

Distribution of Hand Dimensions and Selected Hand Forces in a Sample of the General Public in Germany

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Abstract. Anthropometric data and data about hand strength could be a very important assistance for the ergonomic design of products, such as hand tools, machines etc. The aim of this study is to collect data about hand strength and dimensions of the hand-arm-system of a representative general population in Germany. The study design includes measurement of the maximal isometric strength in three typical cases – pulling, gripping and turning. Also a 3D-scanner was used to determine the anthropometric data of the hand-arm-system of the participants involved. In this article, the methods and first results of this study are described.

Keywords: Anthropometric data, design, ergonomic products, hand forces, screwdrivers, hand tools.

I. INTRODUCTION

From the ergonomic point of view, data about hand strength and hand dimensions are of particular importance. In order to develop ergonomically well-designed tools (e.g. pliers or screwdrivers), it is helpful to know about hand dimensions and strength of potential users. Certainly, there are a number of anthropometric databases in Germany. However, depending on the time of measurement, it is questionable, whether these data still represent today's general public. This is particularly true for data on hand dimensions. Also, no coherent data on hand dimensions and force are available.

II. METHODS

To analyse a large sample of the general public, a standardised method inventory was developed. It consists of a standardised background questionnaire (e.g. age, gender, occupation, sport activities, body weight and height), a 3D scanner to determine relevant hand dimensions and a force-measure-stand to determine maximum forces. The maximal isometric force was determined in three cases, including pulling, gripping and turning.

A. Standardised measurement of force

Participants within this study were asked to exert the maximal isometric force possible on MVE-level (Maximum Voluntary Effort). For this purpose, a test stand with three selected force cases was developed (Fig. 1). Because the

measurement should be carried out in a standing position, a height-adjustable design of the test stand was selected. This allowed, despite intra-individual variations of anthropometric dimension, taking similar body postures by adjusting the height of the test stand.

To achieve a high level of standardisation and reproducibility, the body posture for the selected force cases was specified. For each case, an optimal body posture was defined in such a way that participants could perform hand forces under similar and advantageous conditions (Fig. 2).

As an orientation for the measurement of the *pulling strength*, we used the body postures described in other studies (e.g. Kluth et al, 2007): body in upright position, muscles of the hand-arm-shoulder system involved in force exertion, other arm rests on designated grip to support upper body (Fig. 2, left picture).



Fig. 1. Height-adjustable test-stand

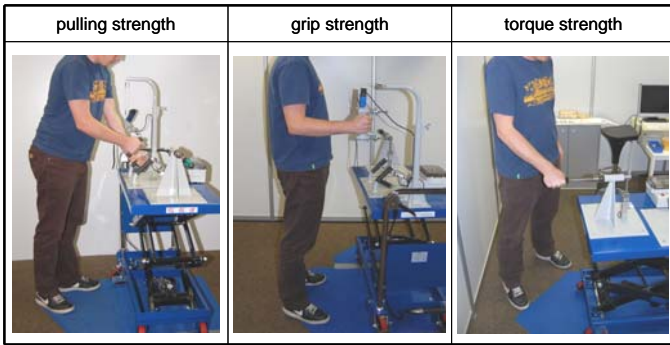


Fig. 2. Body posture while measuring



Fig. 3. Jamar-Dynamometer with threads for adjustment of the hand grip

For the measurement of the *grip strength*, a Jamar-Dynamometer was used. The standardised dynamometer was modified for a continuously variable adjustment of the grip size (Fig. 3). The American Society of Hand Therapists (ASHT) recommends a standardised body posture for measurements by using Jamar-Dynamometer (Fig. 2, picture in the middle), which was adapted for the study design by standing position. In this regard, the elbow should be in flexion at 90°, while the forearm and wrist remain in a neutral position.

For the measurement of the *torque strength*, three screwdrivers with different handle sizes were provided (Fig. 4), and the torque was actuated in the supination direction (Fig. 5). The body posture for this case was adapted from previous studies (see Strasser and Wang, 2007). This allowed a comfortable standing body posture without twisting along the spine (Fig. 2, right picture). By the rotation of the screwdriver with the right hand the subject stands left from the test stand (the same but mirrored position for the left hand), toes form a line at an angle of 60° to the longitudinal axis of the screwdriver.



Fig. 4. Screwdrivers used in this study

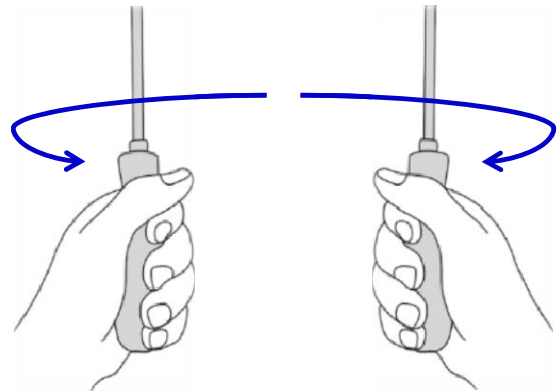


Fig. 5. Direction of rotation by performing torque

B. Method of measurement

For the purpose of standardisation and coherent study design the square method was used, i.e. increasing to and holding of maximal force over a predetermined period of time. The measurement of isometric maximal strength confines to 2 - 6 seconds (Rohmert et al., 1992). Because many untrained persons might participate in this study, the duration of holding the maximal force was decreased to 3 seconds. In this regard, participants were asked to build up their force to a maximum over a 1-second period and to hold the maximal force for 3 seconds (Fig. 6). In the meantime, the software automatically recorded the strength. The strength result is the mean-score during the first two seconds after the 1-second build up phase.

