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The Normal Active Range of Motion of the Index, Middle, Ring, and Little Fingers in a Sample of Indian Population

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Abstract

Background The normative data for finger range of motion (ROM) are not available for the Indian population. The aim of our study was to measure the active ROM of finger joints in normal healthy volunteers in a sample of Indian population.

Materials and Methods This is a prospective observational study conducted as a part of the Indian normative data project of the Indian Society for Surgery of the Hand (ISSH). The study included one participating center from four geographical regions of the country. Certified goniometers were used to measure the ROM of fingers in all centers. A standardized methodology was devised. A pilot study was done to assess the interobserver and intraobserver reliability, following which data were collected by one measurement.

Results This pilot study was performed in 20 hands that showed good interobserver and intraobserver reliability correlation. A total of 390 hands were measured in four participating centers. Active flexion of metacarpophalangeal (MCP) joint was the highest in the middle finger (86.6 ± 10.4 degrees) followed by the index finger (86.0 ± 9.2 degrees), little finger (85.0 ± 8.4 degrees), and ring finger (84.2 ± 8.6 degrees). The index finger (97.2 ± 16.9 degrees) showed maximum proximal

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interphalangeal (PIP) joint flexion followed by the middle finger (96.2 ± 15.8 degrees), ring finger (96.0 ± 15.9 degrees), and little finger (91.8 ± 12.7 degrees). Distal interphalangeal (DIP) joint flexion increased from the index finger (81.6 ± 13.9 degrees) to the little finger (84.6 ± 12.9 degrees). The little finger MCP joint (26.3 ± 6.2 degrees) showed maximum extension followed by the index finger (25.7 ± 6.8 degrees), middle finger (24.7 ± 6.7 degrees) and ring finger (22.3 ± 7.1 degrees). The middle finger (15.6 ± 8.1 degrees) and ring finger (16.2 ± 8 degrees) had more PIP joint extension when compared to the index (13.7 ± 7.8 degrees) and little finger (13.2 ± 8.4 degrees). The ring finger (8.1 ± 6.8 degrees) and the middle finger (8.4 ± 6.9 degrees) had more DIP joint extension when compared with the index finger (6.0 ± 6.0 degrees) and the little finger (6.8 ± 6.7 degrees). Total active motion (TAM) of the middle finger (315.9 ± 31.0 degrees) was the maximum followed by the index finger (310.2 ± 27.3 degrees), ring finger (308.8 ± 29.1 degrees), and little finger (307.8 ± 25.2 degrees). Gender, body mass index (BMI), mother tongue, geographical location, and occupation were factors that had significant correlation, while no significant differences based on side, hand dominance, and age were noted.

Conclusion We have reported normative data of finger ROM and TAM for the index, middle, ring, and little fingers in the Indian population. Finger ROM in the Indian population is highly variable. The observed TAM in the Indian population is higher than what is reported earlier.

Introduction

Finger range of motion (ROM) is one of the basic clinical measurements in hand surgery practice. Most of the available resources give arbitrary values.[1–5] The anthropometric variations between the Indian population and the western world is quite evident, but also of clinical significance is the variation within the Indian population. The Indian population is made up of people from various ethnic origins; there is no single Indian ethnicity in anthropometric terms. A study that includes samples from different geographical zones of the country will not only help us arrive at a homogenized normative data for the whole population but also help us understand the differences between the geographical areas.

The variation in ROM in different fingers is well recognized, but it is not objectively reported. For example, Kapandji mentions the flexion at metacarpophalangeal (MCP) joint is approximately 90 degrees. It falls short of 90 degrees for the index finger but increases progressively for the other fingers. Similarly, the flexion at the proximal interphalangeal (PIP) joints increases in range from the index finger to the little finger to reach a maximum of 135 degrees in the little finger, and the flexion in the distal interphalangeal (DIP) joints is slightly less than 90 degrees and it increases in range from the index finger to the little finger to reach a maximum of 90 degrees in the little finger.[6] These variations, although well recognized, are not quantified or documented in the Indian population. There are studies available that has studied the ROM, but there are no data available specifically for the Indian population.[7–9]

Digital ROM measurement is a basic clinical examination technique in hand surgery. Once the normal values are standardized, it will help us establish tailormade guidelines for Indian patients. The aim of our study was to measure the active ROM of finger joints in normal healthy volunteers in a sample of Indian population.

Materials and Methods

This is a prospective observational study conducted as a part of the Indian normative data project under the aegis of the Indian Society for Surgery of the Hand. The study was designed as a multicentric study with one participating center each from four geographical regions of the country. The study was conducted at the Institute of Craniofacial Aesthetic and Plastic Surgery at SIMS Hospital, Chennai, representing the south zone of India. The Sher-I-Kashmir Institute of Medical Sciences, Srinagar, represented the north zone; Byramjee Jeejeebhoy Government Medical College, Pune, represented the west zone; and AIIMS, Patna, represented the east zone. The study was conducted between January and December 2022. Normal healthy volunteers between 18 and 60 years who consented to participate in the study were included. Volunteers with history of skeletal trauma to the hand, medical conditions affecting the hand, those who had underwent surgery of the hand, and those with deformities were excluded.

