How anthropometric measurements change with hand posture? A pilot study using 3D scanning

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Summary

This work studies the changes that hand posture causes in hand dimensions using 3D scanning technologies and a thorough set of dorsal and palmar measurements, including finger joint width. The results show where bigger changes occur, highlighting the need to control posture in collecting hand anthropometry or morphology.

Introduction

Hand posture affects hand measurements, crucial in ergonomic design and clinical assessments, particularly for conditions that alter hand morphology, such as osteoarthritis. Prior studies examined posture's impact, but focused on dorsal measurements [1] or overlooked joint widths [2,3]. This pilot study offers a comprehensive analysis, with a thorough set of dorsal and palmar measurements, including finger joint widths, key in osteoarthritis characterization, glove fitting and hand exoskeleton design.

Methods

The right hand of 2 healthy persons (1 male aged 55, 1 female aged 34) was marked with anatomical landmarks to obtain the dimensions presented in Figure 1 and 3D scanned using the XOne AI application (v5.2.4, Xplorazzi Tech) in a Redmi Note 10 Pro Android device (108MP cam, 2MP depth sensor).

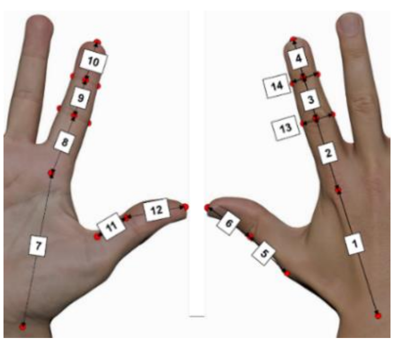

Figure 1: Measured thumb and index finger dimensions (D).

The hand was scanned lying on a flat surface (dorsal and palmar views) and with cylindrical and two-finger pinch grasps. A physical ruler was added to the scanning setup as a scaling reference. MeshMixer software (v3.5.474, Autodesk) was used to obtain the lengths and widths of the thumb and index fingers (Figure 1). The process of scaling and computing dimensions was done three times by one operator.

An ANOVA with subject, measurement, posture, and their interactions as factors was used to check repeatability (with error as mean square of residual variance). The mean value for each dimension was computed. The following ratio was computed as a normalized parameter of the length changes between dimensions in the flat posture and the grasp one:

$$ratio = \frac{grasp\ measurement - reference\ measurement}{reference\ measurement}$$

Results and Discussion

Repeatability error (0.36 mm) indicates low variability of measurements. Table 1 presents the obtained ratios for each measured length, averaged between participants.

Table 1: Mean ratios for each measured length and participant

D	Pinch (%)	Cyl. (%)	D	Pinch (%)	Cyl. (%)
1	-5.82	-11.56	8	-28.67	-14.78
2	16.22	12.12	9	-17.90	-20.99
3	10.46	13.07	10	-7.95	-11.47
4	0.17	-0.05	11	-19.83	-4.86
5	15.47	6.99	12	-5.28	-14.24
6	4.23	3.77	13	6.34	6.60
7	-13.37	-2.01	14	3.78	9.63

As expected, with fingers' flexion, dorsal dimensions tend to expand, while palmar ones compress. Index carpal dorsal length compresses during grasp owing to the wrist extended posture. Bigger changes appear in proximal phalanges, while little is observed for distal ones. Increased width values indicate that finger pressure and positioning systematically impact phalanx thickness.

Conclusions

Posture affects hand dimensions, including lengths and joint widths, highlighting the need to study joint thicknesses. Standardizing posture during data collection would improve reproducibility and comparability, particularly in hand anthropometry studies. Moreover, the results remark the importance of evaluating hand anthropometry in functional postures for studies focused on designing products such as gloves or hand exoskeletons. Relative changes between dorsal and palmar dimensions of each phalange can be used for the design of exoskeleton mechanisms, especially cabled ones.

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