Measuring finger ratios in hands and bones: Testing reliability and accuracy of post mortem methods of 2D:4D assessment in primates

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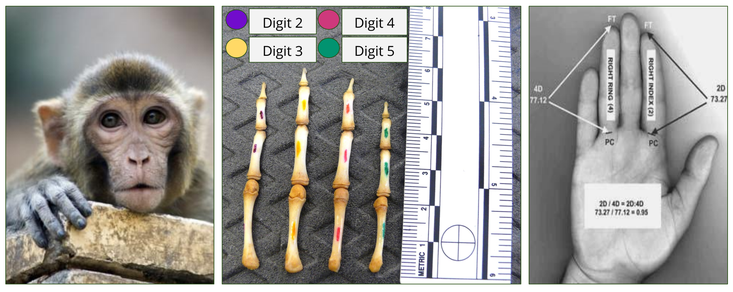
Introduction

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). Scientists 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).

We hypothesize that accurate 2D:4D ratios can be obtained from the hands of living individuals as well as from their disarticulated and articulated bones. We tested our hypothesis by measuring the 2D:4D ratio of a single rhesus macaque (*Macaca mulatta*) hand with and without skin, as well as by measuring the disarticulated and articulated phalangeal (finger) bones after they were processed.



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 hand was 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.

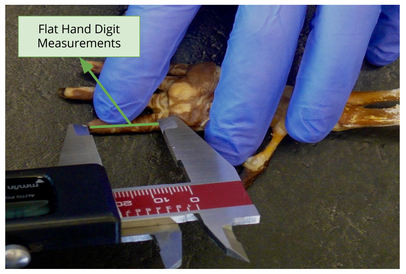


Figure 1. Proximal crease and distal fingertip marking points, used to calculate flat finger length.

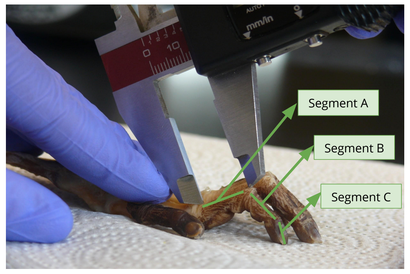


Figure 2. Segmented finger measurements, used to calculate finger length on curled fully fleshed hand.

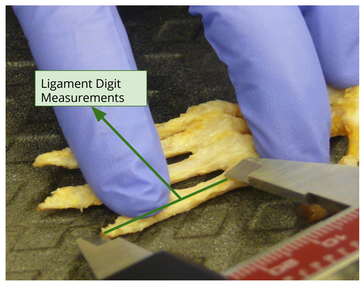


Figure 3. Skinned specimen's hand being measured, from the proximal to the distal end of the phalange.

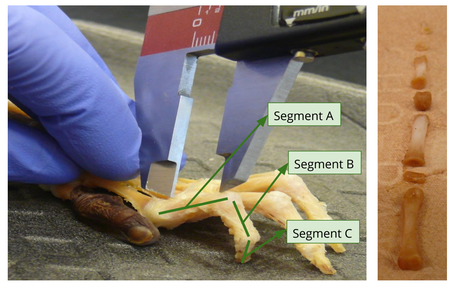


Figure 4a (left). Segmented finger measurements, used to calculate finger length on curled hand without skin. **Figure 4b (right)**. Unarticulated phalange with detached epiphysis.

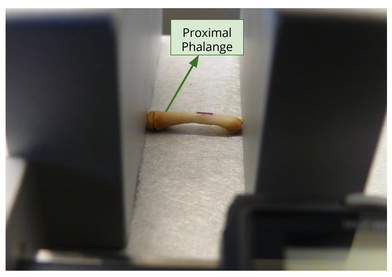


Figure 5. Individual phalange with attached epiphysis being measured in osteometric board

