An ergonomics study on hand parameters for intuitive controls and better precision

Shikha Singh[1], Nidhi Sharma[2], S. K. Jain[3], Sonika Sharma[4]

[1] *PhD Fellow, Department of Anatomy, TMMC & RC, Moradabad, UP, India. Email- shikhasingh6675@gmail.com*

[2]*Associate Professor, Department of Anatomy, Kalyan Singh Medical College Buland Shahar. Email- drnidhivarshney@gmail.com*

[3]*Anatomy, Professor & HOD, TMMC& RC, Moradabad, UP. Postal Add: F2101, Vaishali apartment new faculty block, TMU, NH24 Near Pakabara, Moradabad. Email- drskjain2005@rediffmail.com*

[4]*Assistant Professor, Department of Anatomy, TMMC & RC, Moradabad, UP. Email- soniyasharma.mbd@gmail.com*

Corresponding Author: Shikha Singh,

PhD Fellow, Department of Anatomy, TMMC & RC, Moradabad, UP, India. Email- shikhasingh6675@gmail.com

ABSTRACT

Introduction: The ergonomic research is useful for redesigning tools that increase healthcare providers' productivity. surgeons may experience pain, exhaustion, and injuries as a result of ergonomic difficulties in the operating room, which might have a detrimental effect on their patient outcomes and performance. Small female hands find it more difficult to use devices designed for bigger male hands, which reduces their level of efficiency and increases their risk of musculoskeletal diseases (MSDs). The purpose of this research is to improve efficiency and comfort in surgery by designing surgical tools based on an anthropometric analysis of hand parameters.

Methods:335 Indian healthcare professionals-168 men and 167 women-were the subjects of the research. Every participant's dominant hand was used to assess a range of anthropometric and biomechanical characteristics, such as length of the hand, width, and span of the hand, wrist circumference was measured by using a measuring tape and handgrip strength with a Jamar dynamometer.

Results: Using SPSS version 25, the t-test was used to analyse the data and reveal that there were significant differences ($p = < 0.05$) in the hand dimensions and strength assessments between the both genders. These results highlight the need for surgical tools that are configurable and adaptive in order to meet the ergonomic requirements of all users, especially in light of the issue of instruments that are predominantly made for bigger male hands.

Conclusion: This research emphasizes how important it is to use anthropometric data when designing surgical instruments in order to enhance surgeons' occupational health and improve surgical results. The long-term advantages of these revised devices and their effect on surgical efficiency and safety will be the primary fields of future study.

KEYWORDS: Hand anthropometry, handgrip strength, pinch strength, Instruments,

INTRODUCTION

Anatomically, the human hand is incredibly complicated, that transfers sensory information to the nervous system about the object, temperature, shape, and touch.[1]

There was a statistically significant difference in grip strength between dominant and non-dominant hands, with the dominant hand being stronger, according to several research that looked at how hand dominance affects grip strength.[2]

To increase the effectiveness and comfort of surgical instruments and equipment for humans, hand anthropometries is important.[3]

Smaller hands find it harder to handle instruments which are designed for larger men's hands, it reduces productivity and raises the risk of musculoskeletal disorders.[4]

Hand tools can influence upper-extremity postures, which can be a substantial contributor to a user's physical stress.[5]

Instruments used in the medical field

Instruments were deemed significant since they were directly connected to the surgeon's hand and unquestionably influenced their posture. Instrument handles have been linked to muscular weakness, pressure region, neurological damage, and early tiredness in numerous investigations.[6]

According to the previous explanation, any target demographic for whom hand tools and other manual devices are to be designed must have knowledge of the anthropometry of the hand.[7]

Carpal tunnel syndrome is one of the upper extremity musculoskeletal illnesses (MSD) that dentists and dental hygienists are susceptible to during work. Preventing upper-extremity musculoskeletal diseases (MSD) required proper instrument design.[8] when it comes to ergonomics of hand-tools, the handle is the most important component in addition to its function.

Tool handle configuration When poorly made hand devices are used over time, the user experiences pain and suffering. It may also sometimes result in paraesthesia or numbness. When constructing instrument handles, the dimensions of the hand have a significant role.[9]

Hand length is important when it comes to equipment accuracy, particularly surgical instruments. Surgeons with tiny or large hands may find it challenging to hold surgical tools due to the shape and length of the equipment handle. As a result, they may be forced to hold the equipment handles differently than the creators intended.[10]

It's worth noting that laparoscopic surgical instruments come in a standard size.[11] Surgeons with tiny hands typically have trouble utilizing tools that are larger than the optimal length, especially those with power grip.[12] Due to dearth in the design of laparoscopic instruments, surgeon's experiences localized muscle fatigue that too particularly in the muscles of forearm.[11]A significant problem to be addressed is ensuring a consistent tool design for a given function, both in terms of shape and extension.[13]Thus, the goal of the current research was to evaluate hand anthropometric measures and handgrip strength in adult Indians in order to establish baseline anthropometric values for surgical equipment that would be suitable for Indian health care professionals of either gender.

