A quantitative assessment of variations in the palm surface area as a percentage of total body surface area within the general population

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Abstract: Healthcare professionals who treat burn patients determine fluid requirements for resuscitation based on an estimation of burned body surface area (BBSA) as a percentage of total body surface area (TBSA). Hence, it is important to get an accurate assessment of these values. An overestimation or underestimation of the BBSA percentage can lead to medical complications, negatively affecting a patient's quality of care. Conventional methods to estimate the BBSA percentage include segmenting the three dimensional body surface into a two-dimensional burn chart or estimating the area relative to the palm of the hand with the assumption that the palm represents 1% of the TBSA. These methods introduce inaccuracies due to unreliable assumptions and estimations. For example, methods that rely on a burn chart overgeneralise that the body type of a patient to fit the established body sections in the chart, and methods that use the palm of the hand rely on incorrect assumptions regarding the palm surface area. This paper demonstrates specifically that the assumption that a patient's palm can be estimated as 1% of the TBSA is not reliable. In addition, it summarises, evaluates, and quantifies these inaccuracies, and compares and contrasts the variations for different genders.

Keywords: palm surface area; burn size; body surface area; hand surface area; burn area estimation.

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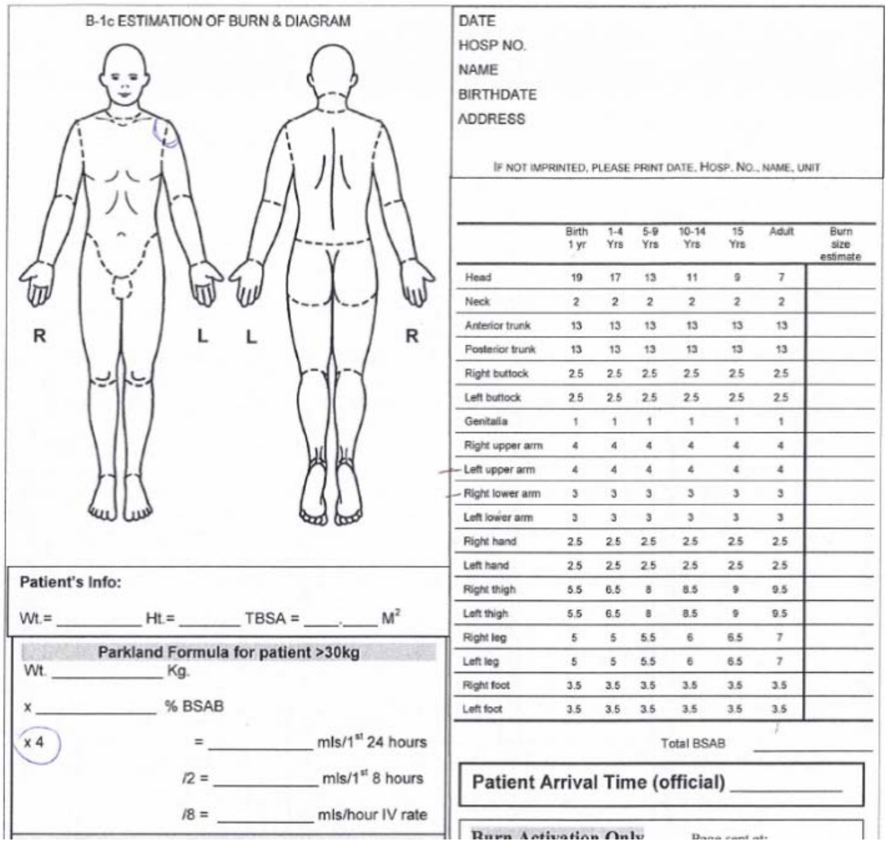
Jasbir Arora is an internationally recognised expert in the fields of optimisation, numerical analysis, and real-time implementation, and his nine books are widely used in these fields. His research interests include optimisation-based digital human modelling, dynamic response optimisation, optimal control of systems, design sensitivity analysis and optimisation of non-linear systems, and parallel optimisation algorithms. He has served as an advisor to more than 45 PhD candidates. He is a Fellow in the American Society of Civil Engineers and American Society of Mechanical Engineers. He is a senior member of the American Institute of Aeronautics and Astronautics.

