator agents are increasing in popularity as an alternative to surgical or energy-based skin tightening procedures. The present study was designed to develop a formula that helps to guide health care providers injecting biostimulators into the correct plane to enhance effectiveness and longevity by targeting precisely the superficial fascial system.

Methods: 150 Caucasian individuals (75 males and 75 females) were investigated with a balanced distribution of age (n=30 per decade: 20–29, 30–39, 40–49, 50–59, and 60–69 years) and body mass index (n=50 per group: BMI≤24.9kg/m^2, BMI between 25.0 and 29.9kg/m^2 BMI≥30kg/m^2). The distance between skin surface and the superficial fascia was measured via ultrasound in the buccal region, premasseteric region, the lateral neck, posterior arm, abdomen, buttocks, anterior thigh, medial thigh, and posterior thigh.

Results: Mean thickness of the superficial fatty layer is variable between the different locations investigated with smallest values for the lateral neck of 3.71mm ± 0.55 [range, 2.00–5.00mm] and greatest values for the gluteal region with 20.52mm±10.07 [range, 6.10–38.40mm]. A formula was developed to estimate the thickness of the superficial fatty layer based on the targeted region, age, gender, and body mass index of the patient: Thickness of superficial fatty layer (mm): Region constant + (XX* BMI) - (YY*Age).

Conclusions: Injections of biostimulators deeper than the calculated values might result in reduced efficacy as the superficial fascial system is not targeted and the effected collagen neogenesis does not affect the skin surface.

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INTRODUCTION

Non-surgical, minimally invasive skin tightening procedures have been shown to provide improvements for patients seeking skin-lifting and/or skin-tightening to overcome the signs of aging.[1–10] The annually statistics report by the American Society of Plastic Surgeons, revealed that a total of 500,428 procedures were performed utilizing biostimulators in 2017.[11] In 2018, this number increased by 0.5% to 502,687 procedures performed in the US alone.

The subdermal architecture is arranged in layers with the following sequence from superficial to deep: skin, superficial fat, superficial fascia, deep fat, and deep fascia.[12,13] This layered arrangement can be found throughout the entire body.[14–18] Of those described layers, the skin, the superficial fatty layer which includes short connective tissue fibers that connect the skin to the superficial fascia and the superficial fascia itself are considered to be a functional biomechanical unit, which has been previously termed the superficial fascial system.[17,19–24] The superficial fascial system has been shown to provide major structural support for the skin and the subcutaneous fat as inclusion of this system into suturing techniques increases wound strength resulting in a better aesthetic and functional outcome after surgical procedures.[25]

The superficial fatty layer and the short connective tissue fibers within it have been previously identified to play a key role in the formation of surface irregularities observed in cellulite.[14] This indicates that the subdermal attachment of the short connective tissue fibers influences the position and the tension of the overlying skin.

Agents classified as biostimulators are injected into the subcutaneous tissue to induce neocollagenesis.[7,9,26] It can be assumed that placing the product deep to the superficial fascial system may result in a limited skin tightening effect as the short connective tissue fibers or the superficial fascia are not precisely targeted. On the contrary, it can also be assumed that biostimulator agents have their greatest effect on the skin surface if they are positioned inside the superficial fascial system ie, between the skin and the superficial fascia where they can directly affect the subdermal short connective tissue fibers improving skin firmness and the support of subcutaneous structures. Of note, this subdermally located layer of fat has been shown to vary in thickness with age, body mass index (BMI), and gender.[15,16,18] This can create challenges in correct product placement and can thus influence the aesthetic outcome of the procedure.

The goal of this ultrasound-based study is to measure the thickness of the superficial fatty layer in a large sample with a balanced distribution of gender, BMI, and age. The measurements will be used to develop mathematical formulas whereby the thickness of the superficial fatty layer can be estimated based on the information of gender, BMI, and the age of the patient. This could potentially guide practitioners to more effective outcomes with biostimulator products as the superficial fatty layer including the short connective tissue fibers can be precisely targeted.

TABLE 1.

Table Showing the Demographic Data of the Study Sample

	n = 150
Gender: n (%)	
Women	75 (50)
Men	75 (50)
Mean Age (years; mean ± SD) [range]	44.02 ± 14.11 [20-69]
Body Mass Index (kg/m²; mean ± SD) [range]	26.93 ± 4.5 [19.6 – 39.2]
Body Mass Index (kg/m²): n (%)	0.3
< 25	50 (33.3%)
25 – 29.9	50 (33.3%)
> 30	50 (33.3%)
Age (years): n (%)	
20 – 29	30 (20)
30 – 39	30 (20)
40 – 49	30 (20)
50 – 59	30 (20)
60 – 69	30 (20)

MATERIALS AND METHODS

Study Sample

150 Caucasian individuals (75 males, 75 females) with a mean age of 44.03 ± 14.08 years [range, 20–68 years] and a mean BMI of 26.93 ± 4.49 kg/m² [range, 19.57–39.18] and Fitzpatrick skin types I–III were investigated applying ultrasound imaging (Table 1). The study was conducted between January and December 2017 at the Vida Skin Surgery and Laser Centre, Clinica Vida, Sao Paulo, Brazil.