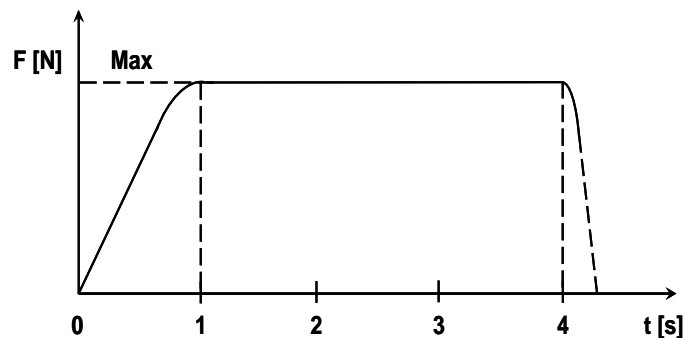


Fig. 6. Trend of the maximum muscle strength: male and female persons in the course of life

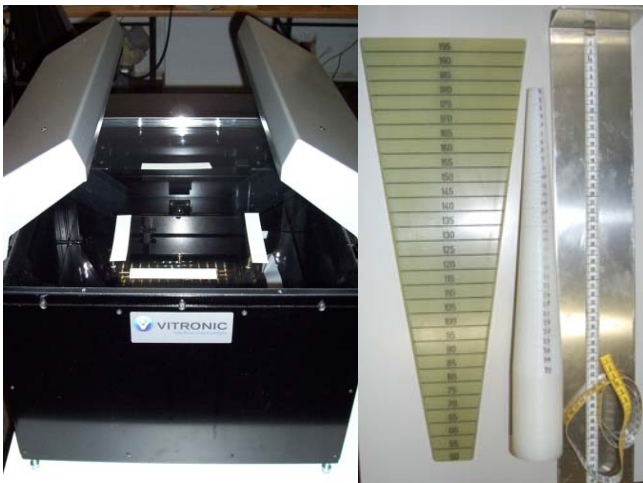


Fig. 7. 3D-scanner (left) and measuring templates (right)

C. Collecting anthropometric data of the hand-forearm system

A 3D-scanner was used to collect anthropometric data of the hand-forearm system. Besides, data that could not be measured by the 3D-scanner was determined with the help of measuring templates.

III. RESULTS

Up to now, 976 subjects (age: 5-91 years) participated in this study, including 335 women and 641 men. In the first analyses only the maximum forces were considered. Generally, women achieved approximately 2/3 of the maximum force level of men. The smallest gender differences were found between young persons (younger than 14 years). From approx. 15 years to the end of 70 years, the development of forces in both genders is about the same. Up from the age of 80 years, an increasing difference between forces of female and male participants was observed. The group of the 40 to 44-year-old men achieved the highest force values. Women between 35 and 39 years performed the maximal forces. The maximal forces in the neighbouring age groups were only slightly lower.

IV. DISCUSSION

Interestingly enough, the level of force only slightly differs among participants in the age from 20 to 60 years. These results are not in accordance with most data from literature, like e.g. from Hettinger (1983). In that publication (among others), the 20 to 25 years old males were described as strongest, with decreasing force with increasing age (Fig. 8).

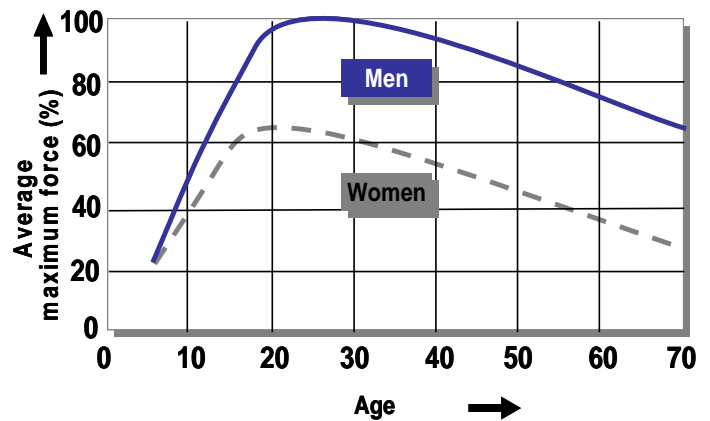


Fig. 8. Trend of the maximum muscle strength: male and female persons in the course of life (Hettinger, 1983)