1 Introduction

Larger burns, estimated greater than 20% total body surface area (TBSA), generally undergo burn resuscitation. Effective treatment of burn patients requires an accurate estimation of the total burned body surface area (BBSA) relative to the TBSA of a patient. Error in this approximation can lead to incorrect determination of fluid requirements and potential complications. For example, over resuscitation could lead to pulmonary oedema, orbital oedema, and abdominal compartment syndrome (ACS). It is important to identify and quantify the potential error in the current methods used to determine the BBSA as a percentage of TBSA. When this error is understood, improved methods for determining BBSA can be investigated and objectively compared.

Traditionally, the primary methods applied to assess the BBSA have been the Lund-Browder burn chart (LBC), rule of nines (RN), and rule of palm (RP), used alone or in any combination. Various studies have shown significant errors in each of these approaches (Amirsheybani et al., 2001; Hammond and Ward, 1987; Butz et al., 2015; Giretzlehner et al., 2013; Haller et al., 2012; Berry et al., 2001). In addition, most patients do not experience burns in full segments of the body, but rather in multiple partial segments. In such cases, further approximations are necessary while using the LBC or RN, which can magnify the error.

Figure 1 The Lund Browder chart


B-1c ESTIMATION OF BURN & DIAGRAM

R L L R

DATE
HOSP NO.
NAME
BIRTHDATE
ADDRESS

IF NOT IMPRINTED, PLEASE PRINT DATE, HOSP. NO., NAME, UNIT

	Birth 1 yr	1-4 Yrs	5-9 Yrs	10-14 Yrs	15 Yrs	Adult	Burn size estimate
Head	19	17	13	11	9	7	
Neck	2	2	2	2	2	2	
Anterior trunk	13	13	13	13	13	13	
Posterior trunk	13	13	13	13	13	13	
Right buttock	2.5	2.5	2.5	2.5	2.5	2.5	
Left buttock	2.5	2.5	2.5	2.5	2.5	2.5	
Genitalia	1	1	1	1	1	1	
Right upper arm	4	4	4	4	4	4	
Left upper arm	4	4	4	4	4	4	
Right lower arm	3	3	3	3	3	3	
Left lower arm	3	3	3	3	3	3	
Right hand	2.5	2.5	2.5	2.5	2.5	2.5	
Left hand	2.5	2.5	2.5	2.5	2.5	2.5	
Right thigh	5.5	6.5	8	8.5	9	9.5	
Left thigh	5.5	6.5	8	8.5	9	9.5	
Right leg	5	5	5.5	6	6.5	7	
Left leg	5	5	5.5	6	6.5	7	
Right foot	3.5	3.5	3.5	3.5	3.5	3.5	
Left foot	3.5	3.5	3.5	3.5	3.5	3.5	

Total BSAB ____________

Patient's Info:

Wt.= ________ Ht.= ______ TBSA = ____.____ M^2

Parkland Formula for patient >30kg

Wt. __________ Kg.

x __________ % BSAB

x 4 = __________ mls/1st 24 hours

/2 = __________ mls/1st 8 hours

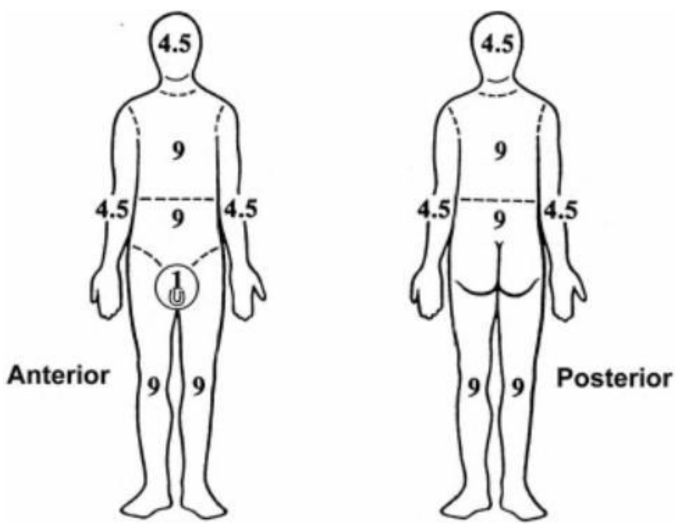
/8 = __________ mls/hour IV rate

Patient Arrival Time (official) __________

The LBC, established in 1944, divides the body into notable segments and assigns percentages of TBSA to each of these segments. As shown in Figure 1, the contributions of the percentages of these major partitions are summed to provide an estimate of the burn size (Lund and Browder, 1944). For example, a healthcare provider today might observe an adult patient with burns covering the right thigh and right leg. According to the LBC, these body parts measure of 9.5% and 7% of the TBSA, respectively. Thus, the BBSA will be estimated as 16.5% of TBSA. This estimate is one of the three parameters in the Parkland formula to calculate resuscitation volume in the first 24 hours after initial burn. The LBC is also related to the age of patients and adjusts for infants and adolescents.

