TWHP (TYPE-WHAT-HOW-POSE): A Novel Nomenclature for Hand Anthropometry

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Abstract. Hand anthropometry data collection of a sample population is a conventional and important first step during design and evaluation of any hand operated product. The purpose of this work is first to discuss some of the deficiencies in the use of hand anthropometry nomenclature in published scientific literature. Based on the limitations observed, a mnemonics-based novel nomenclature system called TWHP (TYPE-WHAT-HOW-POSE) is proposed for easy and efficient referencing and management of the names/titles/labels of different hand anthropometric dimensions. A typical hand anthropometry measurement exercise could involve measurements of features classified as distances, angles, and ratios. Within the scope of this work distance specific dimensions and the associated ratios have been considered for the TWHP nomenclature development.

Keywords: hand anthropometry, nomenclature, standardization, mnemonics

1 Introduction

Hand held products have invited tremendous interest of ergonomics-based research in the past; hand anthropometry especially, finds popular mention and focus in many such works [1]. Research concerning 'human anthropometry' has traditionally been concerned about anthropometric data collection, analysis and its application [2-4]. It does not focus significantly enough on the technical factors such as the nomenclature that facilitates efficient management of anthropometric data. The authors of this paper believe that titles of hand anthropometric dimensions constitute an important category of information which should be managed well as well. An efficient nomenclature is essential for researchers to conduct and present their research effectively, as well as for the future researchers to be able to understand data from past research works quickly and correctly. There are several examples of past research where hand anthropometric dimension titles have been published in textual formats which are cumbersome to interpret and use, and could therefore lead to poor experience of the readers (e.g., labels such as *IndexThk* provided in [5]). In some works the dimension names have been replaced by serial codes representing hand dimensions to be referenced only with the assistance of labeled diagrams (for e.g. in [6]). In other works, even if a diagrammatic guide is provided, the images are difficult to

comprehend (e.g. several figures provided in [7]). There also exist examples of studies where images illustrating the specific anthropometric dimension are neither provided, nor are referenced from any past research works [8]. In some research works, the dimensions are represented through diagrammatic codes which are presented well, but could be significantly time consuming for a reader to decode (for e.g. in [9]). These are some reasons which indicate a need to standardize the hand anthropometric nomenclature for reduced reliance on author specific 'variable hand anthropometric dimension labels/descriptions', as well as on 'problematic diagrams' representing hand dimensions presented in many published papers. On a contrasting note, an example of an easy to manage, standardized mnemonics-based nomenclature could be found in [10]. Here, a title like B1DP is used to represent the breadth (represented by the character 'B') of digit 1 (character '1') at the distal (character 'D') phalange (character 'P'). This strategy makes use of specific characters as substitutes for verbally elaborate titles of standard hand dimensions in a consistent manner across the work. The construction logic of this nomenclature and its utility however, has not been formally discussed in [10].

The aim of this paper is to propose a novel logic-based naming system (TYPE-WHAT-HOW-POSE or in short, TWHP) for hand anthropometric dimensions. This work could be beneficial for researchers to gain a sense of the range of hand anthropometric dimensions collected during hand anthropometry based research. This work should also find interest among the researchers who, like the authors of this paper have faced difficulties using the traditional verbally elaborate style of hand anthropometry nomenclature (e.g. titles like 'breadth of thumb at the distal phalange'). This mnemonics based standardized nomenclature system offers high scope for effective applications in programmable systems.

