Research Article

Correlation between characteristics of fishermen and the perceived pain in grasping activities

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Abstract

Fishermen are essential to marine life. The dimension mismatchs between a fisherman and their fishing equipment, especially the boat engine steering lever, is a concern. The disparity in hand and boat motor steering lever dimensions may put fishermen at risk of work-related injuries and accidents. This research examined the correlation between fishermen's characteristics and grasping hand musculoskeletal disorders (MSDs). Fifty fishermen from Baron Beach, Gunungkidul, Yogyakarta, participated in this study. The independent variables were individual characteristics of fishermen, including internal factors (such as body mass index (BMI)) and external factors (such as work hours per day and work experience as a fisherman). Meanwhile, the dependent variable was MSDs in the form of hand discomfort experienced by fishermen during grasping activities, as measured by modified Indonesian translated Standardized Nordic Questionnaires (SNQ) and Numeric Rating Scale (NRS) instruments. Pearson correlation coefficient analysis was applied to analyze the relationship between individual fisherman characteristics and MSDs on the hands caused by grasping activity. Pearson correlation coefficient's analysis revealed a significant correlation between the duration of a day's labor and discomfort in the thumbs and wrists of fishermen. There are also significant correlations between work experience and thumb, palm, and wrist discomfort. The study also revealed no correlation between BMI factors and the hand and wrist discomfort experienced by fishermen. The findings of this study can be used as a basis for designing ergonomic interventions for hand grasp aides based on anthropometric data collected from fishermen. The design of the tool's hand handle uses a lightweight, durable material coated with a soft, flexible material.

Keywords: Ergonomics, Hand grip, MSDs, Fishermen, Numerical Rating Scale (NRS), Standardised Nordic Questionnaires (SNQ)

1. Introduction

Gunungkidul Regency is one of the regencies in Yogyakarta Province, with a coast length of about 72 km [1]. With this condition, Gunungkidul Regency has potential in the maritime sector, especially in marine fisheries, which is very promising. If calculated as far as 4 miles from the coastline, the potential for capturing fisheries in this district covers an area of 518.56 square kilometers. The potential of Gunungkidul marine fisheries is supported by the length of the coast, starting from the west end to the east end, which consists of seven beaches close to each other. The seven beaches are Baron Beach, Kukup Beach, Sepanjang, Drini, Krakal, Slili, Sundak, and Ngandong Beach.

Based on data from the Regional Planning and Development Agency of Yogyakarta, it is explained that the number of marine fishermen in Gunungkidul in 2021 amounted to 4416 people, with marine fishery catch production of 5211.99 tons [2]. Based on previous study, marine fisheries activities in developing countries including along the south coast of Gunungkidul consist of several activities, such as controlling boats, dropping nets into the sea, pulling nets, catching fish, carrying ice blocks, pouring ice blocks into ice storage boxes, carrying and carrying fish in baskets or boxes, weighing fish, unloading caught fish, pushing boats, and more [3].

One of the problems fishermen faces in carrying out their work is the mismatch between the dimensions of the fisherman's body and the equipment used in his work. The mismatch between the dimensions of the worker's body and work aids can cause workers to experience the risk of work injuries or accidents [4]. One of the fishermen's activities that carries a risk of injury is controlling a motorboat. Fishermen on the south coast of Gunungkidul operated outboard motorboats with 315 boats in 2020 [1]. Fishermen control an outboard motorboat by grasping the steering lever connected to the outboard motor propeller in a sitting position for a long time. The steering lever of the outboard motor is made of cylindrical steel pipe, with the end of the handrail section not coated with hand protection. This situation causes the tip of the outboard motor steering lever to potentially injure the fisherman's palm because it has a sharp profile. The sharp end profile of the steering lever handle can compress and injure the base of the fisherman's palm. In addition, the long steering lever rod can also conduct vibrations originating from the outboard motor to the hands of the motorboat driver. Workers operating workplace vibration devices can suffer symptoms resembling Raynaud's phenomenon. Raynaud's phenomenon is a condition that can cause several areas of the body, such as fingers and toes, to feel numb. Although not dangerous, Raynaud's phenomenon can interfere with daily activities and make the condition uncomfortable [5]. In addition to Raynaud's phenomenon, the risk that fishermen will experience is the vibration white finger (VWF) [6]. This VWF is a condition of momentary numbness, tingling in the fingers, and fingers becoming pale for a long time that occurs due to using vibrating devices for a long time [7].