The RN, established by Wallace in 1951, is another method that categorises body parts and assigns a fixed numerical value for BBSA percentage (Wallace, 1951) to each body part. According to the RN, the body as shown in Figure 2 is divided into multiples of nine. For example, a leg is 18% with 9% for the anterior surface and 9% for the posterior surface. Each arm is 9% (4.5% ventral and 4.5% dorsal surfaces). The head and neck combined is also 9%. The anterior and posterior torsos are each 18%. The groin makes up the remaining 1%. Although splitting the body into areas approximated at multiples of nine makes the mathematical computations easier, the result is an inaccurate approximation (Amirsheybani et al., 2001; Neaman et al., 2011).

Figure 2 The RN



2 Related works

Existing studies have shown the errors in the LBC and RN approaches. As a larger percentage of the population qualifies as obese, these tools become more unreliable (Rae et al., 2013; Neaman et al., 2011; Berry et al., 2001; Livingston and Lee, 2001). An underestimation of the TBSA is likely with obese patients and higher body mass index (BMI). The previously mentioned methods were not developed for a typical 21st century population, and as a result, many studies have shown inaccurate results.

Additional error comes from the Haycock formula being used to calculate TBSA in the Lund-Browder method. Studies have shown that existing TBSA formulas are error prone (Livingston and Lee, 2001; Redlarski et al., 2016). Again, these errors become more significant when considering obese persons.

An alternative procedure employed by burn unit staff to estimate BBSA is the RP. The patient's palm is assumed to be 1% of the patient's TBSA and is used as a guide to roughly estimate the BBSA. However, this procedure has issues in both implementation and accuracy. For example, it is not always clear whether the fingers are to be included in palm surface area (PSA) (Jose et al., 2004). In addition, although studies have shown the PSA is approximately, on average, only 0.75%–0.80% of the TBSA (Rossiter et al., 1996), this method is still commonly used in burn units today. In fact, the LBC considers the hand as 2.5% of the TBSA. Subsequently, the BBSA is overestimated before it is used as input to the Galveston or Parkland formula (depending on the weight of the patient) to estimate the amount of fluid to be administered for resuscitation. A prescription of excess fluids can potentially lead to medical complications. Over resuscitation of burn patients can lead to morbid consequences, such as ACS, pulmonary oedema and/or orbital oedema. In the event of ACS, the patient would need an emergent bedside decompressive abdominal laparotomy and is associated with a high mortality (Pruitt, 2000). However, if the standard was shifted from 1% to 0.8%, the RP would likely still show discrepancies because not all patients' palm surface area percentage (%PSA) matches the average 0.8% due to anthropometric variation. For example, studies have shown a significant difference in PSA in patients with different BMI, where a higher BMI correlates with a lower %PSA (Butz et al., 2015). While this study presents a subjective understanding of how %PSA changes with varying BMI, it uses formulas to estimate TBSA, which introduces error in the calculations.

Previous work has been conducted to review these existing methods and measure variation in PSA across the population. One such study used high-resolution three-dimensional (3D) hand scanners and found a significant difference in %PSA with gender and weight but not height (Yu et al., 2008). The high resolution of the 3D scanner resolution produced results more accurate and reliable than other methods of measurements, such as direct tracing using a planimeter. Men and women were categorised into three groups: underweight, normal, and overweight. Statistical tests of variance and least significant difference found that gender and body weight were significant factors. The results led to a recommendation for gender-specific percentages to be adopted (Yu et al., 2008). The gender-specific distribution, arranged into three body weights and five heights in accordance with population distribution, was used to derive %PSA using %PSA as calculated from body surface data in a previous study. While this study used a 3D scanner for accurate measurement of PSA, they used existing formulas to estimate TBSA for each individual, which again introduces error in calculation of %PSA. A limitation of this study is its incorporation of body surface data from a previous study, in which TBSA was calculated using a set of five heights and three weights.

