Revisiting Leonardo da Vinci's *Vitruvian Man* Using Contemporary Measurements

Five hundred years ago, Leonardo da Vinci attempted to memorialize Vitruvius' description of man's ideal human body. To do this, he manually measured proportions and combined them,[1,2] creating one of the most famous drawings of the human body in the world—*Vitruvian Man*.[3-5] Today, precise anthropometric body lengths can be obtained rapidly on large numbers of individuals. We repeated his approach using contemporary body scanning measurements to determine what Vitruvius' proportions would be in this modern data set and how they would appear if drawn in the style of *Vitruvian Man*. We also extended the process to women.

Methods | Air Force training recruits, typically between the ages of 17 and 21 years, were scanned with the 3-dimensional body scanner (Vitus Smart XXL; Human Solutions) for the purpose of uniform sizing between February 2011 and November 2016 at Lackland Air Force Base in San Antonio, Texas. This study was reviewed and approved by the Human Protection Administrator of the US Military Academy. Because of a nonresearch determination, a waiver of consent was granted.

Seven proportions that Leonardo da Vinci identified were available in the body scanner measurements (**Table**). The same mean proportions and standard deviations were calculated using the body scanner measurements.

All statistical analyses were performed in the statistical program R (R Foundation; 2013).

The scanner-estimated proportions were then applied to draw male and female figures using the same design as *Vitruvian Man*.

Results | The database of body scanner measurements consisted of 63 623 men and 1385 women. Mean male height was 175.1 cm (SD, 6.8 cm) and female height, 163.7 cm (SD, 6.6 cm).

The derived proportions for head height, arm span, breast to crown, and knee height were slightly more than Leonardo da Vinci's estimates (Table). The remaining estimates (groin height, shoulder width, and thigh length) were slightly less. Except for arm span and thigh length, the differences in proportions for men measured by the body scanner and *Vitruvian Man* were within 10%. The difference in arm span was 20% and difference in thigh height was 29% more than *Vitruvian Man*.

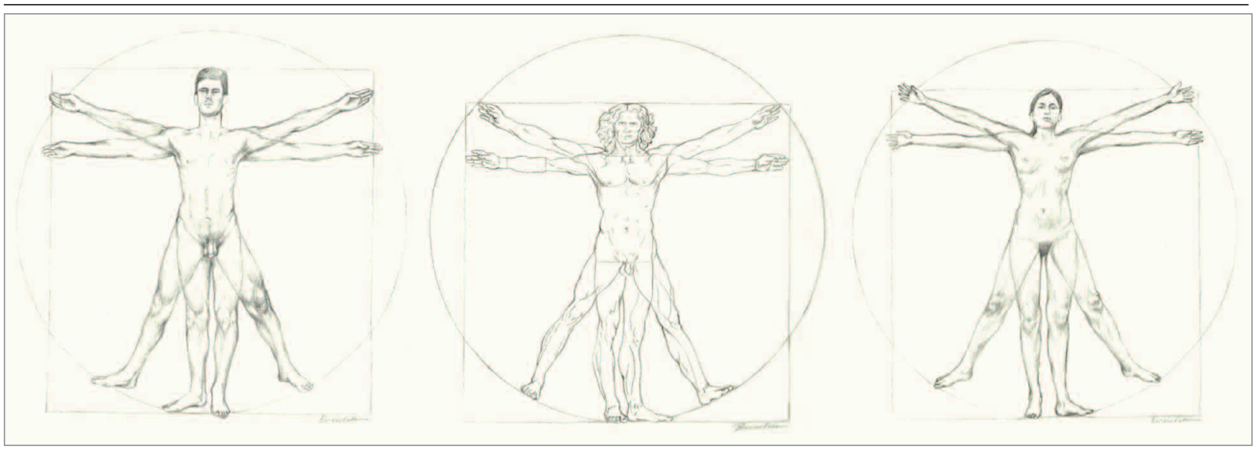
Both male and female drawings (**Figure**) based on the body scanner data depict arms that reach outside of the square and circle from Leonardo da Vinci's drawing, while the center of the circle and square are no longer exactly the navel or the groin.

Table. *Vitruvian Man* and Air Force Recruit Body Site Measurements as a Proportion of Height

Body length[a]	*Vitruvian Man* proportion of total height, cm	Proportion of total height, mean (SD)	
		Men	Women
Head height	⅛ = 0.125	0.14 (0.006)	0.15 (0.008)
Arm span	4/5 = 0.800	0.96 (0.027)	0.92 (0.290)
Groin height	½ = 0.500	0.45 (0.016)	1.46 (0.020)
Shoulder width	¼ = 0.250	0.24 (0.013)	0.25 (0.015)
Breast to crown	¼ = 0.250	0.27 (0.008)	0.28 (0.011)
Knee height	¼ = 0.250	0.27 (0.008)	0.27 (0.075)
Thigh length	¼ = 0.250	0.18 (0.011)	0.18 (0.098)

[a] To match Leonardo da Vinci's proportions, some scanner measurements were combined. The scanner did not include hand or foot measurements. In the case of hand measurements, we applied Leonardo da Vinci's proportion that the hand is one-tenth of body height, so Leonardo da Vinci's proposed arm span from wrist to wrist should be four-fifths of body height.