The total sample consisted of 15 males and 15 females from each of the following decades: 20–29 years, 30–39 years, 40–49 years, 50–59 years, and 60–69 years. Of the 30 individuals investigated (15 males and 15 females) per decade, 10 individuals (5 males and 5 females) had a BMI ≤24.9 kg/m², 10 individuals (5 males and 5 females) had a BMI between 25.0, and 29.9 kg/m², and 10 individuals (5 males and 5 females) had a BMI ≥30 kg/m² (Table 1).

Written information and verbal explanations about the aims and the scopes of the study as well as about the risks of the procedure (ultrasound imaging) were provided to the participants before the inclusion into this study. Following the Declaration of Helsinki protocols (1996), written informed consent to participate in this study was obtained from all participants. This study was conducted in accordance with regional laws and good clinical practice.[27]

Ultrasound Imaging

Ultrasound imaging was performed using a linear 15 MHz transducer (MTurbo portable, Fujifilm SonoSite, Inc., Bothell). Patients were standing upright during the scanning process to account for the effects of gravity. Measurements were performed without application of pressure to the skin as the transducer was placed into the visualization gel only without direct skin contact (Aquasonic® Clear Ultrasound Gel, Parker Laboratories Inc., Fairfield, NJ). Measurements were performed bilaterally in the following locations (Figures 1-3):

FIGURE 1. Photograph of a female head from the right lateral side. The location in which the ultrasound imaging was performed at the buccal region, the premasseteric region and the lateral neck has been marked by the blue lines.

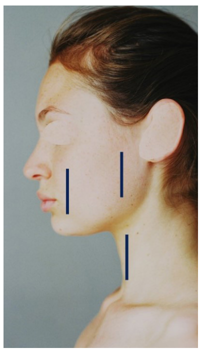
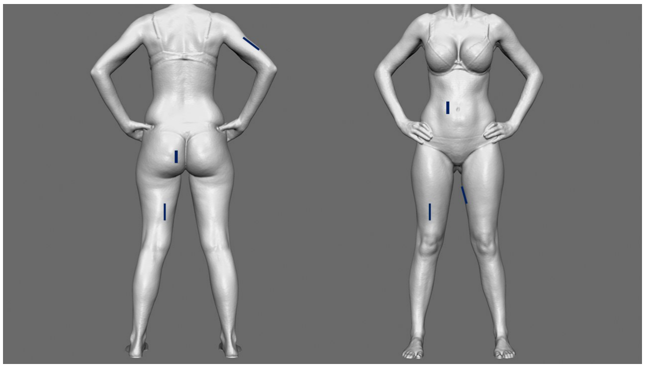


FIGURE 2. Processed 3D scan showing a 22-year-old female from anterior. Ultrasound imaging was performed at the locations marked with the blue line (abdomen, gluteal region, posterior arm, anterior thigh, medial thigh, and posterior thigh).



Face: Buccal region: In a vertical line 1cm posterior to the modiolus (Figure 1 and 4)
Premasseteric Region: In a vertical line 1 cm anterior to the angle of the mandible (Figure 1 and 4)
Neck: Lateral neck: In a vertical line 5 cm inferior to the midline of the mandible (Figure 1)
Arms: Posterior medial third of the arm in the midline (when viewed from posterior) (Figure 2 and 5)
Abdomen: Lateral Abdomen: At the level of the umbilicus in the mid-clavicular line (Figure 2 and 6)
Buttock: Gluteal region: 3 cm superior to the infra-gluteal sulcus in the middle of the buttock (Figure 2 and 7)
Thighs: Anterior thigh: Anterior lower third of the thigh, 5 cm superior to the superior border of the patella in the midline of the thigh (when viewed from anterior) (Figure 2 and 8)
Medial thigh: Medial upper third of the thigh in the midline of the thigh (when viewed from medial) (Figure 2 and 9)
Posterior thigh: Posterior upper third of the thigh in the midline of the leg (when viewed from posterior) (Figure 2 and 10)

All measurements were performed bilaterally. The thickness of the superficial fatty layer was measured at all given areas of interest.

Statistical Analyses

Differences between values obtained in males versus females were calculated using independent Student's t-tests. Correlations between age, gender, and BMI and the measured distances/thicknesses were calculated using Pearson's correlation coefficient (r_p) using bivariate correlations. To identify the influence of age, gender, or BMI, multifactorial linear regression models were calculated, and the R-squared value was used to determine the global fit of the statistical model. All analyses were performed using SPSS Statistics 23 (IBM, Armonk, NY) and results were considered significant at a probability level of ≤ 0.05.

RESULTS

General Results

Five different layers were consistently and bilaterally identified

FIGURE 3. Bar graph showing the mean thickness of the superficial fatty layer in mm independent of age, or BMI for the respective investigated areas of males (blue bars) and females (red bars). Error bars represent a confidence interval of 95%.

