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REVISTA INGENIO

Non-Powered Hand Tool: Size Selection from an Anthropometric Ergonomic Point of View

Herramienta Manual sin Motor: Selección de Tamaño desde un Punto de Vista Ergonómico Antropométrico

Ricardo Arciniega Rocha | iD Óbuda University, Budapest, Hungría
Vanessa Cristina Erazo Chamorro | iD Óbuda University, Budapest, Hungría
Szabo Gyula | iD Óbuda University, Budapest, Hungría

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ABSTRACT
In order to improve production companies are laying out resources to minimize time and save the worker force in each workstation. It means the ergonomist specialist must choose the correct hand device according to each worker. The goal of this research is to set forth an instructions set for tool hand tools selection focused on anthropometrics of the workers in order to rise production using the adequate tool for the task. During the study, the anthropometrical data is processed and evaluated to obtain the dispersion population for each finger length and identified the main body size parameters for design tools. As a result, a methodical guide to help ergonomics team managers to make sure the correct and appropriate tool size selection to reduce the possibility of future illness for workers and the tailored ergonomic design of each workstation according to specific data for the worker.

PALABRAS CLAVE
Riesgos industriales, selección de herramientas, herramientas manuales, seguridad en el trabajo, tamaño de herramienta.

RESUMEN
Con el fin de mejorar la producción, las empresas están disponiendo recursos para minimizar el tiempo y ahorrar mano de obra en cada puesto de trabajo. Significa que el especialista en ergonomía debe elegir el dispositivo de mano correcto de acuerdo con cada trabajador. El objetivo de esta investigación es establecer un instructivo para la selección de herramientas manuales enfocado en la antropometría de los trabajadores para elevar la producción utilizando la herramienta adecuada para la tarea. Durante el estudio, los datos antropométricos se procesan y evalúan para obtener la población de dispersión para cada longitud de dedo e identificar los principales parámetros de tamaño corporal para las herramientas de diseño. Como resultado, se elaboró una guía metódica para ayudar a los jefes de equipo de ergonomía a asegurarse de la selección correcta y adecuada del tamaño de la herramienta para reducir la posibilidad de futuras enfermedades de los trabajadores y el diseño ergonómico personalizado de cada estación de trabajo de acuerdo con los datos específicos del trabajador.

1. Introduction

The methods for tool selection means great concern for the probability of workers' future illness after realizing one task a lot of time due to the repetitively and the necessary force during the work. One of the biggest problems is market dependence, owing that the companies who designed the hand tool tried to make the design for all users but it can be a problem for specific users.

Nowadays, as the globe becomes more industrialized, an increasing number of businesses are investing money and resources to improve production time while keeping human resources in mind. [1]–[3] The monitoring of the number of musculoskeletal problems in developed countries focuses on the method of observation in organizations that utilize hand tools to complete the exact task in each workstation [4], [5].

The variables to control are explained and exposed in the industrial document statements and international standards to reduce their effect on workers, as well as the

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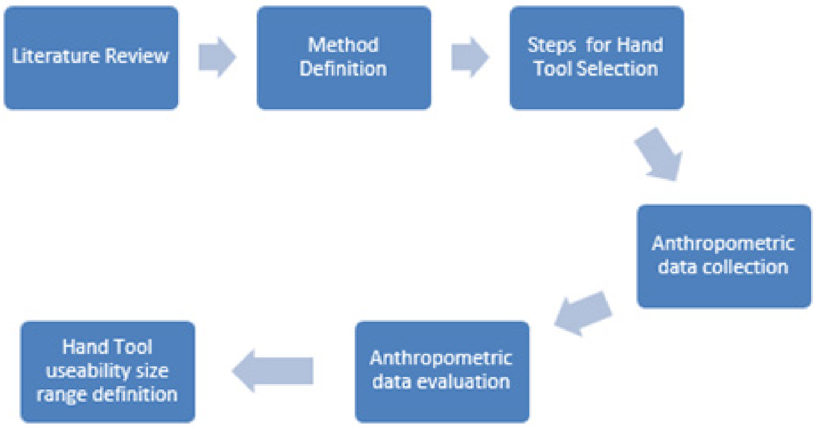
Table 1.
US 2015, occupational injuries

Occupational injuries		
Injury source	Hand machines	Hand devices
total	59,83	52,03
Incidence rate	54	47
Sick days	7	5

Source [11].

Figure 1.
Research process definition



method of data collection, [6] It's also vital to note that some key features can cause a biased in tool selection are not mentioned in the papers.