Thom (2017) highlights the lack of reliability in burn size calculation and attributes the variation in accuracy to disparity between expertise and experience within medical professionals as well as patient body type variations. Technology is currently under development to reduce these issues. For example, smartphone applications (e.g., rapid burn assessor) can rapidly estimate a patient's BBSA and assess need for transfer or referral to a specialised burn unit. The calculation is based on the size of the mobile device itself or using an everyday object like a credit card as a reference tool in the estimation (Kamolz et al., 2014) so that reliance on personal subjective experience is reduced.

Prieto et al. (2011) presents a method for BBSA estimation in which the patient is modelled in a 3D computer-based system. Age, weight, gender, and constitution are suitable to the patient specifically, which essentially eliminates the error from body type variations. However, this study is limited by the 3D models used, which included 80 body types that were only approximations to real body shape.

Another recent study (Desbois et al., 2017) emphasised the need for a personalised 3D model to assess TBSA. The unique 3D model is created by using parameters to morph a representation of a realistic human. However, the assessment of TBSA is influenced by small variations in the morphology and their observed absolute error of 3% with no difference in their scans. However, their 3D model was based on shaping parameters instead of an actual, real human body scan.

A majority of these existing methods assume that a patient's anthropometry will closely match the predetermined values for a given part of the body, which is often incorrect. While many other earlier studies have discussed the potential for the accuracy, none of the studies present detailed analytical results to quantify the impact of the inaccuracy due to patient body type. This paper quantifies the variation of %PSA in a typical male and female, as well as the variations in %PSA change with varying anthropometry within the male and female population. Finally, this paper outlines a novel method to calculate %PSA that accounts for this anthropometric variation across the population. This paper details a method to calculate the %PSA using a much larger dataset, confirms the correctness of the study conducted by Yu et al. (2008), and extends their conclusion by not limiting it to groups of people with similar body types. Rather than using a limited number of a specific set of heights to calculate TBSA, this study calculates TBSA for each subject. Thus, the limitations from Prieto et al. (2011) mentioned above are avoided, as individual body types are uniquely represented in the 3D model dataset. In other words, instead of selecting one out of the eighty body types that match the age, weight, and gender of a patient, each model used by this study was chosen from a database of models in which each model corresponds to a real human scan with unique anthropometric measurements.

3 Method

For 3D digital anthropometry measurements, the Civilian American and European Surface Anthropometry Resource (CAESAR) database was employed (Robinette et al., 1999). The CAESAR database consists of 3D digital scans of real human subjects obtained from whole body laser range scanner. The raw data in the database were refined to remove meshing artefacts. The CAESAR database also comes with forty traditional measurements using tape measures and callipers as well as other demographical information (e.g., age, ethnicity, occupation, etc.) about the scanned subjects. The project presented in this paper employed the post-processed clean 3D meshes and their associated anthropometric information available in the database such as height, gender, and weight.

Four different groups of subjects were selected to quantify the variations in percentage of PSA among the male and female population as well as to understand the differences between genders (Table 1). Group 1 consisted of male subjects with constant height, but varying weight. Group 2 consisted of male subjects with constant weight, but varying height. Group 3 consisted of female subjects with constant height but varying weight. Finally, Group 4 consisted of female subjects with constant weight, but varying height.

Table 1 Definitions for the four selected groups of male and female subjects

	Group 1	*Group 2*	*Group 3*	*Group 4*
Gender	Male	Male	Female	Female
Height	Constant	Varying	Constant	Varying
Weight	Varying	Constant	Varying	Constant

In order to quantify the variation in PSA as a percentage of TBSA across a population, the PSA as well as TBSA was calculated. To accomplish this, each individual in the selected population was represented using a 3D human scan and imported into software as a 3D triangular mesh object. An algorithm was then used to calculate the surface area of both the entire mesh and a specified subset of the mesh to obtain the TBSA and PSA, respectively. %PSA was calculated using the quotient of PSA and TBSA, as shown in equation (1).

$$\%PSA = \frac{PSA}{TBSA} \times 100\% \quad (1)$$

3.1 Data preparation

For the analysis, a 3D digital anthropometry data from the CAESAR project was used. The data is composed of raw 3D whole-body laser range scans of 2,383 individuals residing in North America along with their 48 corresponding anthropometric measurements and demographics data. Each of the 3D scans is defined by a triangular mesh. Individuals included in the 3D scan data wore a bathing cap and tight sports shorts, and a tight sports bra for the female subjects.