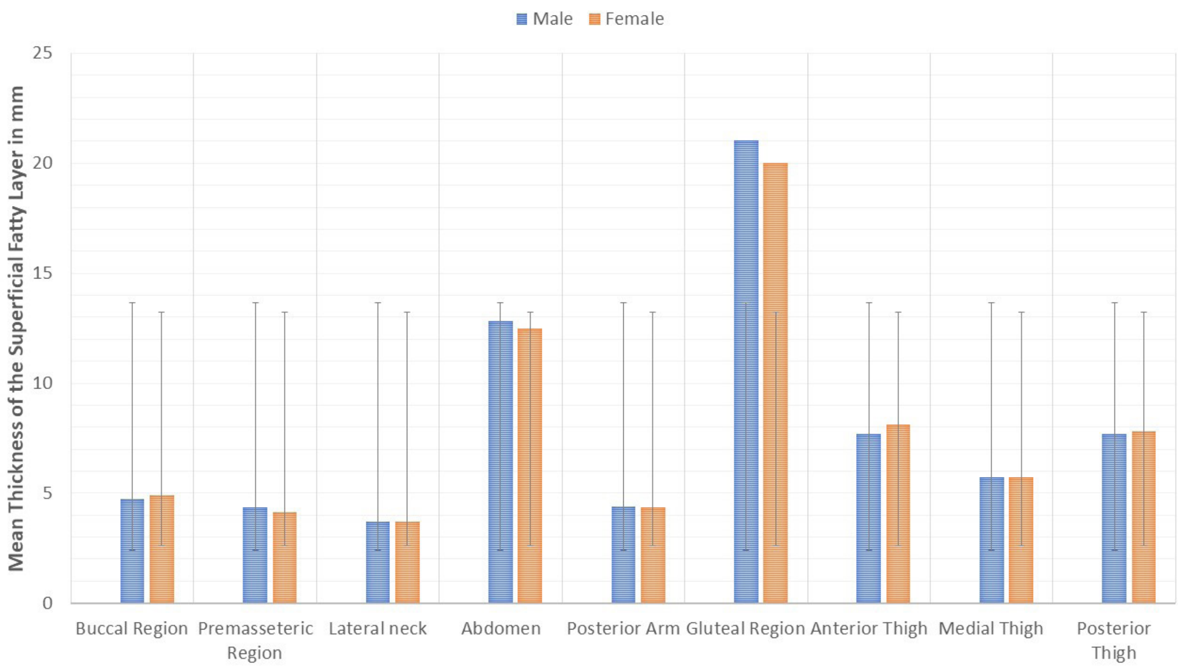


FIGURE 4. Left sided facial cadaveric dissection of a male body donor showing the layers of the lateral face: Skin, superficial fatty layer, superficial musculo-aponeurotic system, deep fatty layer, parotideomasseteric fascia, masseter muscle.

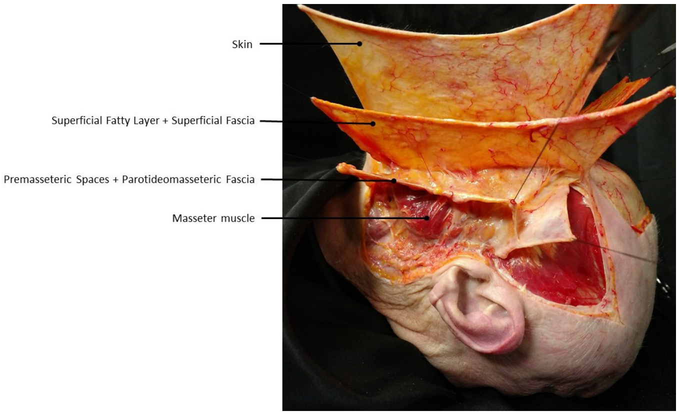


FIGURE 5. Figure showing in the left panel anatomic dissections of the subdermal layers (skin, superficial fatty layer, superficial fascia, deep fatty layer, deep fascia, triceps muscle) of the posterior arm and in the right panel the corresponding ultrasound image scanned in the exact same location.

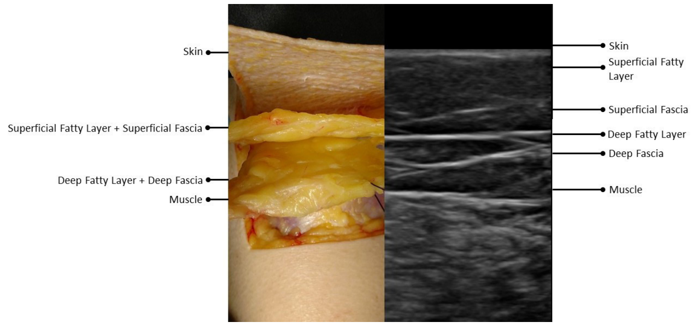


FIGURE 6. Figure showing in the left panel anatomic dissections of the subdermal layers (skin, superficial fatty layer, superficial fascia, deep fatty layer, deep fascia, abdominal external oblique muscle) of the abdomen and in the right panel the corresponding ultrasound image scanned in the exact same location.