Another factor affecting a worker's risk of MSDs is their characteristics. Components of individual worker characteristics that affect worker productivity include age, gender, and duration of work [8]. Previous research revealed that age, gender, duration of work per day, and overall work experience were associated with MSDs in one or more upper extremities [9]. MSDs are one of the main causes of fatigue in workers. A higher risk of fatigue can have an impact on decreasing worker productivity [8].

Furthermore, no previous study in Indonesia analyzed the correlation between individual characteristic factors and the risk of MSDs in fishermen's hands due to grasping activities. Therefore, the purpose of this study was to investigate the correlation between the characteristics of individual fishermen and the pain in the hands that fishermen feel due to grasping activities. The results of this study can be used as a basis for developing ergonomic interventions in activities involving hand grip for fishermen.

2. Materials and methods

2.1 Study Design

This study used a cross-sectional design. The SNQ and NRS questionnaires, version Indonesian [10], were used to collect respondents' demographic data and musculoskeletal disorders of the thumb, index finger, middle finger, ring finger, little finger, palm, and wrist, both left and right sides. This questionnaire was filled out independently by the respondents. The pain data on the hands of the fishermen was obtained through direct measurements of 50 Baron Beach fishermen. The pain severity rating indicated by the respondent is recorded. The scores include a range of values from 0 to 10, with the following cut points on the pain NRS have been recommended: no pain (score 0), mild pain (score 1– 3), mm), moderate pain (score

4 – 6), and severe pain (score 7 – 10) [11]. This data collection was carried out on October 11, 2022.

2.2. Respondents

The respondents of this study were all members of the fishermen's group located at Baron Beach Gunungkidul, which amounted to 50 people. All fishermen meet the criteria to become respondents in this study by having experience working as fishermen for at least one year. Respondents were excluded from the study if they had a history of pain or surgery on the hands and wrists. Before the farmers' participation, they were required to read and sign a consent form. The grasping activities in this study were practiced in an actual field and were approved by the Human Ethics Committee of Universitas Ahmad Dahlan.

2.3. Statistic Analysis

Descriptive statistics were used to analyze individual fishermen's factors and MSDs variables. The independent variable used to conduct this study is the MSDs in the hands due to grasping activities. Meanwhile the dependent variables include individual fishermen's factors. There are two individual factors in the study, namely internal factors and external factors. Internal factors include age, weight, height, and body mass index (BMI) [12]. External factors that are the focus of this study include the duration of work per day and experience working as a fisherman. The results of these internal and external individual factors are then analyzed by mean and standard deviation (SD) [13]. Variables, including age, BMI, duration of work per day, and work experience are presented in terms of quantity and percentage. Meanwhile, the level of pain felt in hands are presented in a rating score. The Shapiro-Wilk test was used for the normal distribution confirmation test for individual fishermen's factors and perceived pain in hands in this study. The Pearson correlation coefficient analysis determines the relationship between individual fishermen's factors and MSDs in the hands due to grasping activities. Variables with a p-value of less than 0.05 are considered statistically significant. The data were analyzed using the SPSS program version 26 [14].

2.4. Hypothesis

This study hypothesizes a significant correlation between individual fishermen's internal and external factors and MSDs in fishermen's hands due to grasping activities when carrying out fishermen's tasks.

3. Results

3.1. Respondents' Demographics Characteristics Data

Data on respondents' demographic characteristics and descriptive statistics can be seen in Table 1.

Table 1 Demographic characteristics data and descriptive statistics of respondents (N = 50)

Characteristics	**N (%)**	**Mean ± SD**
Gender		
• Male	50 (100%)	
• Female	0 (0%)	
Age (years)		45.64 ± 8.33
Height (cm)		164.82 ± 4.97
Weight (kg)		62.72 ± 8.11
BMI (kg/m^2)		23.13 ± 2.71
Work hours/day (hour/day)		10.21 ± 2.01
Work experience (years)		24.54 ± 7.38

All respondents in this study were men aged between 31 and 68 (average 45.64 ± 8.33). The most dominant respondents had a normal 35 (70%) BMI. All respondents use their right hand for activities (100%). Respondents were reported to have worked as fishermen for 24.54 ± 7.38 years, with a working duration of 10.21 ± 2.01 hours per day.