V. ACKNOWLEDGEMENTS

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Inna Ļevčuka, Patriks Serafins, Kristofs Mulemajers, Martins Koihels, Andre Klussmann, Hansjuergens Gebhardts. Roku izmēra un atsevišķu cilvēku roku spēka noteikšana, izmantojot Vācijas iedzīvotāju piemēru

Cilvēka antropometriskie dati un dati par tā roku spēku ir produktu, tādu kā rokas instrumenti (piemēram, plakanknaibles vai skrūvgrīži), darbgaldi u. tml., ergonomiskā dizaina svarīga sastāvdaļa. Šā pētījuma mērķis ir datu vākšana par Vācijas iedzīvotāju roku spēka un apakšdelma izmēriem. Liela kolektīva analīzei tika izstrādāts standartizēts inventārs. No vienas puses, subjektīvo datu par projekta dalībniekiem vākšanai tika izstrādāta standartizēta aptaujas lapa ar jautājumiem par vecumu, nodarbošanos, sporta nodarbībām, ķermeņa masu un augumu, u.tml. No otras puses, objektīvu datu noteikšanai tika izmantots 3D skeneris – roku attiecīgo antropometrisko datu vākšanai, kā arī izmēģinājuma stands – maksimālā izometriskā (statiskā) spēka mērīšanai trīs tipiskākajos gadījumos – vilces, saspiešanas un vērpes. Tā kā mērījumi tika veikti pozīcijā stāvus, tika izvēlēta pēc augstuma regulējama izmēģinājuma stenda konstrukcija, kas atļāva pētījuma dalībniekiem ieņemt līdzīgas ķermeņa pozīcijas, neskatoties uz individuālām atšķirībām. Pētījumā piedalījās 976 cilvēki: 335 sievietes un 641 vīrietis. Datu starpanalizē tika iekļauts tikai maksimālais roku spēks. Viszemākās sasniegtā spēka dzimuma atšķirības tika atklātas starp jauniem cilvēkiem, kas ir jaunāki par 14 gadiem. No 15 līdz 80 gadiem abu dzimumu spēka attīstība notiek aptuveni vienādi. Vīrieši vecumā no 40 līdz 44 gadiem un sievietes vecumā no 35 līdz 39 gadiem sasniedza maksimālo spēka līmeni. Tas ir interesanti, ka spēka līmenis starp pētījuma dalībniekiem vecumā no 20 līdz 60 gadiem atšķiras tikai nedaudz. Iegūtie rezultāti neatbilst datiem mūsdienu literatūrā sniegtajiem datiem, kurā gan vīrieši, gan sievietes vecumā no 20 līdz 25 gadiem sasniedza maksimālo spēka līmeni. Pašlaik pētnieku kolektīvs turpina datu vākšanu. Gala rezultāti tiks prezentēti institūta publikācijā šā gada beigās.

Инна Левчук, Патрик Серафин, Кристоф Мюлемейер, Мартин Койхель, Андрэ Клюссманн, Хансюрген Гебхардт. Определение размеров рук и отдельных сил руки человека на примере населения Германии

Антропометрические данные человека и данные о силе его рук являются важной составляющей эргономичного дизайна продуктов, таких как ручные инструменты (например, плоскогубцы или отвертки), станки и т.п.

Целью данного исследования является сбор данных о силе рук и размеров руки и предплечья населения Германии. Для анализа большого коллектива был разработан стандартизированный инвентарь. С одной стороны, для сбора субъективных данных об участниках проекта был разработан стандартизированный опросный лист с вопросами о возрасте, роде занятий, занятий спортом, массе и росте тела и т.п. С другой стороны, для определения объективных данных, был использован 3D-сканер – для сбора соответствующих антропометрических данных рук, а также испытательный стенд – для измерения максимальной изометрической (статической) силы в трех типичных случаях – тяги, сжатия и кручения. Т.к. измерения проводятся в положении стоя, была выбрана регулируемая по высоте конструкция испытательного стенда, что позволило участникам исследования принимать сходные положения тела, несмотря на индивидуальные различия.

На данный момент в исследовании приняли участие 976 человек, в том числе 335 женщин и 641 мужчина. В промежуточный анализ данных были включены исключительно максимальные усилия рук. Наиболее низкие гендерные различия достигнутых усилий были обнаружены между молодыми людьми моложе 14 лет. С 15-ти и до 80-ти лет, развитие силы обоих полов происходит примерно одинаково. Мужчины в возрасте от 40 до 44 лет и женщины в возрасте от 35 до 39 лет достигли максимального уровня силы.

Любопытно, что уровень силы среди участников исследования в возрасте от 20 до 60 лет отличается лишь незначительно. Полученные результаты не соответствуют данным из современной литературы, в которой и мужчины и женщины в возрасте 20 до 25 лет достигли максимального уровня силы.

Исследовательский коллектив занимается в данный момент сбором дальнейших данных. Конечные результаты будут представлены в виде публикации института в конце текущего года.