METHODOLOGY

335 people participated in this research, and they were divided properly into two groups: males and females. After receiving permission from Teerthanker Mahaveer Medical College and Research Centre's Institutional Ethical Committee (Ref. No. TMU/IEC/20-21/107), measurements were taken out. A proper informed consent form was spread out before commencing the measurements. Additionally, a brief illustration was given about the procedure and the purpose of the study. Some basic information about the participant was noted that include Name, Age, Sex, and Region. The individual's dominant hand was used to measure each parameter. Hand length, hand width, hand span, wrist circumference, and handgrip strength were the parameters that I looked at in my research.

Measurement of Hand Length:

Subjects were asked to stretch their hands out as far as they could move. The length of the hand was measured from the tip of the middle finger to the wrist fold.[14]

Measurement of hand breadth:

A measuring tape was used to measure handbreadth from the radial side of the metacarpal to the ulnar side of the metacarpal.[14]

Measurement of the span of the hand:

The length of the hand was measured with the hand open wide, from the tip of the thumb to the little finger, using a measuring tape.[15]

Wrist Circumference:

To find out the dimensions of the wrist, a measuring tape was wrapped around the joint at the level of the most distant part of the flexing crease.[16]

Hand grip strength:

With the participant seated, arm by side, elbow joint flexed to 90 degrees, forearm half prone, and wrist joint slightly extended, the measurement was taken using a Jamar dynamometer. Following that, the person was told to pull the Jamar dynamometer as far as they could. The outcomes were then recorded.[17]

STATISTICAL METHOD

The Microsoft Excel sheet received the recorded data. Version 27 of SPSS software was used to analyse the data. The parameters of the two groups (males and females) were compared using the unpaired t-test.

RESULTS

Table 1: showing the comparison of anthropometric hand parameters between male and female of healthcare professionals

S. No.	Parameters	Male Mean ± S.D	Female Mean ± S.D	t-value	p-value
1	Hand length	19.30±1.041	17.20±1.798	18.375	<0.05*
2	Hand breadth	10.48±0.586	8.95±0.589	22.930	<0.05*
3	Hand span	21.24±1.482	18.40±1.468	17.671	<0.05*
4	Wrist circumference	17.21±1.117	15.41±1.115	14.821	<0.05*
5.	Handgrip strength	46.68±15.945	17.69±8.49	20.782	<0.05*

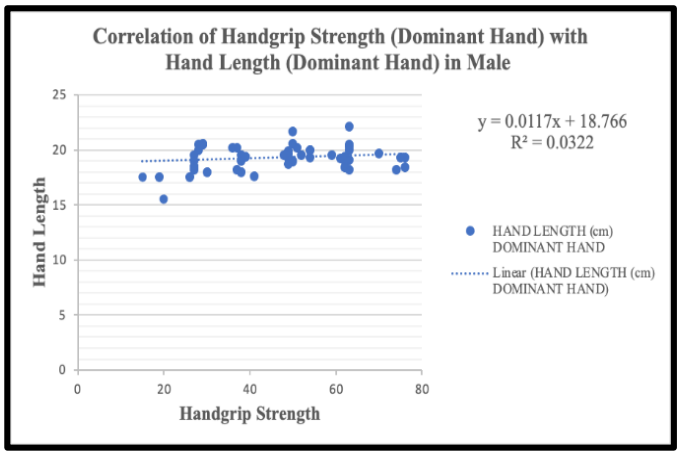
Table 2: Correlation of handgrip strength with hand length, hand breadth, hand span, and wrist circumference in male

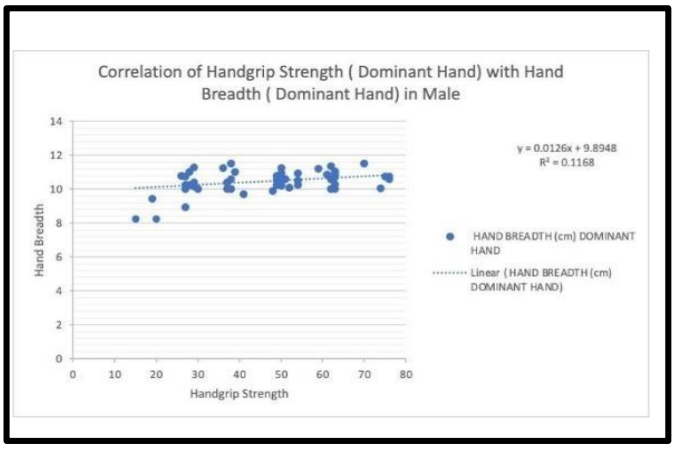
Parameters	N	R-value	P-Value
Hand length	168	.110	.154
Hand breadth	168	.34	.002
Hand Span	168	.233	.002
Wrist circumference	168	.440	.000

