

# Proportions of Hand Segments

## Proporciones de los Segmentos de la Mano

\*Buryanov Alexander & \*\*Kotiuk Viktor

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**SUMMARY:** The analysis of proportions of hand segments has been carried out on the basis of X-ray films of 66 adult patients without developmental abnormalities. There were hand joint topographies determined proceeding from the data obtained. There were suggested methods of practical utilization of the obtained data in the field of medicine.

**KEY WORDS:** Hand; Joints; Phalanges; Proportions; Thermography.

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### INTRODUCTION

Such investigation methods as thermography or isotope scanning allow visualizing inflammation, neoplastic and some other pathological processes, and their location in the body. But the knowledge of regional topography is necessary for exact localization of the process. Such external anatomical landmarks of the hand as bone prominences and creases help to localize its joints and other structures during the clinical examination. On X-ray pictures, MRIs and CT images or during ultrasonography, anatomical structures are well visualized and their localization is not a problem. However, thermography and isotope scanning allow us to see only the shape and outlines of the anatomical region. So the identification of anatomical structures, particularly hand joints, on thermograms and bone scans is often difficult.

It is generally accepted in medical literature that there is certain regularity in the proportion of finger segments. It has been considered for a long time that the relation between phalanges and metacarpals lengths approximates the Fibonacci sequence (Hamilton & Dunsmuir, 2002). The search of the anatomical structures in humans to follow the Fibonacci sequence was encouraged by finding such a ratio in the mollusk Nautilus shell and in the egg. But this statement was disclaimed by Park *et al.* (2003). However, these investigators noted that ratio of distances between the centers of rotation of the finger phalanges (functional phalanges lengths) may be closer to the Fibonacci sequence

(Park *et al.*). But Hamilton & Dunsmuir rejected even that statement (Littler, 1973). It is obvious that segments of all of the five fingers can't fit the same ratio. The cause is different relations between the phalanges lengths in each of the five fingers and even different phalanges numbers. But there is a strong evidence of existence of some constant ratio between finger segments in several investigations. There are a lot of scientific publications on this subject (Case & Ross, 2002; McArthur *et al.*, 1998; Pereira *et al.*, 1998; Richterman, 1998). But measurements are rather different between these studies. Also none of the studies included measurements of all the phalanges and metacarpals of all five fingers of the hand, web heights, and the heights of the soft tissues on the tip of the fingers. That may be caused by different objectives of the investigations, different measurement methods and patients of different ethnic backgrounds. The study of the second to fourth web space height relations to the whole corresponding finger length, including finger tip soft tissues, was carried out by Richterman but only on children (Richterman *et al.*). We did not find similar data for adults. As far as we know there are no scientific articles that describe the ratio between all three phalanges of every finger and all five metacarpals, and considered soft tissues of the finger tip of adults, European adults in particular. The knowledge about the soft tissues of the finger tip gives us additional information for the exact location of the finger joints on thermograms and bone scans, as far as we do not see bones

\* Prof. MD, PhD. National Medical University n.a. Bohomoletz A.A. Department of Orthopedics and Traumatology, 01601, Shevchenko avenue 13, Kiev, Ukraine.

\*\*MD, PhD. National Medical University n.a. Bohomoletz A.A. Department of Orthopedics and Traumatology, 01601, Shevchenko avenue 13, Kiev, Ukraine

on them as opposed to X-ray images. In addition, the data about finger segments and metacarpal ratios are necessary for finger joint implant development, the treatment of finger and metacarpal deformities and defects, and for better understanding the processes of phylogenesis and ontogenesis. Also, knowledge about phalangeal ratios may be useful for clothing design, equipment, and hand tool ergonomic research. Some data obtained by Pereira et al. from measurements on cadavers of Asian origin are not very suitable for our purposes because of their incompleteness concerning soft tissues and because of the different proportions of the skeleton of the Asian population (Pereira *et al.*).

So the aim of our study was to find a regular pattern of length correlations of phalanges with finger tip and metacarpals for the elaboration of the method of hand joints localization on thermograms and bone scans.

## MATERIAL AND METHOD

We studied anterior-posterior X-ray images of right and left hands of 66 adult patients from 19 to 78 years old without any bone pathology or deformities. These X-ray pictures were made to rule out the assumed fractures excluding them intentionally for this investigation. So our patients did not receive any additional ionizing radiation.

Proportions of the hand segments change in phylogenesis and ontogenesis, but the maximum intensity of changes happens in childhood (Richterman *et al.*). The changes after the of 18 years of age are considered to be insignificant.

Emansis Digital X-Ray System and Italray ITH ABT +IR350 were used

to take X-ray images. The length between the X-ray source and the sensor was constant in all cases. The resulting image was 100 % of the real studied anatomical region. We used a radiopaque ruler on every fifth patient and checked its real length and the length on the resulting X-ray image to confirm the measurement accuracy. There were no scaling errors determined in any case. The exploration targets were interarticular lengths of finger bony phalanges and metacarpals, soft tissues length at the finger tips, web heights, and the relative lengths of the segments between the web, the finger joints and the finger tip (Fig. 1).

We utilized the literature data to correlate with our data.



Fig. 1. Anteroposterior X-ray image of the hand with quantities measured. I-V – finger index numbers; tip – soft tissues of the finger tip; pd – distal phalanx; pm – medial phalanx; pp – proximal phalanx; m – metacarpal; pp\* – web height from metacarpophalangeal joint; d – the entire length of the finger skeleton from metacarpophalangeal joint to the tip of the distal phalanx bone; de – the entire finger length from the web space to the very tip of the finger including the soft tissues of the tip.

