# Comparing post-mortem and osteological measures of primate 2D:4D digit ratios

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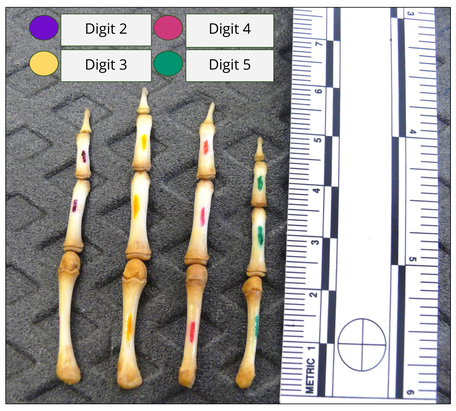
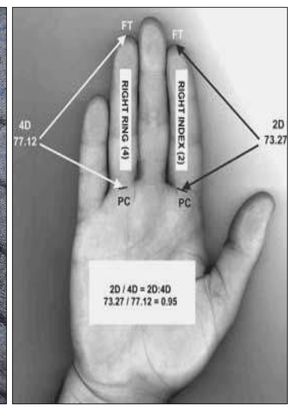
## Introduction

The ratio of the length of the second digit to the fourth digit changes with an individual's exposure to certain hormones, specifically testosterone, while developing in utero (Manning 2002). Researchers therefore use 2D:4D as a proxy for an individual's androgen exposure; a lower ratio demonstrates higher levels of prenatal androgen exposure, and a higher ratio demonstrates lower levels of prenatal androgen exposure (Manning 2002).

2D:4D is measured on intact hands. Ratios can also be obtained from disarticulated and articulated bones. Such measures may vary in accuracy and precision in their estimation of 2D:4D. We tested primate hands with and without skin and with disarticulated and articulated phalanges to determine accuracy and precision. The hands of 10 primate individuals from 7 different species were prepared and measured (table 1).




## Methods

We obtained 2D:4D ratios on the fully fleshed hands by measuring the distance between the proximal crease of the finger and the most distal tip of the finger (Figure 1; Manning et al. 1998; Sandler et al. 2001). All measurements were taken three times for all digits excluding the first, and the results averaged. Hands were also measured in flat and curled states to test accuracy (Figure 2; Figure 4).

The hands were then carefully skinned. The outermost layer of dermal tissue was removed, leaving only subcutaneous layers and ligaments. Fingers were then remeasured (Figure 3; Figure 4). As the proximal crease of the digit was no longer visible, the proximal end of the proximal phalange was used as a proxy. The skinned hand was sewn in a heat resistant mesh and macerated to remove any remaining tissues.

The bones were then color-coded and carefully measured using a small osteometric board. Ratio measurements on the proximal, intermediate, and distal phalanges were taken both separately and as a whole after rearticulating the bones (Figure 5; Figure 6). Ratio measurements were taken with and without epiphyseal plates reattached to the phalanges, as the individual was a juvenile and the bones had not been fully fused.

The ratio of the measurements for each level of preparation to the values for intact hand were calculated. Measurements that were accurate, therefore, will give a value close to 1.0, and those that were more precise will have small standard deviations.

| Specimen | Original State of Hand |
|---|---|
| *Macaca mulatta* (original) | Fully Fleshed |
| *Macaca mulatta* (4) | Tendons/Ligaments |
| *Macaca fascicularis* | Tendons/Ligaments |
| *Macaca nemestrina* | Tendons/Ligaments |
| *Macaca nigra* | Fully Fleshed |
| Gibbon | Bone |
| *Lagothrix* | Tendons/Ligaments |
| *Cacajao* | Tendons/Ligaments |