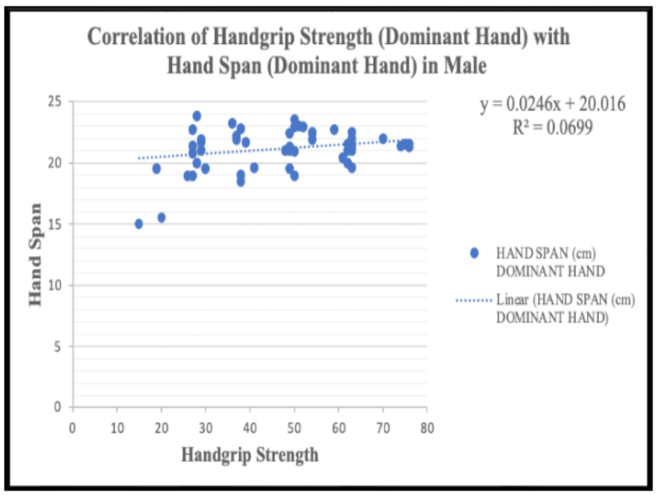
Table3: Correlation of handgrip strength with hand length, hand breadth, hand span and wrist circumference in female

Parameters	N	R-value	P-Value
Hand length	167	.087	.266
Handbreadth	167	0.30	.000
Handspan	167	.202	.009
Wrist circumference	167	.250	.001

Fig 1, 2, 3, 4: Showing correlation of handgrip strength with hand length, hand breadth, hand span, and wrist circumference in male