The evolution of risk assessment tools in the industry are going from paper-pencil worksheets to artificial intelligence to prevent and minimize the causes of worker illness. It is focused on the causes of various occupational illness for specific body parts. As a result, businesses face the challenge of constantly improving their management systems [7]–[9].

The problems related to ergonomic for hand tools are frequently dependent on wrist flexion and extension, as well as excessive muscle effort and a high number of manual movement repetitions [10]. According to the U. S. Bureau of Labour Statistics, there were 100.000 injuries related with hand tools or machines. Table 1. Shows the data for labour injuries (see Table 1).

The ergonomics managers in each factory recognize extremity cumulative trauma disorders as key ergonomic risk factors. In order to improve the current situation, a guide for non-powered tool selection for specific work types will be presented in order to improve production time and prevent worker injuries and future health disorders, this guide is focused on the anthropometrics of workers and the hand dimension analysis to ensure the way for correct and tailored hand tool selection according to the palm-size of the workers (see Figura 1).

Figura 1 shows the approach steps in the research, starting with collecting the data and going through the method definition and finishing with the anthropometric evaluation. This research is structured as follows. Section 2 presents Related works. Section 3 Tool selection method. Section 4 illustrates the Results. Finally, Section 5 presents the Conclusions.

1.1. RELATED WORKS

Commonly, industrial employees utilize hand tools based on their readiness in the workstation; however, before beginning operations in the companies, ergonomics specialists conduct research and pick the appropriate device size; three stages are used in tool selection: i) Known the workplace, ii) anthropometric study, iii) tool selection for workers. Kai WayLi [12] presents «Ergonomic design and evaluation of wire-tying hand tools» (2002),

Table 2.
Injury and possible

Medical problems	Source
Amputations, Cuts, abrasions and punctures	Tools with cutting edges can easily cut body parts
Muscles stress and ligaments inflamation	Repetitive motion all day long, using the same tool
Vision accidents	Flying parts can cause needless and permanent blindness
Fractures	Direct hit with the tool

Source [16].

this offers some ideas on how to build a wire-tying hand tool that will reduce poor posture and physical effort. The research showed that now the wire-tying plier designs minimized labour and employees' difficulty in the sense of physical effort and awkward postures.

During 2013 Harih and Dolšak presents a digital-based hand tool model, constructed from a static digital human-hand model, assuring comfort [13]. Then Sohrabi (2015) introduces The effect of diameter on comfort and force for non-powered hand tools use [14].

In 2015 is presented the use of the Ergonomics in Hand Tool Design [15], by Aptel, Claudon and Marsot, to demonstrate the influence of ergonomics on future illness for workers. Finally, «Usability of machinery» is presented by Szabo (2017), [11] where Wrong operator behaviour is identified as a factor in work accidents.

Whit the given works, it is reasonable to conclude that design optimization and proper tool selection are critical aspects of the present industry trend. However, in most situations, a decision is made without regard for the anthropometrics of workers or their comfort during repetitive job activities. In this regard, the majority of the studies evaluated do not provide a mechanism for selecting tool sizes. This is exactly why the recommended rigorous hand tool selection is so important. As a result, the suggested technique is critical in proving the benefits of choosing the proper tool selection.

2. Method

To determine the selection criteria, the Derived / Compiled Data collecting approach is utilized to analyze the received information using the collected information. The criteria for picking information are focused on gathering the most important ergonomic properties of tools for use in general device selection in the industry to avoid potential future problems based on comments from worldwide occupational health institutes.

Hand devices and other hand tools are always a possible source of injury for employees during typical job tasks. Workplace injuries can be caused by a variety of circumstances, and worker disease can be classified in a variety of ways; Table 2. shown the many injury types (see Table 2).

OHSAS 18001 standard gives regulations for health and security, based in Occupational Health and Safety Management Systems (OHSAS) [17]. To cut down on workplace injuries The European Union directive 89/391/EEC [18] says the need to implement measures to improvements in worker safety. Tool selection is done in several steps, including a) knowing your job, b) observing work environment, c) keeping good work posture, and d) selecting the appropriate tool. Various processes are specified in this context in order to create an appropriate tool selection, with a focus on the task, tool features, and Ergonomic Worker Positions.

2.1. WORK ACTIVITY

Starting the hand tool selection process, the first activity is to recognize the task, considering that tools are created for a specific purpose and that non-correct use can produce tool degradation and damage. As another consequence, incorrect tool operation can generate diseases like pain or injury, as illustrated in Figura 2 (see Figura 2).

