

Anthropometric study of hand parameters for redesigning surgical instruments to combat ergonomic challenges in an operation theatre

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ABSTRACT

Introduction: Anthropometric hand dimensions are used in the design of hand instruments for improving the efficiency and human comfort of surgical equipment and instruments. Instruments built for large male hands make it more difficult for petite female hands to operate them, which reduces their productivity and increases the risk of musculoskeletal diseases. So, the present study was undertaken to evaluate the differences in anthropometric and biomechanical parameters between the dominant hands of adult Indian males and females.

Methods: The study was conducted on 335 Indian health care professionals of which 168 were males and 167 were females. Various anthropometric and biomechanical parameters were measured on the dominant hand of all the individuals included in the study. Length, breadth and span of a hand, as well as wrist circumference, were measured by measuring tape while handgrip strength and pinch strength was recorded by Jamar dynamometer & Jamar pinch gauge respectively. Obtained data were analyzed by applying the t-test SPSS version 27. We considered P-value <0.05 as statistically significant.

Results: A higher statistically significant difference (<0.05) was found in hand anthropometric and biomechanical parameters amongst dominant hands of Indian male and female health care professionals.

Conclusion: The present study was gender-based. All the anthropometric and biomechanical parameters were found to be of dimensions in males as compared to females. This study provides baseline anthropometric & biomechanical values of the Indian hand that will help manufacturers to redesign instruments to improve efficiency and prevent the risk of musculoskeletal disorders amongst health care professionals.

Key words: Hand anthropometry, handgrip strength, pinch strength

INTRODUCTION

All over the world female surgeons are increasing gradually thereby achieving parity with male surgeons. This demographic shift has significant

implications for surgical instrument designers, as female surgeons have to struggle with hand instruments, designed almost exclusively for men.¹ Its efficiency arises from the capacity to execute a powerful grasp, as well as higher extensive nerve control and finger sensitivity. For addressing the demands of daily life, complete hand function and appropriate hand strength are required.² Handgrip strength has been distinguished as a significant considers foreseeing impairment musculoskeletal complication, probability of falls and cracks in osteoporosis and bone mineral thickness.³ Clinically, handgrip strength is an important factor that indicates the health of the individual and their physical stability; It even predicts general morbidity, problems after surgical ps and their outcomes in older

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people.⁴ The length of one's finger and the strength of one's grasp vary as one gets older.⁵

Grip strength rises with age and is roughly equal for boys and girls until they reach the age of ten, after that point boys become much stronger than girls, and it begins to drop after the fourth decade.⁶ In comparison to male surgeons, female surgeons experience more discomfort in their hands.⁷ When it comes to the accuracy of equipment, especially surgical devices, hand length is crucial. Because of the length and form of the equipment handle, surgeons with small or big hands sometimes have difficulty grasping surgical instruments. When women use the oversized tool, a myriad of useability issues can arise based on the difference in biomechanics between men and women.¹ Long-term use of a poorly designed hand instrument results in pain and discomfort to the user. In some cases, it also causes numbness or paraesthesia. Dimensions of hands are an important factor when designing instrument handles.⁸ Unfit designs undoubtedly affect the surgeon's hand directly and their posture also. In previous reports, it was documented that instrument hand exposure caused exhaustion of muscle, pressure areas, injuries to nerves, and easy fatigue.⁹ After laparoscopic surgery, small-handed OBS/GYNS experience more fatigue than large-handed male counterparts, according to a questionnaire survey.¹⁰ A study conducted in Mizoram, India showed that women healthcare workers experienced a greater number of musculoskeletal problems than their male counterparts.¹¹

A surgeon's performance in the operating room can be affected by many factors, including surgeon comfort, ergonomic tool handle design, and fatigue. The design of instruments for laparoscopic surgery often overlooks many ergonomic disadvantages. An ill-designed surgical instrument causes functional and cognitive inconveniences and also hampered touch, sensation, and motor movements.¹²

A study concerning the handle design of disposable laparoscopic instruments revealed that such instruments are not designed for both genders, and it indicates a clear mismatch between surgical instrumentation and a large number of intended users.¹⁰ In the present era where many female surgeons are leading the operation there is a need for instruments that fit the female hands. The designs should require minimal physical adjustment. More importantly, device

design should adapt to people, rather than the other way around. The best way of designing a surgical instrument is according to the dimensions of the hands of both genders.¹