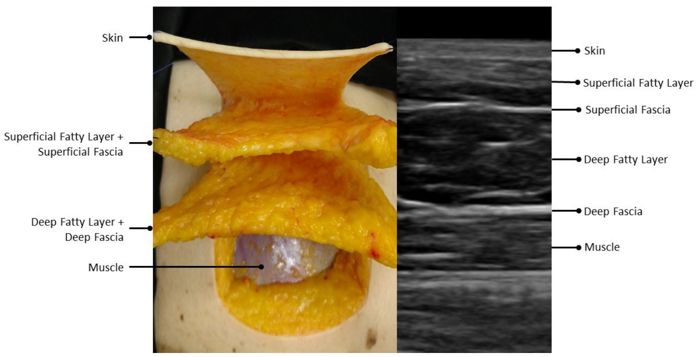


FIGURE 7. Figure showing in the left panel anatomic dissections of the subdermal layers (skin, superficial fatty layer, superficial fascia, deep fatty layer, deep fascia, gluteus maximus muscle) of the gluteal region and in the right panel the corresponding ultrasound image scanned in the exact same location.

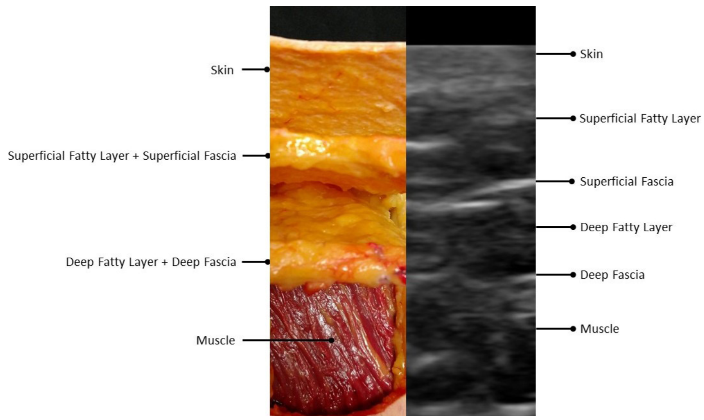


FIGURE 8. Figure showing in the left panel anatomic dissections of the subdermal layers (skin, superficial fatty layer, superficial fascia, deep fatty layer, deep fascia, quadriceps muscle) of the anterior thigh and in the right panel the corresponding ultrasound image scanned in the exact same location.

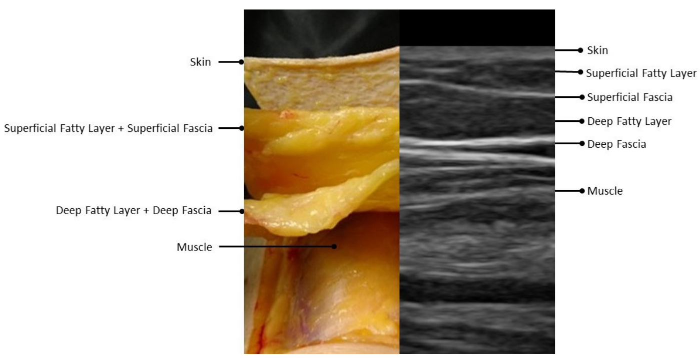


FIGURE 9. Figure showing in the left panel anatomic dissections of the subdermal layers (skin, superficial fatty layer, superficial fascia, deep fatty layer, deep fascia, adductor magnus muscle) of the medial thigh and in the right panel the corresponding ultrasound image scanned in the exact same location.

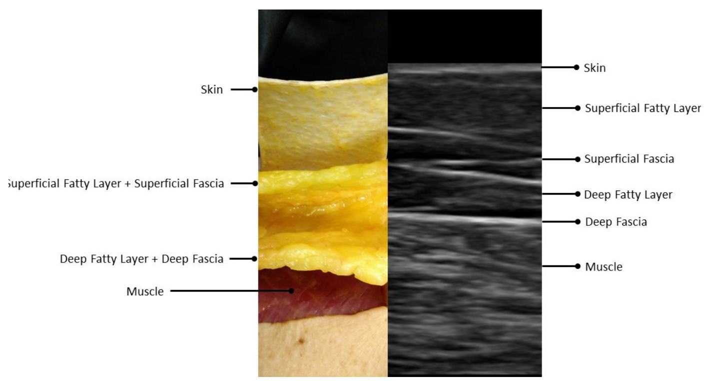
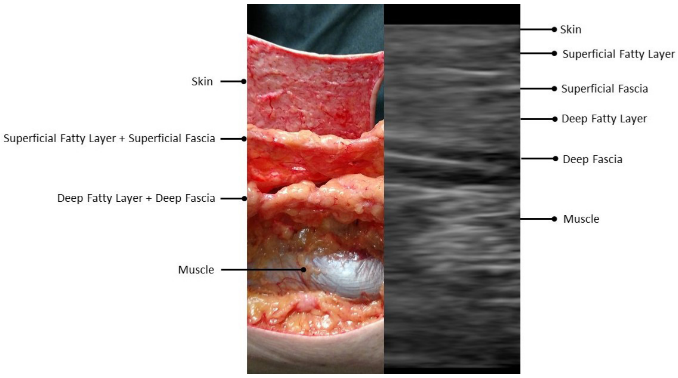