The workspace for manoeuvring the hand tool is a characteristic to decide the correct tool size, it gives the body length of the specific tool for the task.

2.2. TOOL CHARACTERISTICS

The uncomfortable postures, in combination with the hazardous contact stresses, generate a future injury cause. To avoid this, hand tools must be appropriate for the hand, taking into account the primary tool features stated in Table 3 as well as the gadget assessment criteria (see Table 3).

As another important fact, the texture of the handle tool part shall be considered for a good operation during

Table 3.
Tool Characteristics

Parameters	Shape	Physical dimension	Material surface
Features	Feasible shape	Lightweight	Friction for material in contact surface
	Not cutting edge	Correct tool dimension	Homogeneous distribution force

Source [19].

Figure 2.
Research process definition

Figure 3.
Texture of the tool Handle

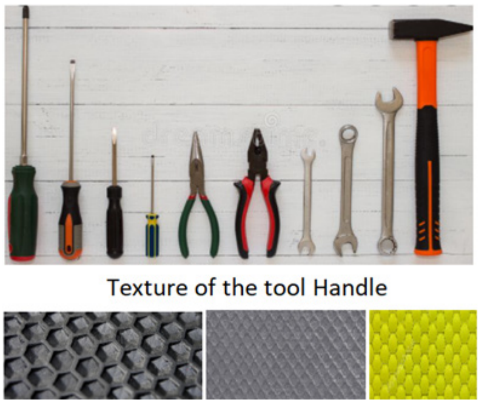


Figure 4.
Power grip

Figure 5.
Single handling tool

the activities in each workstation to ensure the correct manipulation and fixing of the tool. [20]–[22] The different textures and tool shapes are shown in Figura 3.

The texture improves the tool grip increasing the friction between the tool handle and workers hand, this characteristic shall be functional when the tool is static and when the device is moving, in this sense a non-slip tool handle makes secure the tool use.

2.3 ERGONOMIC WORKER POSITIONS-WAY OF HANDLING THE TOOL

In order to determine the correct tool for each workstation, identify the handle manner for these devices. In this sense, the tool applications in connection with the handle manner are analysed in relation to the anthropometrics of the workers' hands to establish the correct selection for tool size [23], [24] (see Figura 4).

The tool handle manner used for small and big hammers is the Power Grip subjection shown in Figura 4, to realize this action the devices are subjected to the total palm of the hand using all fingers to produce the necessary force to hit the materials [25] (see Figura 5).

Single-Handle Tools shown in Figura 5 is the handling way of the tool used for Tube-like tools driven by handle length and diameter. During this way of grip tool, the devices are subjected to the total palm of the hand and the forces are applied through fingers and the thumb (see Figura 6).

The handling way of the tool used for control, precision and accuracy is Pinch Grip shown in Figura 6, to carry out the work activity the devices are subjected between the thumb, index finger and middle finger to provide the necessary force for the task. Figura 7 shows the «Contact Pressure tool grip», which to different from the previous one is the use of the palm of the hand to provide the force to keep the device against the part to be fixed (see Figura 7).

The handling way of the tool used pliers is shown in Figura 8, Double-Handle Tools grip uses the thumb, index

Table 4.
Hand anthropometry

DIMENTION	MIN	MAX	MEAN	DN	Range	SD
HAND LENGTH	15,9	20,5	18,20	3,2526 91193	4,60	0,01
palm length	8,90	11,6	10,25	1,90918 8309	2,70	0,017 12901
THUMB LENGTH	4,00	5,80	4,90	1,2727 92206	1,80	0,0256 9351
MIDDLE FINGER LENGTH	6,90	9,00	7,95	1,484 92424	2,10	0,022 02301
RING FINGER LENGTH	5,90	8,00	6,95	1,484 92424	2,10	0,0230 2217
LITTLE FINGER LENGTH	4,30	6,30	5,30	1,41 4213562	2,00	0,0222 3021
INDEX FINGER LENGTH	6,00	7,90	6,95	1,3435 02884	1,90	0,0243 4123
MAXIMUM GRIP DIAMETER	4,30	5,90	5,10	1,131 37085	1,60	0,0289 0521

Source [27].

Figure 6.
inch Grip handling tool

Figure 7.
Contact pressure handling tool

finger and middle finger to provide the necessary force for the task [26] (see Figura 8).

Employees in the industrial sector represent the majority of each country's economically active population, and numerous studies have been done to collect anthropometric data on them, as shown in table 4 (see Table 4).