Figure. Leonardo da Vinci's *Vitruvian Man* Compared With Contemporary Man and Woman



Artist drawing of a male (left) and female (right) using the body scanner–derived proportion with a redrawn Leonardo da Vinci *Vitruvian Man* (center) using the same squares and circles. Some artistic license was applied to generate drawings in realistic poses; however, the proportions of the drawing were checked to ensure they agreed with the proportions obtained from our analysis.

Discussion | Using proportions from a large modern database of automatically scanned anthropometric measurements in both men and women, a contemporary Vitruvian man (and woman) were created, and close agreement with *Vitruvian Man* was found. All contemporary proportions in men were within 10% of *Vitruvian Man* except for arm span and thigh length.

Limitations of the study include that a heterogeneous sample of young Air Force recruits was used to estimate the proportions. The sample likely differs from the Tuscan men measured by Leonardo da Vinci, although the exact number and age of individuals he measured is not known. Leonardo da Vinci's notes and conclusions did not distinguish whether his insights were derived from a single individual or were aggregated.[1,2] Also, *Vitruvian Man* merged the concept of a perfectly proportioned man[5] with observed measurements and was not a representation of an average man. In fact, he could not rely on formal notions of population means and variability that were developed only over the last few centuries.[6] His notes also did not include measurement precision, and his numerical observations were most likely rounded to the nearest integer. Additionally, the scanner lengths are determined from body reference points, which may differ from his reference points. Despite the different samples and methods of calculation, Leonardo da Vinci's ideal human body and the proportions obtained with contemporary measurements were similar.

Diana M. Thomas, PhD
David Galbreath, MS
Maura Boucher
Krista Watts, PhD

Author Affiliations: Department of Mathematical Sciences, US Military Academy, West Point, New York (Thomas, Galbreath, Watts); Randolph Township Schools, Randolph, New Jersey (Boucher).

Accepted for Publication: March 2, 2020.

Corresponding Author: Diana M. Thomas, PhD, Department of Mathematical Sciences, Thayer Hall, US Military Academy, West Point, NY 10996 (diana.thomas@westpoint.edu).

Author Contributions: Drs Thomas and Watts had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.
Concept and design: All authors.
Acquisition, analysis, or interpretation of data: Thomas, Galbreath, Watts.
Drafting of the manuscript: All authors.
Critical revision of the manuscript for important intellectual content: Thomas, Galbreath, Watts.
Statistical analysis: Thomas, Galbreath, Watts.
Administrative, technical, or material support: Boucher.
Supervision: Thomas, Watts.

Conflict of Interest Disclosures: None reported.

Additional Contributions: We thank Kirsten Cooper, MA, University of North Carolina at Chapel Hill, and Robin Gauthe, BGS (self-employed), for editorial suggestions. No compensation was received.

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COMMENT & RESPONSE

Incisional Negative Pressure Wound Therapy After Surgery for Major Trauma–Related Fractures

To the Editor The results of the Wound Healing in Surgery for Trauma (WHIST) trial by Dr Costa and colleagues[1] should be interpreted with caution until the authors provide information regarding the actual duration of the incisional negative pressure wound therapy because duration is associated with effectiveness.[2]

Because surgical incisions disrupt the barrier function of intact skin, bacteria become free to colonize surgical wounds and form biofilms, increasing the risk of surgical site infection.[3] Yet even in healthy individuals, it takes 3 to 6 days for reepithelialization to occur.[4] Foils such as those used in incisional negative pressure wound therapy protect against external contamination during this critical period.[5]

Our group recently published a comprehensive meta-analysis that assessed all comparative studies on incisional negative pressure wound therapy.[2] The meta-analysis of 28 randomized clinical trials indicated that incisional negative pressure wound therapy reduces surgical site infections with a number needed to treat of 19 (relative risk, 0.61 [95% CI, 0.49-0.76]; $P < .001$; $I^2 = 27\%$). Using meta-regression analysis, we confirmed a significant correlation between incisional negative pressure wound therapy duration and its efficacy to prevent surgical site infections across surgical specialties, with an increase in duration associated with a significantly larger reduction in infections (41 studies; regression coefficient [relative risk], −0.213; $P = .04$).[2] This suggests that it is essential to provide incisional negative pressure wound therapy for a sufficient amount of time for the therapy to be effective (eg, for 7 days). When incisional negative pressure wound therapy dressings are removed earlier, before epithelial restoration, wounds continue to be exposed to colonization. Therefore, any data on incisional negative pressure wound therapy should always be interpreted with consideration of the treatment duration.

In the trial by Costa and colleagues,[1] 1548 patients were randomized to receive either incisional negative pressure wound therapy or standard wound dressings after surgery for traumatic lower limb fractures, with deep surgical site infection at 30 days as the primary outcome. They reported a nonsignificant decrease in deep surgical site infections after use of incisional negative pressure wound therapy (45/770 [5.84%] vs 50/749 [6.68%]; $P = .52$).[1] However, they did not provide any information on the duration of incisional negative pressure wound therapy, on the planned duration of their treatment protocol, or on the actual achieved duration of therapy. This information would be of considerable added value.

Pieter R. Zwanenburg, BSc
Allard S. Timmer, MD
Marja A. Boermeester, MD, PhD, MSc