The raw 3D scan data contains a significant number of meshing artefacts, such as the holes, spikes, and noise shown in Figure 3, which would affect the accuracy of mesh-based calculations methods used in this study. To clean up the 3D mesh, a template-based fitting method presented in Baek and Lee (2012) was applied. This method uses a human 3D model that has complete mesh structures and no artefacts as a template, then deforms that model to conform the 3D scan by minimising the surface disparity. As a result, incomplete regions are filled and the unwanted artefacts are cured accordingly (Figure 4).

3.2 Computational measurement of PSA

The TBSA of each 3D scan was calculated by summing the individual triangles in the triangular mesh (Desbrun et al., 2002) and is shown in equation (2), where b is the length of the base, h is the height of the triangle, and n is the total number of triangles in the 3D mesh. The resulting TBSA was then used to calculate the %PSA in equation (1).

$$TBSA = \sum_{i=1}^{n} \frac{1}{2} bh \quad (2)$$

The data preparation method described above was applied for each scan in the entire database. Hence, any difference in the models as a result of the preparation method will be consistent throughout the entire database. As such, calculation of any surface area percentage, with respect to the total surface of the scan, should not be influenced by this process, as the meshing fit template will affect these surfaces equally.

To calculate the PSA, the indices of individual triangles in the triangular mesh that fully represent the hand were identified. For these purposes, each triangle was indexed within the mesh, and the order of this indexing was confirmed to be consistent across all the subject meshes. Thus, it was sufficient to identify the indices that represent the hand on any single mesh, and the assumption holds that the same indices represent the hand on all other meshes. To this end, one 3D scan was arbitrarily chosen and imported into the Santos™ software to visualise the 3D scan. By adjusting the view of the scan within the Santos™ modelling environment, an expert was then able to carefully draw a line at right angles to the long axis of the forearm at the level tip of the ulna to designate the palm edge. The remaining interior triangles that comprise the palm surface were manually selected, as shown in Figure 5. The indices of the identified triangles for the chosen 3D scan were exported for use in calculating the PSA of all scans.

Figure 3 Raw 3D scan from the CAESAR database (see online version for colours)

Figure 4 Processed 3D model conformed to CAESAR scan

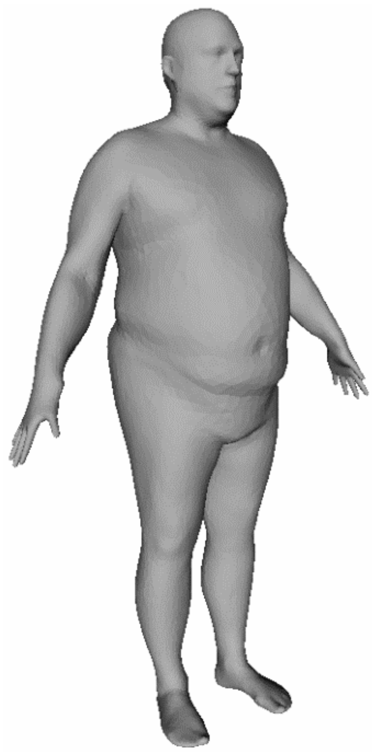
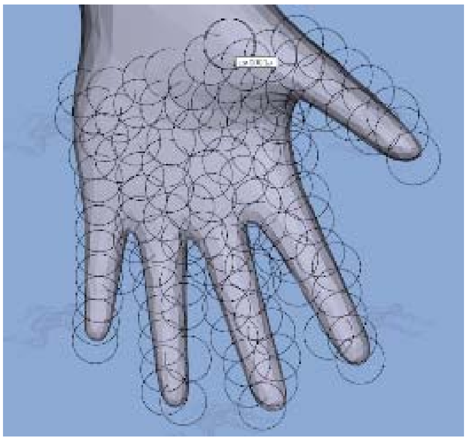


Figure 5 Visual selection of mesh triangles comprising the palm (see online version for colours)



To verify correct index positions and completeness of the palm surface coverage, the triangles associated with the exported indices were plotted as a 3D surface (Figure 6). This processes was repeated as necessary to ensure a complete coverage of all the indices of the palm (Figure 7). The PSA was then calculated using the set of verified indices (*V*) [equation (3)] and subsequently used in equation (1).

$$PSA = \sum_i \frac{1}{2} bh, \ \forall i \in V \tag{3}$$

Figure 6 MATLAB plot with visible holes in the palm as a result of missing triangles (see online version for colours)