3.2. Fisherman's Hand MSDs Data

Data on the distribution of pain perceived by respondents based on the results of the Standardized Nordic Questionnaire (SNQ) and Numerical Rating Scale (NRS) are presented in Figure 1.

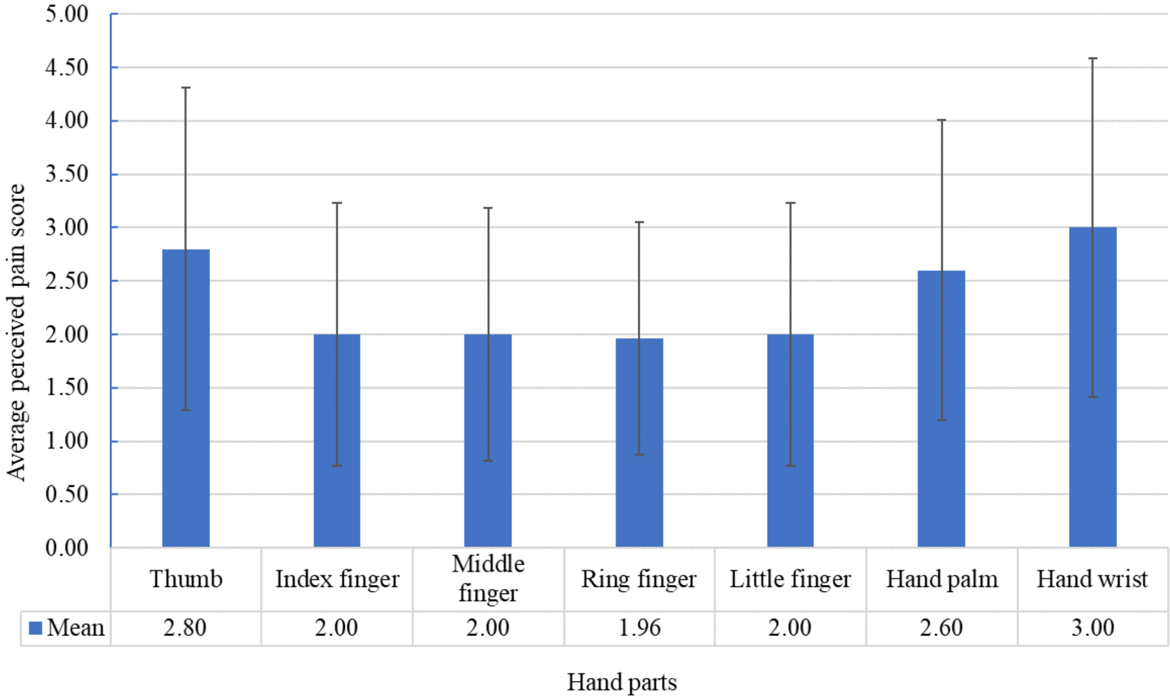

Figure 1 Distribution of pain perceived by respondents

The results of the modified Standardised Nordic Questionnaires (SNQ) and Numerical Rating Scale (NRS) showed that the part of the hand that experienced the most significant pain was the right hand, with severity levels in order being the wrist (average pain score 3.00 ± 1.59), thumb (average pain score 2.80 ± 1.51), palm (average pain score 2.60 ± 1.41), index finger, middle finger, little finger (mean pain score 2.00 ± 1.23; mean 2.00 ± 1.18; mean 2.00 ± 1.23 respectively), and ring finger (mean pain score 1.96 ± 1.09). The pain in the left hand is not as high as in the right hand because all respondents actively use the right hand as the dominant locomotor of movement.

3.3. Correlation Between Individual Factors and Complaints of Hand Pain in Fisherman

The correlation between individual factors and complaints of hand pain in fishermen is shown in Table 2.