Anthropometric data of hands is one of the most important considerations in the design of instruments, workplace gadgets, hand tools, and a variety of other objects for human usage. Lack of correctly prepared machinery and equipment may result in decreased job performance and a higher risk of work-related accidents.¹³ Anthropometry hand dimension is highly significant and used in the design of instruments that are related to human hands. Anthropometry data is extremely valuable when it comes to creating functions involving the human hand. Without this information, the designs will not fit the individuals who will utilize them. As a result, information on human hand sizes must be incorporated into the design of various facilities.¹⁴ Present study was done to provide baseline anthropometric values of hands of adult males & females for designing surgical equipment appropriate for either gender of Indian health care professionals.

METHODS

This study was a descriptive observational study. Study participants included 335 Indian health professionals including faculty and resident from the department of surgery (including general surgery, gynecology & obstetrics, ENT, ophthalmology, anesthesia, and dentistry that regularly use instruments for the treatment of patients. Out of the total participants, 168 were males and 167 were females. IEC approval was obtained from the Institutional Ethical Committee at TMMC & RC, TMU (Ref. No.-TMU/IEC/20-21/107). The study was conducted from November 2020 to October 2021. Informed consent was taken from each subject before starting the procedure. All the parameters were measured on the dominant hand of the individual including length, breadth, span, the circumference of the wrist, handgrip strength, and pinch strength. All the hand parameters were measured by measuring tape, handgrip strength by Jamar dynamometer (Alpyog), and pinch strength is measured by using a Jamar pinch gauge (model no. 65861).

The length of the dominant hand was measured by asking the individual to extend his/her hand to the fullest and the measurement was done with the help of measuring tape from the wrist crease up to the tip of a middle finger.¹⁵ (fig 1)

Handbreadth was measured from the lateral side of the metacarpal (index finger) to the medial side of the metacarpal (little finger) with the help of measuring tape.¹⁵ (fig 2)

The span of the hand was measured in a wide-opened hand by using flexible measuring tape from the most distal margin of the thumb to the distal margin of the little finger.¹⁶ (fig 3)

Wrist Circumference:

Wrist circumference was measured by using a measuring tape by placing the measuring tape all around the wrist joint at the level of the distal end of the flexion crease.¹⁷ (fig 4)

For measuring the handgrip strength we ask the volunteer to sit in a comfortable position with his/her arm by the side, forearm in half prone position, elbow in a flexed position at 90° and the wrist slightly extended. Then the subject was asked to pull the Jamar dynamometer as much as possible and the readings were recorded.¹⁸ (fig 5)

Measurement of pinch strength: It was measured with the help of a pinch gauge in the same position as tested the hand grip strength. Key pinch strength was measured by placing the pinch gauge in between the pad of the thumb and the lateral side of the middle phalanx of the index finger.¹⁹ (fig 6)

The data was recorded on the Performa sheets later it was transferred to Microsoft Excel and data was analyzed using SPSS software version 27.

RESULTS

The mean value of hand length in male 19.30±1.041 and females was 17.20±1.798 t-value calculated was 18.375. In the comparison of hand length in both genders, the p-value came out to be < 0.05 which was found to be significant statistically. The average value of handbreadth in males was 10.48±0.586 and in females was 8.95±0.589. The t-value calculated was 1.639. In the comparison of handbreadth in both genders, the p-value came out to be < 0.05 which was found to be significant statistically. The average value of hand span in males was 21.24±1.482 and for females, it was 18.40±1.468 t-value calculated was 17.671. In the comparison of hand span in both genders, the p-value came out to be < 0.05 which was significant statistically. The average value of wrist circumference in males was 17.21±1.117 and in females was 15.41±1.115, and the t-value calculated was 14.821. In the comparison of wrist circumference in both genders, the p-value came out to be < 0.05 which was statistically significant. (Table 1)

The average value of handgrip strength in males was 46.68±15.945 and in females was 17.69±8.49. The t-value calculated was 20.782. In the comparison of hand pinch strength in both genders, the p-value came out to be < 0.05 which was found to be statistically significant. The average value of pinch strength was 4.02±1.4 in males and 3.25±1 in females, with a t-value of 14.502 and a p-value of <0.001. (Table 2)