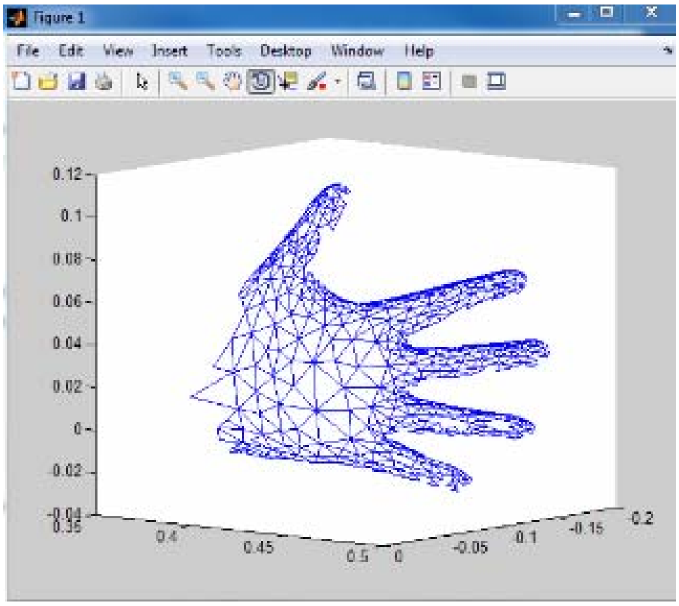
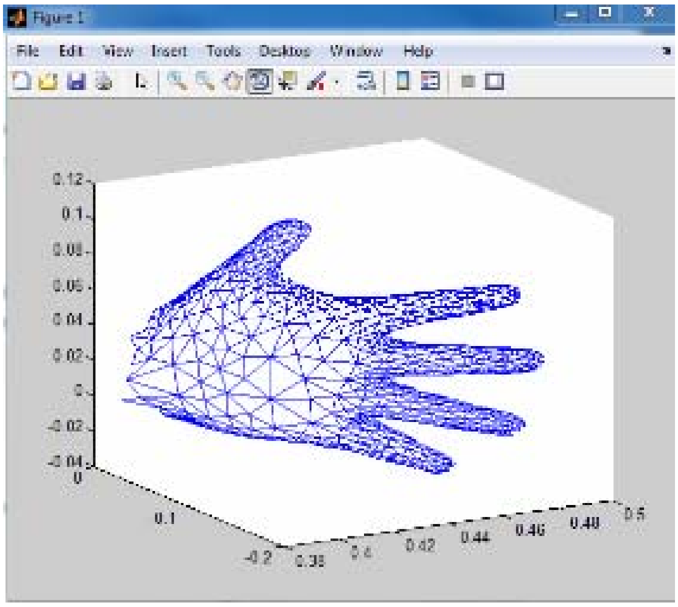


Figure 7 MATLAB plot with no missing mesh triangles in the palm (see online version for colours)



3.3 Statistical analysis

A statistical analysis is needed to determine if significant difference in %PSA extends and exists beyond population classified by BMI. More specifically, an analysis of %PSA is completed for the four different groups considered in Table 1.

In order to study the variation among the population, the mean height and mean weight dimensions for the male and female were used to narrow the 3D scan database to a smaller test sample. The constant weight and constant height values are based on the mean values of male and female height and weight in the CAESAR database. Twelve female scans in the database matched the mean height and 13 female scans matched the mean weight. These subjects matching the mean height and mean weight were selected as the test sample used to analyse the palm to TBSA ratio. A similar process was applied to males in the database to determine one test sample with mean height and another with mean weight.

Thus, the test samples consisted of: 12 female scans with varying weight but a constant height of 1,633 millimetres, 13 female scans with varying height but a constant weight of 74.47 kilograms, 11 male scans with varying weight but a constant height of 1,775 millimetres, and 11 male scans with varying height but a constant weight of 90.48 kilograms. The results for the four groups are shown in Table 2 and Table 3.