Table 2 Correlation of individual factors and complaints of hand pain in fishermen (N = 50)

Individual factors	Hand parts	Pearson coefficient (p-value)- right side
BMI	Thumb	0.011 (0.942)
	index finger	0.060 (0.679)
	middle finger	0.131 (0.363)
	ring finger	0.108 (0.456)
	little finger	0.028 (0.094)
	hand palm	0.025 (0.862)
	hand wrist	0.052 (0.721)
Work hours/day	Thumb	0.392 (0.005)*
	index finger	0.055 (0.706)
	middle finger	0.094 (0.614)
	ring finger	0.040 (0.781)
	little finger	0.042 (0.772)
	hand palm	0.222 (0.122)
	hand wrist	0.362 (0.010)*
Work experience	Thumb	0.391 (0.005)*
	index finger	0.106 (0.463)

Individual factors	Hand parts	Pearson coefficient (p-value)-right side
	middle finger	0.122 (0.398)
	ring finger	0.186 (0.197)
	little finger	0.221 (0.122)
	hand palm	0.284 (0.046)*
	hand wrist	0.307 (0.030)*

Asterisks represent significance (*p < 0.05)

The results of Pearson correlation coefficient analysis showed a significant correlation between the duration of work in a day factor and pain in fishermen's thumbs (r = 0.392 at a p-value of 0.005) and pain in fishermen's wrists (r = 0.362 at a p-value of 0.010). The work experience factor also had a significant correlation with pain in the thumb, palm, and wrist (r = 0.391 at a p-value of 0.005, r = 0.284 at a p-value of 0.046, and r = 0.307 at a p-value of 0.030, respectively). The study also revealed no significant influence between BMI factors and the pain perceived by fishermen in the hands and wrists.

4. Discussion

The respondents in this study were fishermen in a group of fishermen at Baron Beach, Gunungkidul, Yogyakarta. All respondents were male fishermen still actively using their right hand to drive a motorboat. Fishermen's activities involve many hand-gripping activities, including grasping bamboo pickets, grasping ship motor steering levers, lifting fish boxes, and others. The dominance of hand extremity dramatically affects the effectiveness of completing a worker's job tasks [15]. Workers who predominantly move using the right hand will have difficulty if they have to change their activities using the left hand, and vice versa.

The dominance of the right hand in doing work can often impact the onset of injury or skeletal muscle disorders in the right-hand extremity, such as pain in the fingers and right wrist [16]. The potential for injury and pain arising in the fingers and right wrist is caused by the high force and muscle tension that must be generated by the right hand in its activities as a consequence of the dominance of the use of the right hand [17]. Fishermen also experienced the exertion of the right-hand muscle style as respondents in this study because all respondents were fishermen who were dominant in right-handed activities. In addition to high muscle exertion, the potential for injury to the right hand is also caused by an imperfectly circular finger position [18]. In addition, injury is also caused by the hard and pointed surface of the handrail [19], and the dimensions of the handrail diameter are too large [20].

This study investigates the influence of individual fishermen's factors on pain arising from hand-grasping activities. The results of the modified SNQ and NRS questionnaires showed the highest pain experienced in the right wrist, right thumb, and right palm, with a pain score of 3.00, 2,80, and 2.60, respectively. These three parts of the hand are indeed the most important parts when doing grip activities [21].

The thumb is the essential part when grasping objects in a circular position grasping objects [22]. The palm is sometimes to be the part of the hand that makes surface contact with the stem with a pointed tip [23]. The hand wrist will suffer pain from bending the palm when doing an imperfect hand grip [24]. In addition, the pain in the hands perceived by fishermen is also an accumulation of pain arising from the duration of work over a long period of time [25].

This fact reinforces the findings in this study that there is a significant correlation between the duration of work in a day and pain in fishermen's thumbs and wrists. Work experience factors also significantly correlate with thumb, palm, and wrist pain [26]. It is necessary to carry out an ergonomic intervention in the form of a hand grip design to minimize pain in fishermen's hands.

Ergonomic interventions can be grouped into three categories, namely (1) engineering interventions, (2) administrative interventions, and (3) behavioral interventions [27]. Ergonomic interventions that are in accordance with the problems faced by fishermen are engineering ergonomic interventions, namely the design of assistive devices for hand grip. This assistive device for hand grip was designed using 50 anthropometric data directly measured from fishermen's respondents.