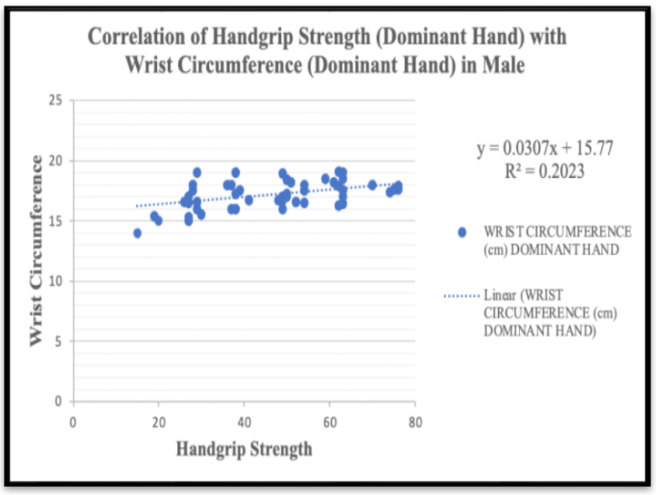
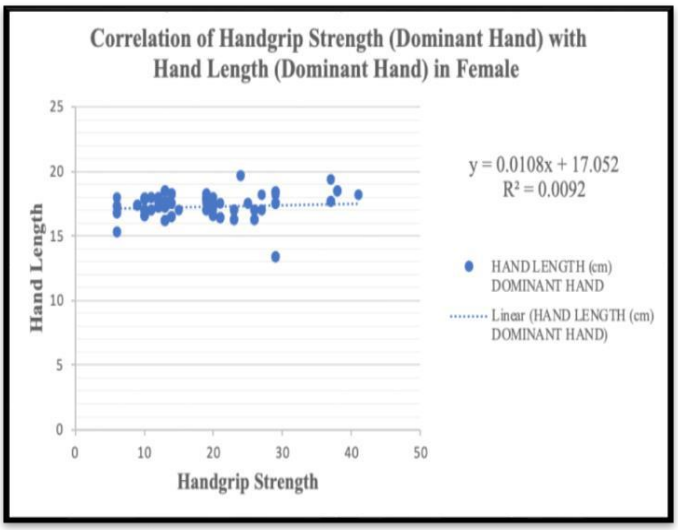
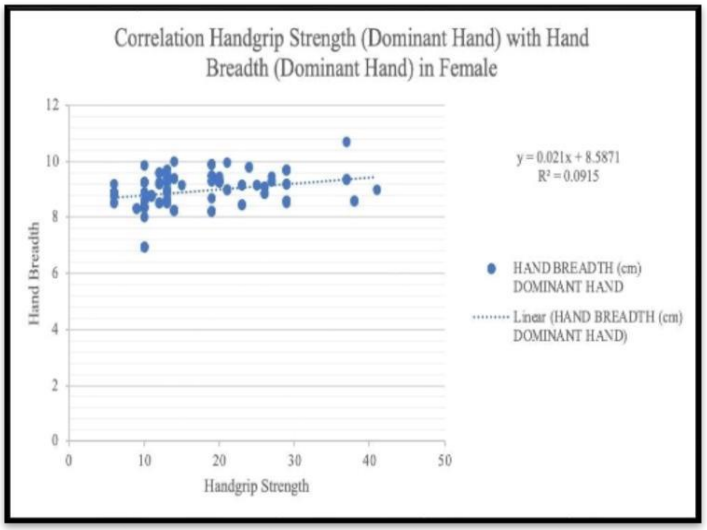
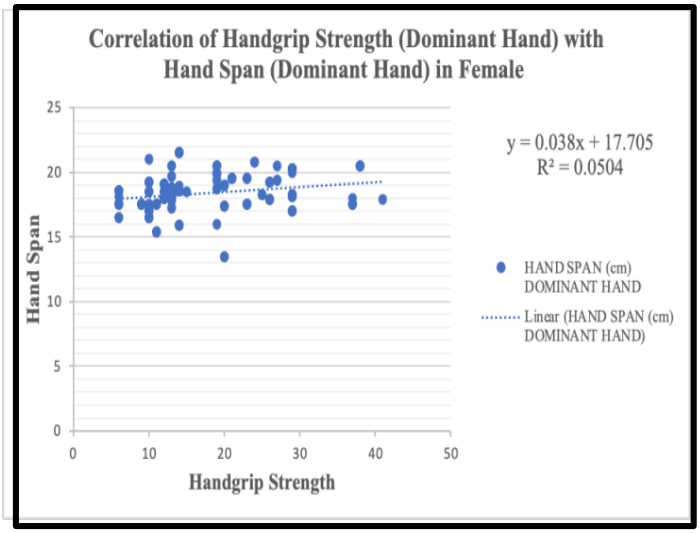
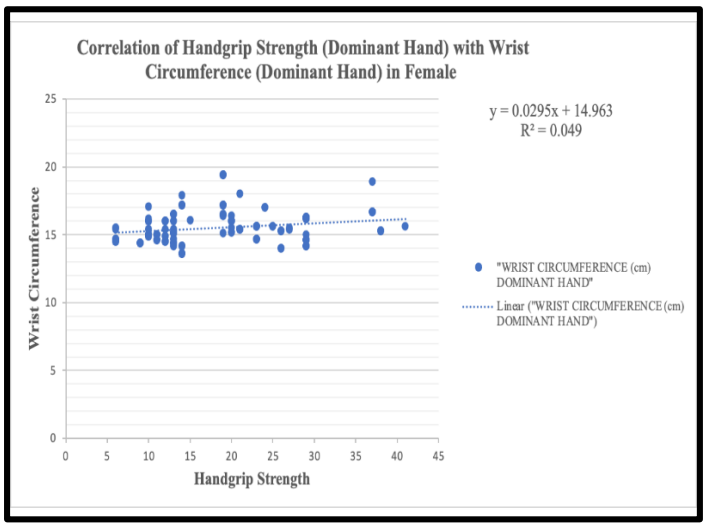


Fig 1, 2, 3, 4: Showing correlation of handgrip strength with hand length, hand breadth, hand span, and wrist circumference in female









Males' average hand length was 19.30±1.041, while females' average hand length was 17.20±1.798. The computed t-value was 18.375. According to the results, there was statistical significance (p-value < 0.05) for hand length in both genders. Male handbreadth averaged 10.48±0.586, whereas female handbreadth averaged 8.95±0.589. The computed t-value was 1.639. According to the results, there was statistical significance (p-value < 0.05) for hand length in both genders. Males' mean hand span was 21.24±1.482, while females were 18.40±1.468. The computed t-value was 17.671. According to the results, there was statistical significance (p-value < 0.05) for hand length in both genders. Male wrist circumference averaged 17.21±1.117, whereas female wrist circumference was 15.41±1.115. The computed t-value was 14.821. According to the results, there was statistical significance (p-value < 0.05) for hand length in both genders. The mean handgrip strength for men was 46.68±15.945 while for women it was 17.69±8.49. The computed t-value was 20.782. According to the results, there was statistical significance (p-value < 0.05) for hand length in both genders.