Table 2 Dataset of palm surface area percentage for the 11 male scans and 12 female scans with a constant height and varying weight

Group 1: male (1775 mm)		*Group 3: female (1633 mm)*	
Weight (kg)	*Right palm percentage*	*Weight (kg)*	*Right palm percentage*
113.15	0.7645%	76.87	0.8160%
80.95	0.8386%	60.32	0.8389%
103.63	0.8394%	66.21	0.7942%
77.78	0.8547%	65.99	0.8388%
62.36	0.9150%	61.68	0.8578%
78.46	0.8306%	63.95	0.8723%
74.83	0.8678%	64.17	0.8471%
90.48	0.8386%	78.68	0.7311%
98.87	0.8289%	48.30	0.8822%
106.35	0.7745%	112.7	0.7775%
70.52	0.8721%	87.07	0.7195%
		116.33	0.7336%

Table 3 Dataset of palm surface area percentage for the 11 male scans and 13 female scans with a constant weight and varying height

Group 2: male (90.4762 kg)		*Group 4: female (74.47 kg)*	
Height (mm)	*Right palm percentage*	*Height (mm)*	*Right palm percentage*
1,791	0.8318%	1,695	0.8090%
1,770	0.8183%	1,712	0.8126%
1,766	0.8422%	1,766	0.8424%
1,921	0.8729%	1,675	0.8056%
1,749	0.8441%	1,748	0.8544%
1,775	0.8386%	1,628	0.8375%
2,008	0.9047%	1,657	0.8488%
1,769	0.8384%	1,613	0.8166%
1,829	0.8349%	1,801	0.8809%
1,792	0.8458%	1,657	0.8367%
1,762	0.8466%	1,769	0.8553%
		1,632	0.8028%
		1,702	0.8159%

TBSA and PSA were calculated for each of these samples to determine the percentage of error and variance within the sample population. In addition, the coefficient of variation was calculated for the four different groups using equation (4). To further quantify the variance within the data, the error percentage was calculated for each test sample. The error percentage [equation (5)] is defined as the difference between the maximum and minimum values for %PSA within the group divided by average %PSA. Two 1-sided F-tests were conducted: female right palm and male right palm. A t-test of means was conducted in the %PSA of the male and female datasets to test if the two populations have the same means.

$$Coefficient\ of\ variation = \frac{Standard\ deviaion}{Average} \times 100\% \quad (4)$$

$$Error\ Percentage = \frac{(Maximum\ Palm\ Percentage - Minimun\ Palm\ Percentage)}{Average\ Palm\ Percentage} \quad (5)$$

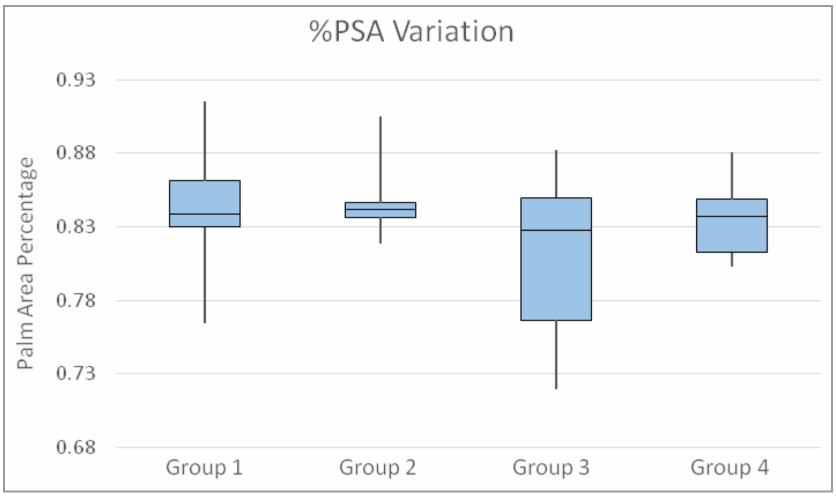
4 Results

The mean value for %PSA was 0.8386% in group 1, 0.8471% in group 2, 0.8091% in group 3, and 0.8322% in group 4. The variance in %PSA, multiplied by a factor of 1,000, was 0.0178%, 0.0054%, 0.0327%, and 0.0057% for groups 1, 2, 3, and 4, respectively, as shown in Table 4. For both genders, there is a significant statistical difference ($p < 0.05$) within the variance of the %PSA in groups with constant height and constant weight. There is no significant difference for the mean of the %PSA in either gender. Box and whisker plots in Figure 8 are used to indicate the first and third quartiles along with the median, minimum, and maximum values.