The main hand anthropometric data needed to design an assistive device for hand grip includes seven hand dimensions, namely handbreadth (across thumb) (HBT), palm length (PL), maximum grip diameter (MGD), index finger breadth (IFB), index finger thickness (IFT), hand breadth (metacarpal) (HBM), and maximum spread (MS) [28]. All hand anthropometric data must meet the pre-requisite tests, which include normality tests meeting normal distribution criteria (p-value > 0.05) [29], data adequacy tests by meeting the criteria of N > N', where N is the amount of data taken, and N' is the amount of data to be collected [30], and data uniformity tests to ensure that no data lies outside the lower and upper limits of the distribution of these data [31]. The analysis carried out on all anthropometric data from fishermen's hands is a percentile calculation analysis. The calculation of percentiles of hand anthropometric data follows the concept of calculating percentiles in previous studies [32].

Based on the calculation of the percentile of hand anthropometric data, a proposal was made to design an assistive device for hand grip that can minimize the pain perceived by fishermen. The design of this assistive device for hand grip was designed using SolidWorks software, as shown in figures 2-4.

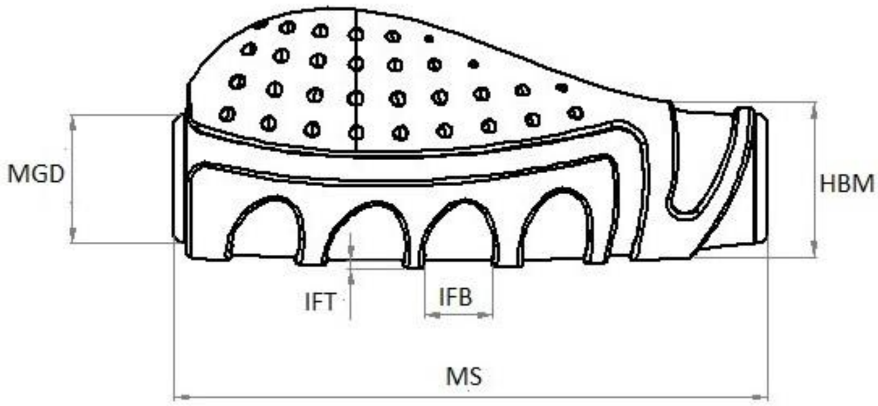

Figure 2 Proposed assistive device design for hand grip - front view

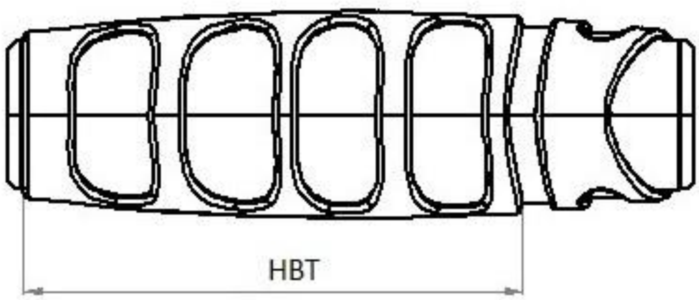

Figure 3 Proposed assistive device design for hand grip - top view

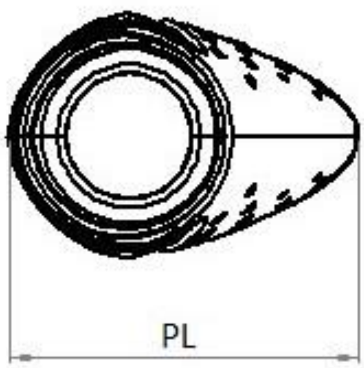

Figure 4 Proposed assistive device design for hand grip - side view

The proposed design of this assistive device for hand grip is recommended to use lightweight and strong materials coated with soft and soft materials [33]. The soft layer of material can reduce the pressure concentration on the hand palm as a result of contact between the skin surface of the hand palm and the hard grip surface of the hand [34].