FIGURE 10. Figure showing in the left panel anatomic dissections of the subdermal layers (skin, superficial fatty layer, superficial fascia, deep fatty layer, deep fascia, biceps femoris muscle) of the posterior thigh and in the right panel the corresponding ultrasound image scanned in the exact same location.



in all investigated individuals: skin, superficial fat, superficial fascia, deep fat, and deep fascia. The thickness of the superficial fatty layer varied highly with smallest values for the lateral neck with 3.71mm ± 0.55 [range, 2.00–5.00mm] and greatest values for the gluteal region with 20.52mm ± 10.07 [range, 6.10–38.40mm]. Influence of BMI and age are presented region specific in Table 2.

Face: Buccal Region (Figures 1–4)

The mean thickness of the superficial fatty layer independent of age or BMI, was in males 4.75 mm ± 0.72 and in females 4.89mm ± 0.97 with P=0.164. In those with a BMI <24.9 kg/m^2 the mean thickness was for males/females 4.24mm ± 0.61/4.46mm ± 1.16, whereas it was in those with a BMI of 25.0–29.9kg/m^2 5.12mm ± 0.68/5.25 mm ± 0.80 and for those with a BMI >30.0 kg/m^2 it was 4.90mm ± 0.58/4.96mm ± 0.73. Increasing BMI values correlated significantly with an increase in superficial fatty layer thickness (r_p = 0.395, P<0.001) whereas increasing age correlated significantly with a decrease in its thickness (r_p = -0.295, P<0.001). Multifactorial linear regression revealed the following formula to compute the thickness of the superficial fatty layer based on information of age and BMI:

Male: *Thickness of superficial fatty layer in mm:*
*3.619+(0.072*BMI)-(0.018*Age)*
Female: *Thickness of superficial fatty layer in mm:*
*3.519+(0.079*BMI)-(0.017*Age)*

Face: Premasseteric Region (Figures 1–4)

The mean thickness of the superficial fatty layer independent of age or BMI, was in males 4.34 mm ± 0.57 and in females 4.14mm ± 0.69 with P=0.009 In those with a BMI <24.9 kg/m^2 the mean thickness was for males/females 4.13mm ± 0.64/3.54mm ± 0.56, whereas it was in those with a BMI of 25.0–29.9kg/m^2 4.24mm ± 0.52/4.22 mm ± 0.50 and for those with a BMI >30.0kg/m^2 it was 4.64mm ± 0.39/4.68mm ± 0.45. Increasing BMI values correlated significantly with an increase in superficial fatty layer thickness (r_p = 0.590, P<0.001) whereas increasing age correlated significantly with a decrease in its thickness (r_p = -0.426, P<0.001). Multifactorial linear regression revealed the following formula to compute the thickness of the superficial fatty layer based on information of age and BMI:

Male: *Thickness of superficial fatty layer in mm:*
*3.901+(0.055*BMI)-(0.024*Age)*
Female: *Thickness of superficial fatty layer in mm:*
*1.683+(0.114*BMI)-(0.014*Age)*

TABLE 2.

Table Showing the Correlation Coefficient (r_p) Between the Thickness of the Superficial Fatty Layer and BMI/Age, Respectively.

Region	Correlation between thickness of superficial fascial system and BMI	Correlation between thickness of superficial fascial system and Age
Buccal Region	r_p = 0.395 (P < 0.001)	r_p = -0.295 (P < 0.001)
Premasseteric Region	r_p = 0.424 (P < 0.001)/ r_p = 0.748 (P < 0.001)*	r_p = -0.569 (P < 0.001) / r_p = -0.325 (P < 0.001)*
Lateral Neck	r_p = 0.615 (P < 0.001)	r_p =-0.424 (P < 0.001)
Posterior Arm	r_p = 0.754 (P < 0.001)	r_p = -0.355 (P < 0.001)
Abdomen	r_p = 0.829 (P < 0.001)	r_p = -0.104 (P < 0.001)
Gluteal Region	r_p = 0.933 (P < 0.001)	r_p = -0.101 (P = 0.013)

*a statistically significant difference (p = 0.009) could be observed between males and females, thus a correlation coefficient was given for males and females.