2   Proposed Nomenclature

Some general reference terms associated with hand anthropometry have been provided in Figures 1 and 2. The elements of TWHP nomenclature have been described under four categories of hand dimension descriptors arranged sequentially. These are the dimensions describing information about - the 'TYPE' of measurement used; 'WHAT' specific part of the hand is being measured; 'HOW' is the measurement being made of the hand dimension; and the 'POSE' which is assumed by the hand during measurement of the hand dimension. Each title/name of an anthropometric dimension in this system would make use of at least two or more instances of these 4 components. The 'HOW' and 'POSE' are conditional parts for a dimension title. However, the 'TYPE' and 'WHAT' components are essential components in any title. This is because to define any anthropometric dimension it is essential to have information on the nature of the measured dimension (TYPE), and the specific part of the human hand (WHAT) which is being measured. A more elaborate discussion is provided in section 2.1. New elementary mnemonic codes proposed in the nomenclature for different hand anthropometric dimensions have been provided in Table 1.
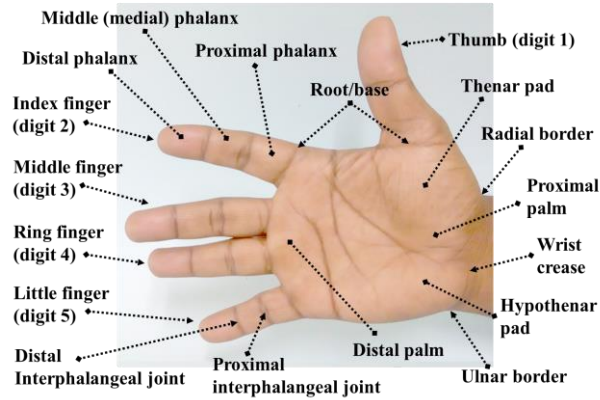
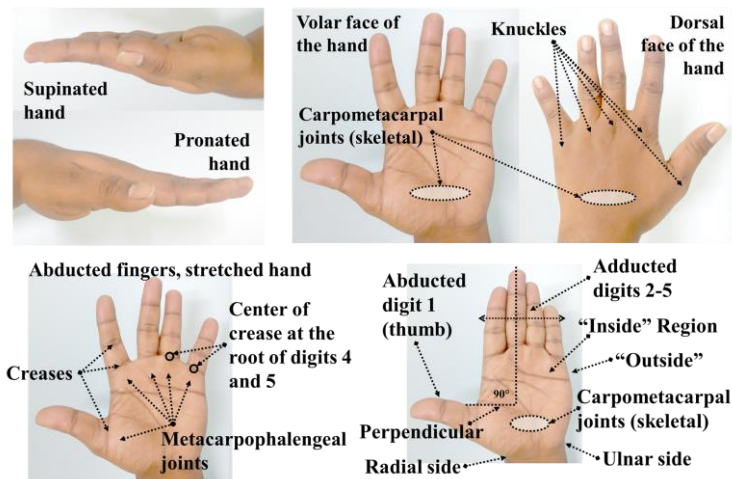**Fig. 1.** Standard terms associated with different volar hand surface features

Fig. 2. Standard terms associated with different hand features and postures

Table 1. New elementary codes for different features of hand anthropometric dimensions

Code	Name	Description specific to this work
TYPE		
B	Breadth	In the conceptual reference to a rectangular region, refers to the linear dimension of the smaller side.
C	Circumference	Refers to the peripheral distance measured across a single block of solid mass.
D	Diameter	In the conceptual reference to a circular region, refers to the maximum distance between any two points on the boundary.
L	Length	In the conceptual reference to a rectangular region, refers to the linear dimension of the longer side.

R	Ratio	It is the result of a mathematical relation involving division of one quantity by another.
S	Span	It refers to the maximum dimension between two landmarks typically measured when the posture is a stretch, spread, or, abduction of some kind.
T	Thickness	It is used to represent the 'depth' of a feature.
X	Custom dimension	It refers to non-traditional customized type of hand dimensions.
WHAT		
B	Body	It is used to refer to the whole human body.
C#	Carpal bones/carpometacarpal joint	Refers to one of the five joints in the wrist that articulate the distal row of carpal bones and the proximal bases of the five metacarpal bones. The point where digit articulation begins.
D#	Digit	Refers to one of the fingers in either hand. This term also has references to positive integers possibly due to the practical use of fingers during counting operations.
F	Fist	Refers to a hand posture where the fingers are bent in towards the palm and held there tightly, typically in order to strike a blow or grasp something.
G	Grip	Refers to a posture adopted by the hand when holding an object or while simulating such an action.
H	Hand	Refers to the whole hand.
J#	Joint	Refers to one of the joints of the fingers.
K#	Knuckles	Refers to the part of a finger at a joint where the bone is near the surface, especially where the finger joins the hand. It is referenced in the outer-hand (back of the palm) context.
M#	Metacarpal bones/ Metacarpophalengeal joint	One end of the metacarpal bones forms the knuckles and the bottom end is where they join to the wrist at the carpometacarpal joint.
P	Palm	The inside part of the hand beginning from the wrist to the base of the fingers.
P#	Phalange	The phalanges are the bones that make up the fingers of the hand. There are fourteen phalanges on each hand. Three phalanges are present on each finger with the exception of the thumb which possesses only two. These begin at the metacarphophalengeal joint and end at the finger tips.
W	Wrist	The region of the joint between the hand and the forearm; it contains eight bones, called the carpal bones.
HOW		
ab	Abducted	Is to draw away (as a limb) from a position near or parallel to the median axis of the body.
ad	Adducted	If a person has the fingers spread wide apart, bringing them together would be adduction.
cn	Centre	Place in the middle.
cr	Crease	A line or ridge produced by folding.
di	Distal	Situated away from the centre of the body, or from the point of attachment.