3. Results and discussion

Three main hand measure sizes are important to enable proper tool selection based on the style of handling: index finger length, middle finger length, and maximum grip diameter. After processing the worker's hand anthropometric data in Table 4 to make sure that the work population can use hand tools, ergonomics managers should select tools with part sizes that fall between the shaded zone shown in distribution graphic to ensure that 90% of population can used during the work (see Figura 9).

Index finger length in contact pressure subjection and pinch grip subjection is the main measure, for these task which are performed with this finger, such as the little touch between the hand tool and the body. Anthropometric data are provided in Figura 9.

Considering tool activities are performed using the thumb, middle, and index fingers, as well as the tiny contact between the gadget and the body, the maximum handgrip diameter is the most relevant dimension for single handle tools and power grip tools. These anthropometric data are provided in Figura 10 (see Figura 10). Finally, with double-handed tools, the middle finger is the most significant size because tool activities are performed with this finger, such as the little touch between the gadget and the body, as shown in Figura 11 (see Figura 11).

Figure 8.
Double handle tool

Figure 9.
Index finger length

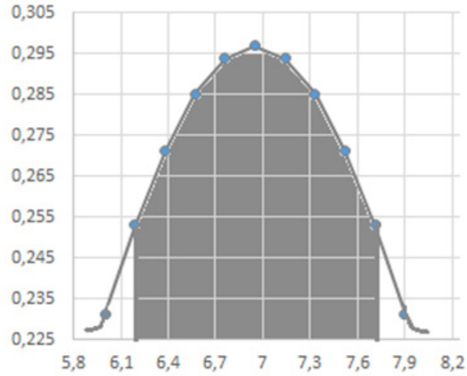


Figure 10.
Handgrip diameter

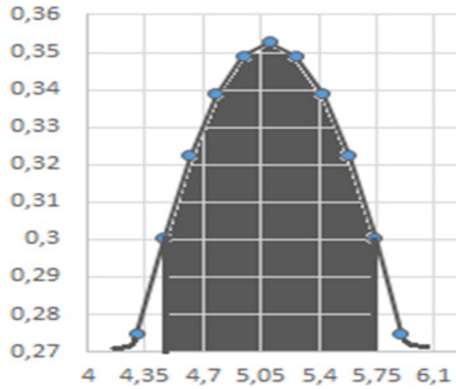
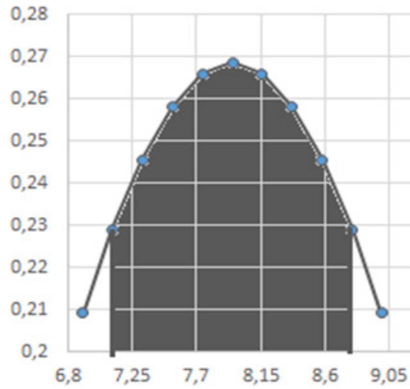


Figure 11.
Middle finger



Increasing productivity and resource efficiency are the industry's main goals in order to enhance profitability. The environmental supervisors will be selective in the size of tools they use to guarantee that this goal protecting the worker from disease met [24]. In order to minimize the possible risk and be agree with previous studies where the safety and healthy workplace is defined [28], this study identified the main used parts during the activities where is needed hand tools.

Another contribution of this study identified the common handling grips subjection for hand tools in concordance with the literature presented by Debesh M. and Suchismita Satapathy [29] in «Hand Tool Injuries of Agricultural Farmers of South Odisha in India».

The international organizations for establishing the standards suggest the dimensions for hand tools focused only from a point of view of task characteristic [30], [31], in this project as a result, is presented the necessary steps for a correct tool selection, each stage has some steps for tool evaluation before the find the chosen one.

4. Conclusion

Index finger length in contact pressure subjection and pinch grip subjection is the main measure, for tool activities are performed using the thumb, middle, and index fingers, the handgrip diameter is the most relevant dimension for single-handle tools and power grip tools, with double-handed tools, the middle finger is the most significant size because tool activities are performed with this finger. In concordance with some studies where the method of tool selection is considered [15] taking into account the demographic data of each region and country the selected instrument must be between 10.19 millimetres and a maximum dimension of 11.71 centimetres in order to achieve it for tasks associated to contact pressure subjection. The specified instrument for pinch grip subjection must have a dimension of 6.19 millimetres to a maximum of 7.71 centimetres, the specified tool for activity requiring single-handle tools and power grip applications should be between 4.46 millimetres and a maximum size of 5.74 centimetres, and for activities involving double hand tools, the recommended tool should be lower than 7.11 centimetres in concordance with the OSHA international standard that suggested the values between these limits [32].

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