Lateral Neck (Figure 1 and 3)

The mean thickness of the superficial fatty layer independent of age or BMI, was in males 3.71 mm ± 0.55 and in females 3.71 mm ± 0.55 with P=0.925 In those with a BMI <24.9kg/m^2 the mean thickness was for males/females 3.25mm ± 0.36/3.21 mm ± 0.38, whereas it was in those with a BMI of 25.0–29.9kg/m^2 3.87mm ± 0.44/3.87 mm ± 0.46 and for those with a BMI >30.0 kg/m^2 it was 4.01mm ± 0.53/4.05mm ± 0.40. Increasing BMI values correlated significantly with an increase in superficial fatty layer thickness (r_p = 0.615, P<0.001) whereas increasing age correlated significantly with a decrease in its thickness (r_p = -0.424, P<0.001). Multifactorial linear regression revealed the following formula to compute the thickness of the superficial fatty layer based on information of age and BMI:

Male: *Thickness of superficial fatty layer in mm:*
*2.723+(0.068*BMI)-(0.019*Age)*
Female: *Thickness of superficial fatty layer in mm:*
*2.064+(0.083*BMI)-(0.014*Age)*

Posterior Arm (Figure 1, 3, and 5)

The mean thickness of the superficial fatty layer independent of age or BMI, was in males 4.39 mm ± 0.84 and in females 4.36mm ± 0.97 with *P*=0.780. In those with a BMI <24.9 kg/m^2 the mean thickness was for males/females 3.70mm ± 0.55/3.54mm ± 0.68, whereas it was in those with a BMI of 25.0–29.9kg/m^2 4.39mm ± 0.74/4.34mm ± 0.79 and for those with a BMI > 30.0kg/m^2 it was 5.09mm ± 0.55/5.21mm ± 0.62. Increasing BMI values correlated significantly with an increase in superficial fatty layer thickness (r_p = 0.754, *P*<0.001) whereas increasing age correlated significantly with a decrease in its thickness (r_p = -0.355, *P*<0.001). Multifactorial linear regression revealed the following formula to compute the thickness of the superficial fatty layer based on information of age and BMI:

Male: *Thickness of superficial fatty layer in mm: 1.847+(0.133*BMI)-(0.024*Age)*
Female: *Thickness of superficial fatty layer in mm: 0.667+(0.172*BMI)-(0.021*Age)*

Abdomen (Figure 1 ,3, and 6)

The mean thickness of the superficial fatty layer independent of age or BMI, was in males 12.81mm ± 2.88 and in females 12.48mm ± 3.44 with *P*=0.376 In those with a BMI <24.9 kg/m^2 the mean thickness was for males/females 9.41mm ± 1.14/8.24mm ± 1.30, whereas it was in those with a BMI of 25.0–29.9 kg/m^2 13.97mm ± 1.78/13.72mm ± 1.50 and for those with a BMI >30.0kg/m^2 it was 15.03mm ± 1.61/15.48mm ± 1.72. Increasing BMI values correlated significantly with an increase in superficial fatty layer thickness (r_p = 0.829, *P*<0.001) whereas increasing age correlated significantly with a decrease in its thickness (r_p = -0.104, r_p=0.071). Multifactorial linear regression revealed the following formula to compute the thickness of the superficial fatty layer based on information of age and BMI:

Male: *Thickness of superficial fatty layer in mm: 0.544+(0.491*BMI)-(0.023*Age)*
Female: *Thickness of superficial fatty layer in mm: -5.059+(0.686*BMI)-(0.020*Age)*

Gluteal Region (Figure 1, 3, and 7)

The mean thickness of the superficial fatty layer independent of age or BMI, was in males 8.89mm ± 0.73 and in females 11.13mm ± 0.91 with *P*=0.373. In those with a BMI <24.9kg/m^2 the mean thickness was for males/females 12.10mm ± 2.05/7.14mm ± 0.51, whereas it was in those with a BMI of 25.0–29.9kg/m^2 18.57mm ±3,64/19.24 mm ± 3.73 and for those with a BMI >30.0kg/m^2 it was 32.43mm ± 1.70/33.62mm ± 1.93. Increasing BMI values correlated significantly with an increase in superficial fatty layer thickness (r_p = 0.933, *P*<0.001) whereas increasing age correlated significantly with a decrease in its thickness (r_p = -0.101, *P*=0.080). Multifactorial linear regression revealed the following formula to compute the thickness of the superficial fatty layer based on information of age and BMI:

Male: *Thickness of superficial fatty layer in men:- 23.484+(1.788*BMI)-(0.086*Age)*
Female: *Thickness of superficial fatty layer in mm:- 43.052+(2.419*BMI)-(0.043*Age)*

Anterior Thigh (Figure 1, 3, and 8)

The mean thickness of the superficial fatty layer independent of age or BMI, was in males 7.70mm ± 2.27 and in females 8.10mm ± 2.31 with *P*=0.131 In those with a BMI <24.9kg/m^2 the mean thickness was for males/females 5.36mm ± 0.64/5.78mm ± 0.84, whereas it was in those with a BMI of 25.0–29.9 kg/m^2 7.52mm ± 1.33/7.83mm ± 1.32 and for those with a BMI >30.0kg/m^2 it was 10.23mm ± 1.16/10.70mm ± 1.11. Increasing BMI values correlated significantly with an increase in superficial fatty layer thickness (r_p = 0.892, *P*<0.001) whereas increasing age correlated significantly with a decrease in its thickness (r_p = -0.159, *P*=0.006). Multifactorial linear regression revealed the following formula to compute the thickness of the superficial fatty layer based on information of age and BMI:

Male: *Thickness of superficial fatty layer in mm: -2.981+(0.432*BMI)-(0.023*Age)*
Female: *Thickness of superficial fatty layer in mm: -3.616+(0.480*BMI)-(0.026*Age)*

Medial Thigh (Figure 1, 3, and 9)

The mean thickness of the superficial fatty layer independent of age or BMI, was in males 5.73mm ± 1.05 and in females 5.74mm ± 1.27 with *P*=0.964. In those with a BMI <24.9kg/m^2 the mean thickness was for males/females 4.98mm ± 0.77/4.50mm ± 0.87, whereas it was in those with a BMI of 25.0–29.9kg/m^2 5.59mm ± 1.00/5.82mm ± 0.91 and for those with a BMI >30.0kg/m^2 it was 6.63mm ± 0.59/6.91mm ± 0.60. Increasing BMI values correlated significantly with an increase in superficial fatty layer thickness (r_p = 0.769, *P*<0.001) whereas increasing age correlated significantly with a decrease in its thickness (r_p = -0.253, *P*<0.001). Multifactorial linear regression revealed the following formula to compute the thickness of the superficial fatty layer based on information of age and BMI:

Male: *Thickness of superficial fatty layer in mm: 2.103+(0.161*BMI)-(0.016*Age)*
Female: *Thickness of superficial fatty layer in mm: 0.358+(0.239*BMI)-(0.024*Age)*

Posterior Thigh (Figure 1, 3, and 10)

The mean thickness of the superficial fatty layer independent of age or BMI, was in males 7.71mm ± 3.07 and in females 7.84mm ±3.34 with *P*=0.721. In those with a BMI <24.9kg/m^2 the mean thickness was for males/females 4.75mm ± 0.44/4.53mm ± 0.87, whereas it was in those with a BMI of 25.0–29.9kg/m^2 6.83mm ± 1.46/6.96mm ± 1.44 and for those with a BMI >30.0kg/m^2 it was 11.54mm ± 1.28/12.03mm ± 1.12. Increasing BMI values correlated significantly with an increase in superficial fatty layer thickness (r_p = 0.925, P<0.001) whereas increasing age correlated significantly with a decrease in its thickness (r_p = -0.172, P=0.003). Multifactorial linear regression revealed the following formula to compute the thickness of the superficial fatty layer based on information of age and BMI:

Male: *Thickness of superficial fatty layer in mmn:*
*-7.026+(0.610*BMI)-(0.039*Age)*
Female: *Thickness of superficial fatty layer in mm:*
*-9.750+(0.712*BMI)-(0.035*Age)*

DISCUSSION

This ultrasound-based study investigated the thickness of the superficial fatty layer in various regions of the body: face, neck, arms, abdomen, buttock, and thighs. The results reveal that the thickness varies based on location, with smallest mean values for the lateral neck of 3.71mm ± 0.55 [range, 2.00–5.00mm] and greatest values for the gluteal region of 20.52mm ± 10.07 [range, 6.10–38.40mm]. Based on the results obtained we were able to compute a formula whereby the thickness of the superficial fatty layer could be estimated if information on gender, age, and the BMI of the patient is available. The results reveal that the formula computed is different for each body region which accounts for the variation in superficial fatty layer thickness.

The strengths of the study are the large sample size (n=150) with equal distribution of males and females (each n=75) and a balanced distribution of age (n=30 per decade: 20–29 years, 30–39 years, 40–49 years, 50–59 years, and 60–69 years) and BMI (n=50 per group: BMI ≤24.9 kg/m^2, BMI between 25.0 and 29.9kg/m^2 BMI ≥30kg/m^2). This unique cohort allows analysis of the thickness of the superficial fatty layer per each anatomic region of clinical interest in individuals 50 years apart, and capability to draw conclusions about the influence of age on the variation in thickness relevant for biostimulator injections. Using three different BMI groups facilitates investigation of the influence of body habitus on superficial fatty layer thickness within and across the different age groups and genders. Another strength of the study is the non-invasive nature of the ultrasound imaging. Real time measurements were obtained without skin contact and applied pressure, ie sound waves were transmitted via the visualization gel, preserving the original tissue thickness.

Limitations of the study are that the ultrasound-based measurements were performed with subjects standing in an upright position. This might potentially limit the applicability of the measurements as some biostimulator injections are performed with the patient in the supine or prone position which can cause a shift in soft tissue proportions and thus a change in the reported thicknesses. Futures studies, however, will need to provide evidence for this potential postural change. Another limitation is that this study investigated Fitzpatrick types I–III patients. It is unclear whether the results are generalizable to darker skinned patients.