in	Inner	Situated inside or further in; internal.
mx	Maximum	As great or high as possible or permitted.
ot	Outer	On the outer side; external.
pp	Perpendicular	At an angle of 90° to a given line, plane, or surface.
pn	Pronation	Hand in the pronated posture with the volar region facing up.
pr	Proximal	Situated nearer to the centre of the body or the point of attachment.
rd	Radial	Situated near the radius or the thumb side of the hand.
rt	Root	The point or origin or attachment.
st	Stretched	Be made longer or wider without tearing or breaking.
su	Supination	Hand in the supinated posture with the volar region facing down.
tp	Tip	The pointed or rounded end or extremity of something slender or tapering.
ul	Ulnar	Situated near the little-finger side of the human hand.

2.1 Nomenclature Description and Use

2.1.1 TYPE

In the TWHP nomenclature system, the first character (TYPE) indicates the spatial nature of the dimension, i.e. whether the anthropometric dimension is a measure of breadth (B); circumference (C); diameter (D); length (L); ratio (R); span (S); or thickness (T) of any feature in the hand (Table 1). These characters (B,C,D, etc.) constitute the elementary mnemonic units in the TWHP system for constructing the title/name of any hand dimension. Specific applications may warrant the need for measurement of non-standard (less frequently measured) dimensions as well. Such dimensions have been encoded by using the character 'X' as the 'TYPE' of a dimension. Also, if the first character is an 'X', brackets '[]' follow it and contain within them, the reference to the specific hand features being used in this measurement (examples in section 2.1.3). Apart from the 'X' TYPE of dimensions, brackets have also been used for constructing the ratio 'R' TYPE of dimensions (examples in section 2.1.3).

2.1.2 WHAT

The second character in the nomenclature is 'WHAT' and is used to specify the specific hand region of which the measurement is being made. The set of characters used in the second position to describe the 'WHAT' content in the nomenclature are – B (entire body); C# (carpometacarpal joint); D# (specific digit/finger); H (hand); J# (joint); K# (knuckle); M# (metacarpophalangeal joint); P (palm); P# (phalange); and Wrist (W) (Table 1). Therefore, a 'CW' title in the TWHP nomenclature refers to a measurement of the 'circumference' ('C' is the 'TYPE') of the 'wrist' ('W' is the

'WHAT' descriptor). Along with the 'WHAT' category of mnemonic representations, a '#' sign provides an indexical reference to one or more fingers (as a standard practice, thumb is considered digit 1; little finger is digit 5; the other fingers sequentially follow in between 1 and 5). C#, D#, J#, K#, M# and P# as 'WHAT' codes, are also references to a specific finger or its sub-features. References could be made to a specific finger in the hand (by substituting the '#' with a 1, 2, 3, 4 or 5), as well as to the specific features within a finger (for e.g. phalanges referred to by P#; joints by J#, etc.).

2.1.3 HOW

The reference to sub-features of a finger is also accompanied with information on other details such as the position of this feature. This specific information is denoted by making use of a 'HOW' descriptor. Two or more integers used in succession after a 'WHAT' character could be used for referring to the indices of two or more features of the same dimension category/class which are employed in the construction of this hand feature being measured. For e.g., the title LM12 refers to a length (L) 'TYPE' dimension (distance) measured between the same common feature, metacarpal (M) of digits 1 and 2. Candidates for the second character could also be standard hand states, or orientations of the hand when the measurements are to be made, such as a fist (F); or, a grip (G). A CF would therefore refer to the 'circumference' (C) of the 'fist' (F). Anthropometric dimension titles gain additional clarity and specificity with the use of subscripts (presented for easy readability as lower case mnemonics). These lower-case mnemonics represent the 'HOW' component in the TWHP nomenclature. Specific to the different parts of the fingers, references could also be made to the relative position of a specific feature in relation to its position with respect to the human body. For e.g., qualifiers (HOWs) like 'pr' (proximal) and 'di' (distal) can be used to represent if the feature is near or far from the main body.