**RESULTS AND DISCUSSION**

We determined that the joint spaces of metacarpophalangeal joints of the second to fourth digits projects approximately 15-25 % proximally to the web depending on the index number of adjacent finger (Table III). This parameter (web height) ranged greatly between fingers of different index numbers and between fingers of the same index number. In our opinion the main cause is the different degree of finger abduction at the moment of the X-ray shot. It is explained by different degree of web stretching and subsequent motion of its border proximally or distally. Of course dimensions of the joints are not limited by joint spaces on anteroposterior X-ray images, but our aim was to choose standard points that correspond to metacarpophalangeal joints. So we consider our measurement results as such as satisfying our aim. The measurement results of phalanges and metacarpals lengths are presented in Table I. The ratio of phalangeal and metacarpal bones of the hand is presented in Table II. The phalangeal width, the cortical width, the hand breadth, the thickness and the circumference usually differ

significantly between the right and the left hands. Nevertheless the lengths of the phalanges and metacarpals, and subsequently the ratio of phalangeal and metacarpal bones, differ very little between the corresponding fingers of the left and the right hands. The difference was within 0,5 % and mostly much less. So the measurements were summarized by computing arithmetic means and SD for right hands only. The level of significance of all statistical data was 5%.

The ratios of segments of the 2<sup>nd</sup> and the 4<sup>th</sup> rays are alike, while the ratios of the 1<sup>st</sup> and the 5<sup>th</sup> rays differ significantly. So we suppose it is impossible to bring the ratios of the phalanges of all five digits under the same objective laws.

We measured the relative distances (in percentages) to the joints of the fingers (Table III). The relative length from the tip of the finger to the distal interphalangeal joint comparatively to the external finger dimensions is (tip + pd)x100% / de. The relative length from the distal interphalangeal joint of the finger to the proximal interphalangeal joint comparatively to the external finger

Tab. I. The lengths of phalanges, metacarpals and soft tissues of the distal phalanges.

Finger	tip – soft tissues of the tip of the distal phalanx (mm)	pd–distal phalanx (mm)	pm–medial phalanx (mm)	pp–proximal phalanx (mm)	m–metacarpal (mm)
I	5.67±0.61	21.67±1.60		31.57±3.13	46.22±3.94
II	3.84±0.59	15.82±2.26	22.38±2.51	39.78±4.94	68.12±6.27
III	3.95±0.61	17.40±1.85	26.33±3.00	44.63±3.81	64.60±5.38
IV	3.95±0.60	17.30±2.22	25.65±3.29	41.37±3.87	58.00±5.06
V	3.73±0.62	15.96±2.45	18.11±2.54	32.74±2.77	53.69±4.36

Values are presented as arithmetic mean ± SD.

Table II. The incremental dimensions of phalanges and metacarpals shown as ratios.

Finger	pd – distal phalanx	pm – medial phalanx	pp – proximal phalanx	m – metacarpal
I	1		1.5	2.1
II	1	1.4	2.5	4.3
III	1	1.5	2.6	3.7
IV	1	1.5	2.4	3.4
V	1	1.1	2.1	3.4

Data are reported as a ratio of the phalanges and metacarpals. The results are corrected to the nearest tenths.

Tab. III. The lengths from the tip of the finger to the joints in percents to the entire finger length.

Finger index number	I	II	III	IV	V
tip + pd	49,36	27,80	26,32	28,25	33,92
pm	-	30,97	33,11	33,61	31,99
pp*	just proximal to the 1 <sup>st</sup> web space <sup>1</sup>	15,52	15,33	18,49	24,72

Values are presented as percents. 1 definite value is impossible to measure due to mobility of the 1st metacarpal and significant inconstancy of web stretching and subsequent motion of its border proximally or distally. tip – soft tissues of the finger tip; pd – distal phalanx; pm – medial phalanx; pp\* – web height from metacarpophalangeal joint.

dimensions is  $pm \times 100\% / de$ . The relative length from the web to the metacarpophalangeal joint comparatively to the external finger dimensions is  $pp^* = (tip + d - de) \times 100\% / de$ .

Abbreviations in the expressions above: tip – the height of the soft tissues of the finger tip above the apex of the distal phalanx, pd – the length of the osseous distal phalanx, pm – the length of the medial phalanx, pp\* – the web height (to the metacarpophalangeal joint), d – the length of the bony skeleton of the finger which is equal to the sum of lengths of the three osseous phalanges, de – the length of the finger (we mean external finger length rather than the length of its bony skeleton).

## CONCLUSION

The obtained results allow the improvement the localization of the finger joints on thermal images and bone scans that lack any other landmarks for the exact localization of the hypo-/hyperthermic area or zone of high or low uptake of radiopharmaceutical. The understanding of normal ratio of the phalanges and metacarpals allows a substantiated approach to reconstructive operations on the hand, particularly to those restoring length of injured finger segments and metacarpals in cases of defects.

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**RESUMEN:** Se analizaron en radiografías de 66 pacientes sin anomalías del desarrollo las proporciones de los diferentes segmentos de la mano. De acuerdo a los datos obtenidos se determinó una topografía de las articulaciones. Se proponen modos de empleo en la medicina de los datos obtenidos en este estudio.

**PALABRAS CLAVE:** Mano; Articulaciones; Falanges; Proporciones; Termografía.

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Correspondence to:  
Kotiuk Viktor  
04111, Salyutnaya str. 13, app. 57  
Kiev  
UKRAINE

Tel. (044)-449-35-64 (home)  
068-321-42-87 (cell)

Email: kotyuk@yandex.ru  
kotyuk\_v@ukr.net

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