The drawback of the present research is that it does not concentrate on the area of the body conducting repeated motions while engaging in grasping activities, namely repetitive finger movements. Another instrument is the Occupational Repetitive Action (OCRA), used to measure repetitive activities. Future research will be more interesting, assuming direct measuring techniques are employed, for example, surface Electromyography (sEMG), to evaluate muscle usage for each position around the finger area and observation-based evaluation tools. Another limitation of the present research is that most respondents are right-handed. It may be more advantageous to include respondents who are likewise dominant in using the left hand more equally to compare prior findings.

5. Conclusions

This study revealed that external individual characteristic factors significantly correlate with the potential for MSDs pain in the hands perceived by fishermen when carrying out hand grip activities. The factor of the duration of work per day has a significant relationship with pain in the thumb and wrist of fishermen. Furthermore, the work experience factor was also significantly correlated with pain in the thumb, hand palm, and hand wrist. The study also found that none of the internal individual characteristic factors significantly correlated with the pain of fishermen's hands and wrists.

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7. References

[1] Statistics Indonesia [Internet]. 2022 [cited 2022 Jun 14]. Available from: https://gunungkidulkab.bps.go.id/publication/2021/02/26/acc2288db947eb9841c96c11/kabupaten-gunungkidul-dalam-angka-2021.html

[2] The Regional Planning and Development Agency of Yogyakarta [Internet]. [cited 2023 May 23]. Available from: http://bappeda.jogjaprov.go.id/dataku/data_dasar/index/132-perikanan-tangkap

[3] Shrestha S, Shrestha B, Bygvraa DA, Jensen OC. Risk Assessment in Artisanal Fisheries in Developing Countries: A Systematic Review. Am J Prev Med. 2022;62(4):e255–64.

[4] Trisusanto D, Bariyah C, Kristanto A. Design of ergonomic work facilities on assembly station of mozaic stone for increasing work productivity. Asia-Pac J Sci Technol. 2020;25(01):25–01.

[5] Stringer T, Femia AN. Raynaud's phenomenon: Current concepts. Clin Dermatol. 2018;36(4):498–507.

[6] Budd D, Holness DL, House R. Functional limitations in workers with hand-arm vibration syndrome (HAVS). Occup Med Oxf Engl. 2018;68(7):478–81.

[7] Shen SC, House RA. Hand-arm vibration syndrome: What family physicians should know. Can Fam Physician Med Fam Can. 2017;63(3):206–10.

[8] Ulfah N, Nurcahyo PJ, Dwiandhono. Quantitative Models of Fatigue and W orkload Management for Improving. Productivity of Rice Milling Labors. Kesmas Natl Public Health J. 2013;7(10):477–80.

[9] Jain R, Meena ML, Dangayach GS, Bhardwaj AK. Association of risk factors with musculoskeletal disorders in manual-working farmers. Arch Environ Occup Health. 2018;73(1):19–28.

[10] Kristanto A, Wati E, Bariyah C, Ma'ruf F. The correlation between smartphone use and musculoskeletal symptom. J Curr Sci Technol. 2023;13(2).

[11] Hawker GA, Mian S, Kendzerska T, French M. Measures of adult pain: Visual Analog Scale for Pain (VAS Pain), Numeric Rating Scale for Pain (NRS Pain), McGill Pain Questionnaire (MPQ), Short-Form McGill Pain Questionnaire (SF-MPQ), Chronic Pain Grade Scale (CPGS), Short Form-36 Bodily Pain Scale (SF-36 BPS), and Measure of Intermittent and Constant Osteoarthritis Pain (ICOAP). Arthritis Care Res. 2011;63 Suppl 11:S240-252.

[12] Elgaeva EE, Tsepilov Y, Freidin MB, Williams FMK, Aulchenko Y, Suri P. ISSLS Prize in Clinical Science 2020. Examining causal effects of body mass index on back pain: a Mendelian randomization study. Eur Spine J. 2020;29(4):686–91.

[13] Penev S, Shevchenko PV, Wu W. The impact of model risk on dynamic portfolio selection under multi-period mean-standard-deviation criterion. Eur J Oper Res. 2019;273(2):772–84.

[14] III WEW. Using IBM® SPSS® Statistics for Research Methods and Social Science Statistics. SAGE Publications; 2019. 248 p.