Subscripts have also been employed to provide information on the postural state of hand and its different parts. Information can be provided about the postural state of adduction (ad), or abduction (ab); pronation (pn), or supination (su) (Figure 2). Specific information could also be provided regarding the spatial relations, such as a surface landmark being inside (in), or outside (ot); at the tip (tp), or center (cn) of a hand feature. The 'HOW' codes have also been used to specify the degree, or extent in the context of measuring a hand dimension. The 'HOW' mnemonics can provide specific information about a dimension by using a qualifier such as 'mx' (the maximum extent of a dimension); and while referencing surface sub-features, qualifiers such as 'rt' (the root of a feature), or 'cr' (crease) could be employed. Therefore, a BHmx title stands for the maximum (mx) breadth (B) of hand (H).

In addition to the cases discussed earlier, additional 'WHAT' elements can be used to specify a complex hand anthropometry dimension. For e.g., in the last case discussed (i.e. BHmx), if an additional qualifier 'J1pr' is added to the title, a complex name BHmxJ1pr is formed. The component 'J1pr' here serves as an additional reference piece of information. Here, the reference to measurement of maximum hand breath (BHmx) is being made – at the proximal (pr) joint (J#) of digit 1 (character '1').

In TWHP, parentheses '()' are used in situations where multiple subscripts (HOWs) are used. For e.g. the label (J1rt)cn refers to the center (cn) of the root (rt) joint (J#) of digit 1 (character '1'). As a more complex example, the distance between the radial end of the wrist crease to the ulnar end of the root of digit 2 can be referenced by a TWHP title of X[(Wcr)rd-(D2rt)ul]. The 'X' TYPE here represents that a relatively non-traditional is being invoked. Like in typical logic based representational systems, parenthesis and brackets find special use here for systematic and efficient processing of hierarchically structured information. An additional element, hyphen '-', has been utilized here in the sense of its application within linguistic systems, typically representing connect or the spread and range of a parameter/concept, or distance between two entities. In TWHP system, hyphens have been used only when brackets '[]' are used - an application specific to the use of 'X' TYPE of dimension. Similar to the hyphens, the forward slash '/' sign has been used when ratio (R) TYPE of dimensions are invoked. A slash in a ratio dimension would separate the numerator and the denominator values in the relation being presented. Here, the character preceding the slash sign is the numerator and the one following it, is the denominator. For e.g., an R[LH/BH] refers to a ratio relation commonly referenced as the 'hand shape index' which is determined by dividing the length of the hand by the breadth of the hand [11].

2.1.4 POSE

Hand posture (POSE) is the fourth component in this nomenclature system. A 'POSE' descriptor is an optional component in the TWHP nomenclature which could be used for explicitly describing the posture adopted by a hand when measurement of a specific hand feature is made. It is invoked by including in addition to the 'TYPE' component, the 'WHAT' component(s) inside curly brackets '{}'. For e.g., a term '{Hst}' introduced to a title would refer to a POSE ('{}') in which the hand (H) is stretched (st). Similarly, complex 'POSE' descriptors could be used to refer to a more complicated hand configuration. An example of one such configuration is the breadth of a stretched hand measured with reference to the tips of digits 1 and 5, with all fingers adducted except the thumb. This could be encoded as BD15tp{HadD1ab} in TWHP system. The 'POSE' information is provided towards the tail end of the title.

3 Discussion and Conclusion

Hand anthropometry measurement is a standard exercise performed by professionals and researchers in different contexts such as tool design; workplace design; during occupational rehabilitation, etc. Scientific literature in this field appears to be plagued with ambiguous and non-standard nomenclature based on the use of non-standardized titles/names for hand dimensions. For e.g., the same anthropometry dimension represented by a 'CJ3pr' in the TWHP system has been invoked through four different titles, viz. 'proximal interphalangeal joint: digit 3', 'digit 3 proximal interphalangeal joint circumference', 'circumference at PIP joint of digit 3', and

'proximal joint: circumference (middle finger)' in [7], [9], [12] and [13], respectively. In the past, there appears to have been no published scientific discussions on designing 'standardized mnemonics-based nomenclature for hand anthropometry'. The use of traditional verbally elaborate titles of hand dimensions can make hand anthropometric data handling a cumbersome task. Therefore, a novel hand anthropometry nomenclature named TWHP (TYPE-WHAT-HOW-POSE) has been proposed in this work. This is a logic based nomenclature; utilizes mnemonic abbreviations, and has been built on the basis of an extensive literature review of hand anthropometry-based research works. It is proposed that the TWHP system should help reduce the need to use long and complicated titles/names of hand anthropometry dimensions, and also in visualizing and organizing this information more logically and efficiently. Being a logic-based methodology, this framework is potentially programmable and therefore also opens up the scope for its efficient use in computational applications.

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