Table 4 Mean, variance, coefficient of variation, and error percentage values of percent palm surface area for the four groups

Results for %PSA	*Mean*	*Variance × 10^3*	*Coefficient of variation*	*Error percentage*
Group 1	0.8386%	0.0178%	5.03%	17.95%
Group 2	0.8471%	0.0054%	2.74%	10.20%
Group 3	0.8091%	0.0327%	7.07%	20.11%
Group 4	0.8322%	0.0057%	2.87%	9.39%

Figure 8 Variation of percent palm surface area within the four groups (see online version for colours)



The coefficient of variation for male sample with constant height and varying weight is 5.0341% while it is 2.7365% for male sample with constant weight and varying height. For the female scans with constant height and varying weight, the coefficient of variation for %PSA is 7.07%. As for female scans with constant weight and varying height, the coefficient of variation for the %PSA is 2.87%. The results for both male and female groups show a coefficient of variation in the test sample with constant height is more that of the subset with constant weight. These results reinforce the initial observation that weight has a stronger relation to %PSA than does height.

The test samples containing scans with constant weight and varying height consistently had a lower variation within both male and female population. The constant weight male sample resulted in a %PSA of 17.95%. For constant height male sample, the error percentage was 10.20%. For the female test sample with a constant height, the error percentage was 20.11%. The female sample with a constant weight showed an error percentage of 9.39%. These results suggest that weight has a greater impact on TBSA than height, as was observed in female population. In addition, there is a significant difference ($\alpha < 0.05$) between %PSA within all test sample sets, whether male or female and regardless of whether height or weight is constant.

5 Discussions

The mean values of %PSA found above support the initial hypothesis that 1% is not a good estimate for %PSA. In addition, there is not much difference between mean values of %PSA for male population with varying heights or varying weights. However, within female population, there is a relatively large difference.

The coefficient of variation for %PSA is more than double in female test sample with constant height and varying weight when compared to the female test sample with constant weight and varying height. This means that the variability relative to the mean is more than twice as much for the female population with varying weight than for the female population with varying height. With male scans, the difference in the coefficient of variation between constant height and varying weight versus constant weight and varying height provided similar results. Thus, with males, the extent of variability in the weight-varying group is considerably more, and in this case almost double, than in the height-varying group.

The statistical results from the two 1-sided F-tests for equality of variance showed a significant different exists ($p < 0.05$) in the variation of %PSA in all four cases. The variance in the female %PSA with constant height significantly differs from the variance in the female %PSA with constant weight ($p = 0.0027$). This follows from the earlier result that weight has a stronger influence on %PSA than does height. The existence of statistical significance means this is an extreme result. For example, a p-value of 0.0027 means there is a 0.27% chance a result as extreme is obtained.

The discrepancy between the coefficients of variation was smaller for the males than the females. There was still statistical significance between the variation in the right palm for males with varying weight and constant height and constant weight and varying height. As expected, the p-values are closer to the significance level ($\alpha = 0.05$) despite statistically differing variances in the right hand ($p = 0.036$).

When concluding the presence of a significant difference in the variance of a set of data, the mean should be evaluated to ensure the statistical significance comes from the variance in the data, not variance in the mean. The result from the t-test of means indicates there was no significant difference in the means in either gender. Analysing the female with the varying height versus the varying weight, there was no statistical difference between the mean in the palm ($p = 0.194$). Similarly, with the males, the means do not significantly differ in the palm ($p = 0.565$). These results confirm the conclusion of Yu et al. (2008) that body weight is a significant factor when analysing %PSA. Since %PSA differs in subjects with similar body measurements, it also confirms the conclusion from Desbois et al. (2017) that it is important to personalise a model to a patient. To further strengthen these findings, the results presented in this study used actual human scans from previously collected data rather than a 3D model estimated through fitting and morphing of body parameters.

6 Conclusions

Treatment of burn patients depends on the accuracy of BBSA estimation. In this paper, a novel method to calculate the PSA and TBSA across a population represented by 3D scans was introduced and used to quantify the variance in %PSA, which directly affects the accuracy of BBSA estimates. This method also objectively studies the differences in how the %PSA is affected by changes in weight and changes in height for male as well as female populations. The study results reaffirm the inaccuracies of using a palm to relatively estimate BBSA and the errors introduced into the %PSA due to this assumption were quantified. Furthermore, this work suggests that there is a need for a method that can adjust for anthropometric differences, adapting to varying BMI and body type. A method that can account for these variances would provide more accuracy and thus improve care for burn patients.

Additional work that builds upon this method to accurately estimate %PSA in an individual is currently under investigation. This additional work is made possible by the findings presented in this study and is aimed to help the burn community with ultimate goal to improve burn patient care.

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