Grip strength and hand length in male was weakly positive correlation. Handgrip strength and breadth (moderately favourable). and handgrip strength with hand span was showing (weak positive). Handgrip strength and wrist circumference was showing (moderate relationship)

female hand length and grip strength in relation to each other showing (no significant association)

hand breadth, hand span, and Hand circumference with handgrip strength, was showing (moderate positive)

DISCUSSION

Based on our research, the average hand length for men was 19.30 ± 1.041, whereas for women it was 17.20 ± 1.798. The hand length p-value was determined to be statistically significant (0.05).

Our research validated the findings of Asadujjaman,[18] Md. et al.'s study on hand anthropometric assessment using stature estimate in the Bangladeshi community. In males, the average hand length was 18.51±082, whereas in females, it was 16.71±0.75. The findings of their study were statistically important (p<0.05) for both men and women. According to **Zhand et al**.[19] in Korean, men are taller, have longer, bigger hands, and are shorter than women. All anthropometric parameters (length of the hand, width, palm length, thumb figure, index figure, and ring figure) were greater in males than in females in similar research by **Jee and Yun et al**. conducted on a Korean population.[20] comparable research **Ishak et al**. Males were found to have larger heights, hand breadths, lengths, and thumb figures compared to females in Western Australia. Our research's findings align with this study.[21] Our research found that the mean hand breadth values for men and women were 10.48 ± 0.586 and 8.95 ± 0.589, respectively. The hand breadth p-value was found to be statistically significant (<0.05). The average hand width of the Korean population was 7.8 cm for females and 8.6 cm for men, according to another research by **Jee SC et al**.[22]

Similar to this, **Ishak NI et al**. In Western Australia, the right-hand breadth of the population measured 9.10 cm for men and 7.93 cm for women, while the left-hand breadth was 9.04 cm for men and 7.84 cm for women.[23] The same results were found in another study by **Vanishri P. et al**. on the estimation of stature hand length and hand breadth by anthropometric measurements in South Indians. The mean value of hand length in males was 19.74 ± 0.23 and in females was 18.63 ± 0.18. The study's findings were statistically significant (p<0.0) in both genders, and the p-value of hand breadth was statistically significant (<0.05).[22] Turkey Dental College researchers **Cakit E. et al**. conducted a study on hand anthropometric measures. The average palm breadth of men was 87.32 ± 4.67, while the females had a mean value of 76.06 ± 4.66. Their study's results were statistically insignificant (p>0.05) for both genders.[24]Anthropometric measures of hand in obstetricians and gynaecologists were studied by **Bayraktar N. K. et al**.[25] Male hand length was 183.9±0.8, while female hand length was 169.7± 2.01. Male hand breadth was 87.5± 7.7, while female hand breadth was 76.3± 12.1.36. These results clearly demonstrated the men' bigger hands than the females.

Our research indicates that the average hand span in men was 21.24 ± 1.482 and in females, 18.40 ± 1.468. According to the findings, there was statistical significance (p-value <0.05) in the hand span for both

genders. There was no significant link found between hand grip strength and hand length in females, but there was a modest positive correlation seen in men. Hand grip strength and hand width showed a relatively good association in both genders. Hand span and handgrip strength had a weakly positive correlation in males and a moderately positive correlation in females. There was moderate positive correlation seen in both male and female wrist circumference and hand grip strength. Research conducted by **Chahal A et al**. observed in junior basketball players the correlation between hand anthropometry and hand grip strength. In both hands, there was a strong association between all anthropometric measurements and handgrip strength, with the non-dominant hand showing a somewhat higher correlation.[26] Male industrial workers in the state of Haryana were the subjects of a study conducted by **Chandra A. et al**. on hand anthropometric dimensions. They observed a statistically significant relationship between wrist circumference and hand length in their investigation.[27]

CONCLUSION

The current study, titled an ergonomics study on hand parameters for intuitive controls and better precision, was conducted with a focus on gender differences. Our findings indicate that males exhibited larger dimensions across all hand parameters when compared to females.

The current study demonstrates a statistically significant difference in hand dimensions between the two genders. These factors should be considered to enhance the design of the instruments based on the dimensions measured in both genders. The design of instruments is typically based on the functions they are intended to serve, rather than the specific needs of the user, despite being 4tilized by individuals of all genders. Surgeons have to use the instruments for extended periods, which can lead to various complications. If the users' hands are not appropriate to the instruments, leading to musculoskeletal disorders, discomfort, and numbness.

The anthropometric baseline data of hand characteristics from our research will assist manufacturers in creating surgical equipment that improve healthcare professionals' productivity and reduce their risk of developing musculoskeletal illnesses.

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