[15] Lutsky K, Kim N, Medina J, Maltenfort M, Beredjiklian PK. Hand Dominance and Common Hand Conditions. Orthopedics. 2016;39(3):e444-448.

[16] Berlanga-de-Mingo D, Lobo-Escolar L, López-Moreno I, Bosch-Aguilá M. Association between multiple trigger fingers, systemic diseases and carpal tunnel syndrome: A multivariate analysis. Rev Espanola Cirugia Ortop Traumatol Engl Ed. 2019;63(4):307–12.

[17] Shiri R, Varonen H, Heliövaara M, Viikari-Juntura E. Hand dominance in upper extremity musculoskeletal disorders. J Rheumatol. 2007;34(5):1076–82.

[18] Currie KB, Tadisina KK, Mackinnon SE. Common Hand Conditions: A Review. JAMA. 2022;327(24):2434–45.

[19] Wollstein R, Michael D, Harel H, Carlson L. The Influence of Hand Dominance in Wrist Fracture Post-Operative Functional Evaluation. Plast Surg Oakv Ont. 2021;29(4):250–6.

[20] O'Brien L, Hardman A, Goldby S. The impact of a hand therapy screening and management clinic for patients referred for surgical opinion in an Australian public hospital. J Hand Ther Off J Am Soc Hand Ther. 2013;26(4):318–22; quiz 322.

[21] Crop JA, Bunt CW. Doctor, my thumb hurts. J Fam Pract. 2011;60(6):329–32.

[22] Lewis WG, Narayan CV. Design and sizing of ergonomic handles for hand tools. Appl Ergon. 1993;24(5):351.

[23] Halim I, Fakulti Kejuruteraan Pembuatan UTMM, Umar RZR, Mohamed MSS, Ahmad N, Saptari A, et al. The Influence of Hand Tool Design on Hand Grip Strength: A Review. Int J Integr Eng. 2019;11(6).

[24] Vyavahare R. Anthropometric and Strength Data of Indian Agricultural Workers for Equipment Design: A Review. Agric Eng Int CIGR J. 2012.

[25] Patel TS, Kanase S, Chotai K, Patil A. Correlation of Anthropometric Characteristics of Hand with Writer’s Cramp. Turk J Physiother Rehabil. 2021;32(3):5261–8.

[26] Yaseen A, Yaseen H, Yaseen A. Work related thumb pain, its prevalence, risk factors and prevention among physical therapists. Int J Endorsing Health Sci Res IJEHSR. 2019;7(1):01–10.

[27] Kristanto A, Neubert MS, Puntumetakul R, Sessomboon W. Adaptable ergonomic interventions for patients with cerebral palsy to rice farmers activities: Reviews and recommendations. Asia-Pac J Sci Technol. 2019;24(4).

[28] Pheasant S. Bodyspace: Anthropometry, Ergonomics And The Design Of Work: Anthropometry, Ergonomics And The Design Of Work. CRC Press; 1996. 260 p.

[29] Aslam M. Analysing Gray Cast Iron Data using a New Shapiro-Wilks test for Normality under Indeterminacy. Int J Cast Met Res. 2021;34(1):1–5.

[30] Dorr DA, D’Autremont C, Pizzimenti C, Weiskopf N, Rope R, Kassakian S, et al. Assessing Data Adequacy for High Blood Pressure Clinical Decision Support: A Quantitative Analysis. Appl Clin Inform. 2021;12(4):710–20.

[31] Busa-Fekete R, Fotakis D, Zampetakis E. Private and Non-private Uniformity Testing for Ranking Data. In: 35th Conference on Neural Information Processing Systems. 2021. p. 9480–92.

[32] Bonin D, Ackermann A, Radke D, Peters M, Wischniewski S. Anthropometric dataset for the German working-age population using 3D body scans from a regional epidemiological health study and a weighting algorithm. Ergonomics. 2022;1–15.

[33] Wang C yi, Cai D chuan. Hand tool handle design based on hand measurements. MATEC Web Conf. 2017;119:01044.

[34] Germann R, Schröder N, Matthiesen S. The contact length parameter as a geometric factor for user-centered design of pistol grip geometries of power tools. Appl Ergon. 2022;99:103636.