The results of the present study confirm clinical observations where different magnitudes of superficial fatty layer thickness are observed. In the lateral neck, superficial fatty layer thickness is 3.71mm ± 0.55 [range, 2.00–5.00 mm] whereas in the gluteal region the thickness is 20.52mm ± 10.07 [range, 6.10–38.40 mm]. This difference in thickness influences treatment strategies especially when injecting biostimulators. The superficial fatty layer is not a homogenous mass of fat composed of adipocytes exclusively but is rather a highly organized compound structure with honeycomb-like architecture.[23,25] This architecture is formed by adipocytes arranged in fat lobules which are surrounded by walls composed of fibrous connective tissue.[25] These fibrous connective tissue walls together form a 3D fibrous connective tissue framework which encloses the fat lobules. Together, these fibrous connections form septae which attach to the underside of the dermis[25] and expand into deeper layers. The deep attachment of these septal connections is the superficial fascia.[16,18] Together, the skin, the superficial fatty layer, the connective tissue fibers that connect the skin to the superficial fascia and the superficial fascia itself are considered to be a functional biomechanical unit which has been previously termed the superficial fascial system.[17,19–24] The thickness of the superficial fatty layer which increases in thickness with increasing BMI values[15,16,18] influences the status of the superficial fascial system.

In cellulite, an aesthetic condition which predominantly affects post-pubertal females, increasing BMI is a risk factor for its development and its severity.[14] It was recently demonstrated that the fibrous connections between the skin and the superficial fascia contribute to the stability of the superficial fascial system and that this stability is primarily influenced by gender with females having less stable subdermal fibrous connective tissue architecture.[14] In the same cadaveric investigation, males were shown to have a higher number of fibrous connective tissue septae per area spanning the distance between the dermis and the superficial fascia. This resulted in significantly increased tensile strength values versus females when tested in an experimental load-until-failure study design.[14]

The results of those previous investigations demonstrate that the subdermal fatty layer, containing the fibrous connective tissue septae, is of crucial importance for maintaining skin tension and position. Alterations to this delicate arrangement influences skin surface appearance of which the most frequent are skin laxity and surface irregularities frequently observed in cellulite and aging. These aesthetic conditions can be explained by alterations in the superficial fascial system: reduced tension of the superficial fascial system can result in skin laxity whereas increased tension of the superficial fascial system and its components (like the superficial fatty layer due to increased

BMI) can result in skin surface irregularities.

Understanding and respecting this delicate subdermal architecture may increase the efficacy and the longevity of biostimulator treatment. Biostimulators have been shown to induce collagen synthesis via various pathways.[1] Ultimately, those pathways result in an increased content of collagen within the adjacent connective tissues. If the targeted tissue is the superficial fascial system, effects on the skin could be expected including reduction in skin laxity and surface irregularities. Newly formed collagen could result in an increased amount and/or increased thickness of the connective tissue fibers that connect the skin to the superficial fascia. Being anchored to the superficial fascia, the alteration in conformation and/or tension of those septae could reduce skin laxity by bringing the skin closer to the superficial fascia. In dimple-type cellulite, the increase in collagen content in the superficial fascial system could lead to an increase in containment forces that stabilize the skin around depressions. As dimples are the result of soft tissue protrusion next to the subdermal attachment of vascularized "super-septae", injecting biostimulators around areas with dimples can reduce the difference in skin level between the bottom of the dimple (original skin level) and the wall around the dimple (protruded skin level). This stabilization effect can be induced by the injection of biostimulators especially if the superficial fascial system is targeted.

The present study provides a mathematical formula to compute the thickness of the superficial fatty layer, which is an integral part of the superficial fascial system. With this formula, the maximal depth of biostimulator injections can be estimated if the age, gender, and the BMI of the patient are known. The result of the calculated region-specific formula can guide aesthetic providers towards more effective treatments as the output is the maximal depth of biostimulator injections targeting the superficial fascial system. Injections deeper than the calculated value (results are in millimeters) might result in a reduced efficacy as the superficial fascial system is not targeted and the induced neocollagenesis does not impact the fibrous connective tissue septae that connect the skin to the superficial fascia.

CONCLUSION

The results of the present study reveal that the thickness of the superficial fatty layer is highly variable in the human body as it depends on the investigated region, age, gender, and BMI. The superficial fatty layer is an integral component of the superficial fascial system which influences skin laxity and skin surface irregularities. The result of the calculated region-specific formula can guide aesthetic providers towards more effective treatments as the output is the maximal depth of biostimulator injections whereby the superficial fascial system is targeted. Injections deeper than the calculated values might result in a reduced effectiveness as the superficial fascial system is not targeted and the induced collagen formation does not affect the fibrous connective tissue septae and thus ultimately the skin surface.

DISCLOSURES

None of the other authors listed has any commercial associations or financial disclosures that might pose or create a conflict of interest with the methods applied or the results presented in this article.

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AUTHOR CORRESPONDENCE

Sebastian Cotofana MD PhD

E-mail:................……......................... cotofas@amc.edu