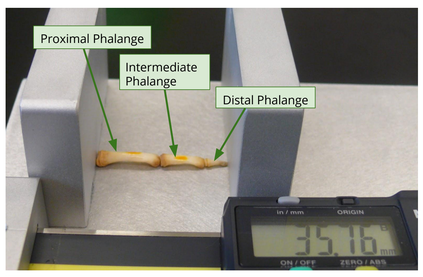
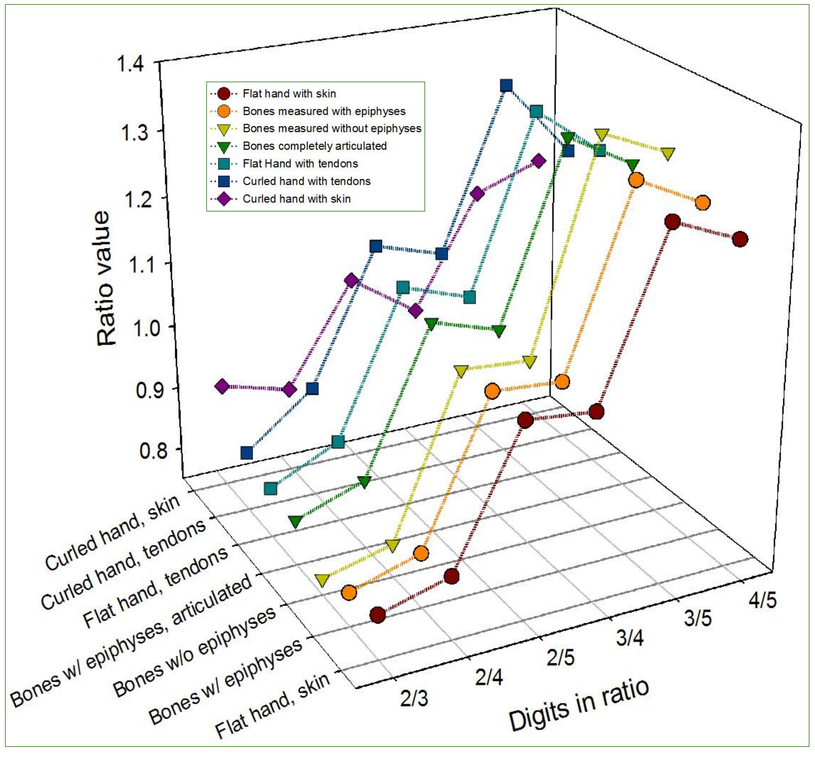


Figure 6. Fully articulated third digit with attached epiphysis being measured in osteometric board.

Figure 7: Accuracy of Measurements



Results

We found that the 2D:4D measurements obtained in all flattened measurements closely correlated to the true value (r = 0.997 - 0.999), but the measurements obtained from the curled and mummified hands were considerably less correlated (r = 0.9962 - 0.9818). Different levels of accuracy were compared to the true value as measured from the flattened hand with skin (see table below). When the different methods were ranked according to how closely they correlated to the true value, it was found that the most accurate measurement was taken from the disarticulated phalangeal bones with the epiphyses reattached (Figure 7).

State of hand when measured	Correlation coefficient	Rank order
Fully Fleshed, Flat	1	0
Bones With Epiphyses, Unarticulated	0.99997	1
Bones w/o Epiphyses, Unarticulated	0.99949	2
Bones With Epiphyses, Articulated	0.99924	3
Tendons, Flat	0.99689	4
Tendons, Curled	0.98178	5
Fully Fleshed, Curled	0.962296	6

Conclusions

The 2D:4D ratios obtained from all flattened measurements closely correlated to the original measurement obtained on the fleshed hand (r = 0.997 - 0.999). The measurements taken on the unarticulated bones with the epiphyses attached most closely correlated to the original ratio. Therefore, the most accurate ways of obtaining 2D:4D ratios are either on hands with visible proximal creases on the digits, or on the unarticulated bones with the epiphyseal plates reattached.

The most closely correlated ratios (r = 0.99 and above) were all found in flattened hands, indicating that measuring 2D:4D ratios on curled hands is less accurate and therefore less reliable. The measurements taken on subcutaneous tissues and ligaments also yielded lower correlation coefficients, likely because it is difficult to consistently discern whether or not one is measuring from the most proximal end of the proximal phalange due to the lack of a visible proximal crease or exposed bone.

Measurements taken after reattaching the epiphyseal plates yielded higher correlation coefficients than measurements taken without them. The slightly higher correlation coefficient of unarticulated bone ratios compared to articulated bone ratios reflects the difficulty of manually rearticulating the bones in so that no spaces between phalanges occur. We recommend measuring 2D:4D using the disarticulated bones with epiphyseal plates attached as the most accurate post-mortem method.

References

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