**Figure 1**. Proximal crease and distal fingertip marking points, used to calculate flat finger length.

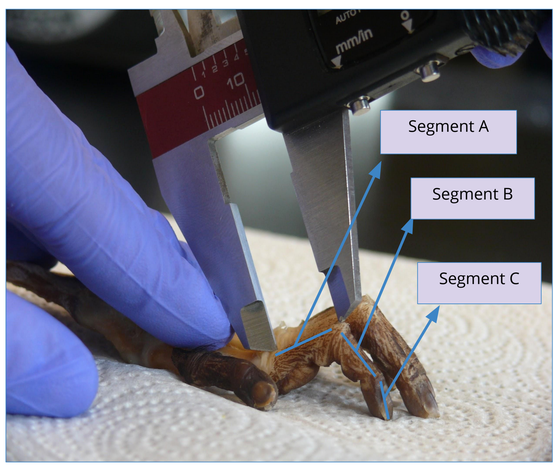



**Figure 2.** Segmented finger measurements, used to calculate finger length on curled fully fleshed hand.

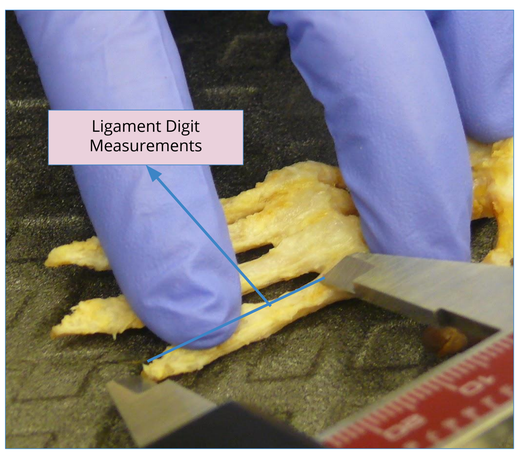



**Figure 3.** Skinned specimen's hand being measured, from the proximal to the distal end of the phalange.

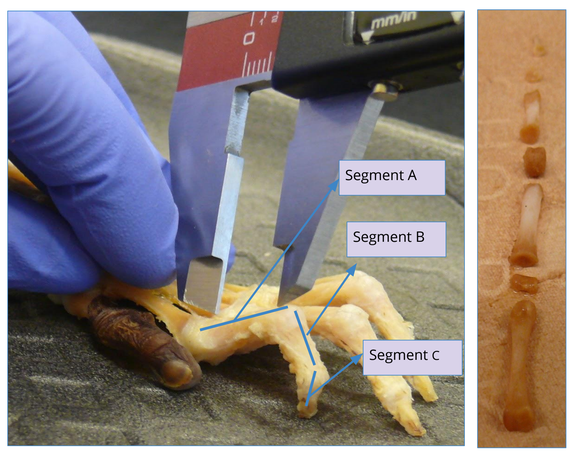





**Figure 4a (left).** Segmented finger measurements, used to calculate finger length on curled hand without skin.
**Figure 4b (right)**. Unarticulated phalange with detached epiphysis.

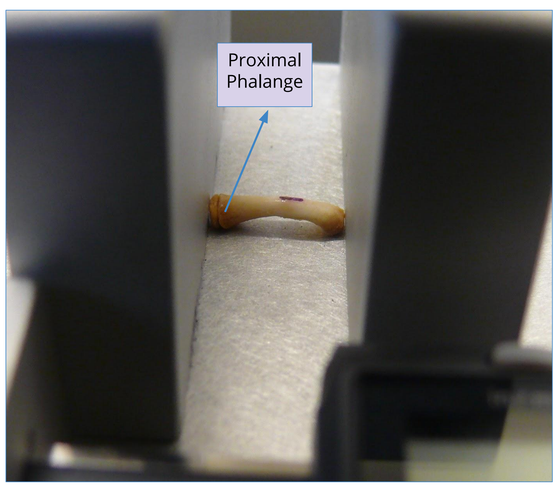



**Figure 5.** Individual phalange with attached epiphysis being measured in osteometric board

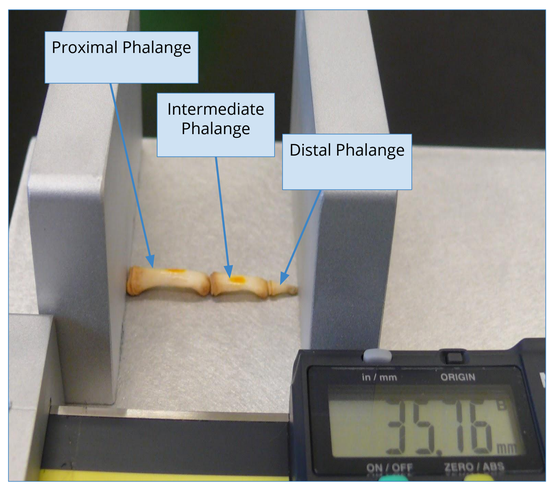
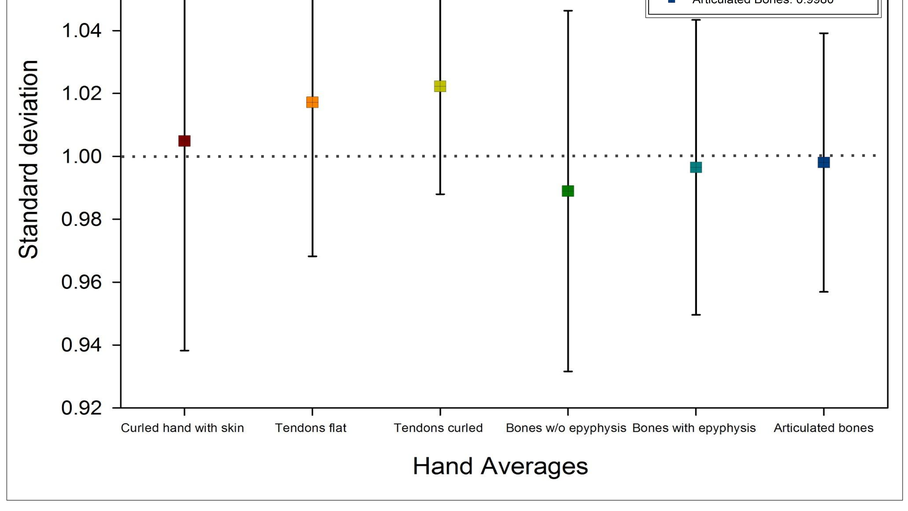