Table 1: Comparison of anthropometric parameters of dominant hand of male and female health care professional

Parameters	Mean ± SD (Male)	Mean ±SD (Female)	t-Value	p-Value
Hand Length (cm)	19.30±1.041	17.20±1.798	18.375	.000
Hand Breadth (cm)	10.48±0.586	8.95±0.589	1.639	.000
Hand Span (cm)	21.24±1.482	18.40±1.468	17.671	.000
Wrist Circumference(cm)	17.21±1.117	15.41±1.115	14.821	.000

Table 2: Comparison of biomechanical hand parameters of dominant hands of male and female health care professionals

Parameters	Mean ± SD (Male)	Mean ±SD (Female)	t-value	p-value
Handgrip Strength (kg)	46.68±15.945	17.69±8.49	20.782	.000
Pinch grip strength (pounds)	4.02 ±1.4	3.25±1	14.502	.001



Figure 1: Measurement of hand length



Figure 2: Measurement of hand breadth



Figure 3: Measurement of hand span

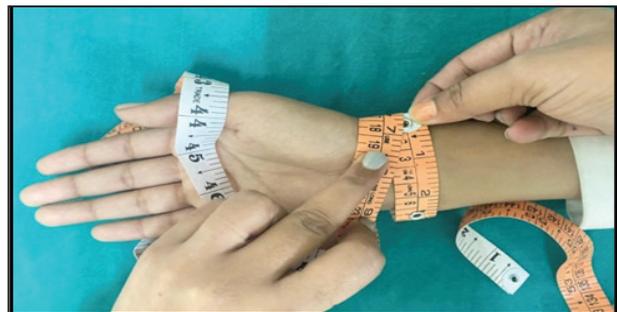


Figure 4: Measurement of wrist circumference



Figure 5: Measurement of hand grip strength



Figure 6: Measurement of key pinch strength

Discussion

The results of this study can be used to build a reference table for designing hand instruments based on gender for Indian health professionals. According to our study, a statistically significant difference (<0.05) was observed in the hand anthropometric and biomechanical measurements of male and female health professionals. The outcome of our study supports the study conducted by Asadujjaman et al. on hand anthropometric measurement from stature estimation in the Bangladeshi population. According to them the average value of hand length in males and females was 18.51 ± 0.82 and 16.71 ± 0.75 respectively ($p < 0.05$).²⁰ Zhand et al. in the Han Chinese population and Krishan et al. reported that males have longer and wider hands and taller

statures than females.^{21,22} another study by Jee and Yun et al. In the Korean population states that all the anthropometric parameters were higher in males than females including, handbreadth, palm length, index finger length, ring finger length, hand length, thumb figure length.²³ Anthropometric studies conducted by Ishal et al. amongst the Western Australian population conclude that height, hand length, hand breadth, palm length, and thumb length were greater in the males.²⁴ Cakit E. et al carried out a study on anthropometric measurements of hands in Turkey Dental college and found that the mean values of hand dimensions and biomechanical strength are significantly larger in males as compared with females ($p < 0.01$).²⁵ Bayraktar et al did the study on hand anthropometric measurements in obstetrician-gynecologists. According to their study

mean hand length in males and females was 183.9 ± 0.8 and 169.7 ± 2.01 respectively, while mean values of handbreadth in males and females were 87.5 ± 7.7 and 76.3 ± 12.1 respectively.²⁶ A study conducted by Ngee Wei Lam on the multiethnic Asian population for handgrip strength and pinch strength found that the values of hand grip and pinch strength were statistically higher in males as compared to females ($P < 0.001$).²⁷ Pinch strength and grip strength are always more in boys than girls of the same age and it is proved by numerous research on biomechanical parameters of hand.^{28,29}

CONCLUSION

Although surgical errors can happen in any aspect of patient treatment, a vigorous approach is required by everyone involved in the health sector to eliminate or reduce their frequency. The present study was gender-based and we found that there were higher dimensions of all the hand anthropometric & biomechanical parameters in male doctors as compared to females. Data from our study can be taken into consideration for better designing of the medical instruments appropriate for either gender of health care professional. The gender-specific instrument for surgeons is of great help in the surgical arena as it will improve their efficiency in providing better medical care.

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