**Figure 6.** Fully articulated third digit with attached epiphysis being measured in osteometric board.

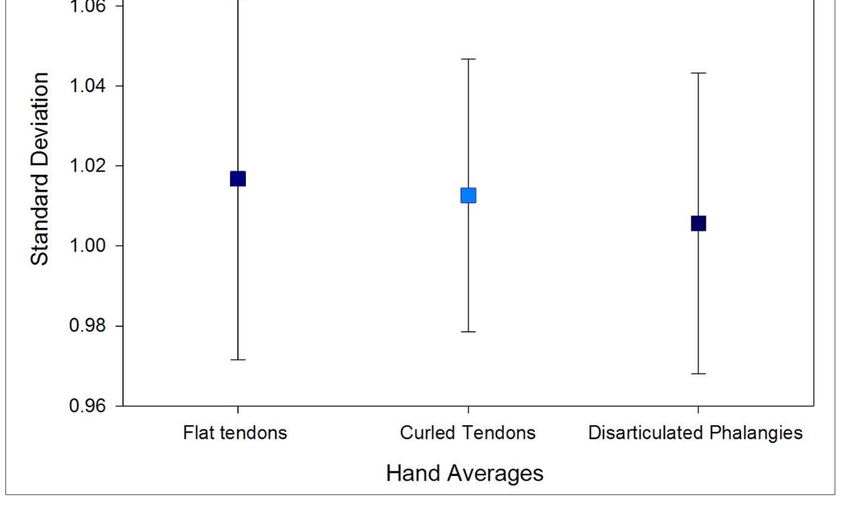
## Results

Three of the hands that were prepared had skin so that original 2D:4D measures could be taken and used for comparison (Figure 7). These results showed that the most accurate estimate of intact 2D:4D was the one taken from articulated bones. The measures taken with tendons were less accurate. The most precise method, in terms of having the smallest standard deviation, was made on a curled hand with tendons, but this measure was also the most inaccurate of the true value. Seven hands had tendons but not skin. The ratios for each stage were therefore compared to the articulated bones as this was the most accurate measure from the first data set. Of these measures, the most accurate in terms of fit to the articulated bones, but all of the measures were imprecise as they had large standard deviations (Figure 8)

## Figure 7: Accuracy of Measurements




## Figure 8: Hands Without Skin




## Conclusions

Our data show that it is possible to measure 2D:4D ratios on hands without skin, and that the most accurate measure to estimate intact hand ratios is to use articulated bones. These measures can therefore be taken on osteological specimens as well as determined from fossils.

During this study, one of the challenges that most likely contributed to the lack of precision was the difficulty in determining landmarks after the skin was removed. In some levels of preparation, landmarks could be seen, and this would have increased precision but these landmarks were not accurate representations of overlying skin folds. Therefore we recommend that when researchers wish to determine 2D:4D from hands without skin, the hands be fully prepared and the measurements taken from articulated bones.

## References

Allaway, Heather et al. 2009. "Digit Ratios (2D:4D) Determined by Computer-assisted Analysis Are More Reliable than Those Using Physical Measurements, Photocopies, and Printed Scans." *American Journal of Human Biology*. Volume 21, Issue 3: p. 365-70.
Manning, John T. 2002. *Digit Ratio: A Pointer to Fertility, Behavior, and Health*. New Brunswick, NJ: Rutgers University Press.
Manning, J. T., D. Scutt, J. Wilson, and D. I. Lewis-Jones. 1998. "The Ratio of 2nd to 4th Digit Length: A Predictor of Sperm Numbers and Concentrations of Testosterone, Luteinizing Hormone and Oestrogen." *Human Reproduction*. Volume 13, Issue 1: p. 3000-004.
Sandler, Adrian D. 2001. "The 2nd to 4th Digit Ratio and Autism." *Journal of Developmental & Behavioral Pediatrics.* Volume 22, Issue 5: p. 339-40.