We decided to use goniometers to measure the ROM as the validity and reliability of finger goniometers have been established by various studies.[10–13] Measurements of finger ROM were made using Jamaar's hyperextension goniometer. The goniometers were calibrated, certified, and shipped to the participating centers.

To ensure uniformity, the methodology of ROM measurements was standardized and a protocol was created. Angles of maximum flexion and maximum extension of the MCP, PIP, and DIP joints of the index, middle, ring, and little fingers were measured. The positioning of the examiner, the examinee, the position of the hand, and the positioning of the goniometer to measure each joint were standardized and included in the protocol. This protocol was shared with all the participating centers. Multiple online meetings were conducted to train the researchers from the different participating centers. The emphasis was on standardization of measurements and to avoid measurement errors. In addition, demographic data and factors that may influence finger ROM like occupation, handedness, and body mass index (BMI) of the volunteers were collected using a standardized questionnaire. A standardized proforma for data collection was used. The sample size was calculated based on standard statistical methods and a sample size of 30 for each geographical zone was estimated to be adequate. The study population comprised volunteers from the outpatient department (OPD) with no history of hand injury or medical condition involving the hand.

An initial pilot study was conducted on 10 patients in Chennai to validate the protocol and methodology. Two observers measured the ROM in these patients individually. In addition, one observer performed two measurements in these individuals at a minimum interval of 1 week. Inter- and intraobserver reliability was assessed. Once the pilot study was complete, the multicentric study was initiated. The data from the different centers were collated and analyzed.

We have represented all flexion ROM and hyperextension ROM as a positive value measured from the neutral position for ease of understanding. Mean, median, and standard deviation were calculated for all continuous data. Percentage was computed for all categorical data. Independent *t*-test for two groups and one-way analysis of variance (ANOVA) test for more than two groups were done to find significant differences. Wherever the data were not in normal distribution, the Mann–Whitney *U* test and Kruskal–Wallis test were done. Correlation analysis was done using Pearson's correlation test. In the pilot study, inter- and intraobserver reliability was assessed using intraclass correlation (ICC), absolute agreement, and consistency. SPSS version 20 was used and a *p*-value of less than 0.05 was considered significant.

Results

The pilot study was performed in 20 hands. The interobserver and intraobserver reliability was assessed. The ICC coefficient showed good interobserver (0.528–0.883) and intraobserver reliability (0.645–0.949). The rest of the study was done by a single measurement by one investigator.

In total, 195 volunteers were enrolled in the study: 53 volunteers from Chennai, 52 volunteers from Srinagar, 50 volunteers from Pune, and 40 volunteers from Patna. A total of 390 hands were measured. The demographic details including age, sex, mother tongue, hand dominance, and occupation are reported in ►**Table 1**. The findings of individual zones and the collated national data are summarized in ►**Table 2**.

Active flexions of the MCP, PIP, and DIP joints for the index, middle, ring, and little fingers were compared. Active flexion of the MCP joint was the highest in the middle finger (86.6 ± 10.4 degrees) followed by the index finger (86.0 ± 9.2 degrees), little finger (85.0 ± 8.4 degrees), and ring finger (84.2 ± 8.6 degrees). PIP joint flexion showed a radial progression with the index finger (97.2 ± 16.9 degrees) having maximum flexion of the PIP joint followed by the middle finger (96.2 ± 15.8 degrees), ring finger (96.0 ± 15.9 degrees), and little finger (91.8 ± 12.7 degrees). Active flexion of the DIP joint showed an ulnar progression with increasing flexion from the index finger (81.6 ± 13.9 degrees) to the little finger (84.6 ± 12.9 degrees). The differences were statistically significant (►**Fig. 1**).

Active extension of the MCP joints was analyzed. The little finger (26.3 ± 6.2 degrees) showed maximum extension, followed by the index finger (25.7 ± 6.8 degrees) and the middle finger (24.7 ± 6.7 degrees). The ring finger (22.3 ± 7.1 degrees) showed the least MCP extension. The differences were statistically significant. The analysis of the PIP joint extension revealed that central fingers, middle (15.6 ± 8.1 degrees) and ring (16.2 ± 8 degrees) fingers, had more extension when compared with the peripheral digits, the index finger (13.7 ± 7.8 degrees) and the little finger (13.2 ± 8.4 degrees). The DIP joint extension analysis revealed a similar pattern; the central fingers, ring finger (8.1 ± 6.8 degrees) and middle finger (8.4 ± 6.7 degrees), had more extension than the peripheral digits, the index finger (6.0 ± 6.0 degrees) and the little finger (6.8 ± 6.7 degrees). The differences were statistically significant (►**Fig. 1**).

Total active motion (TAM) was studied; TAM of the middle finger (315.9 ± 31.0 degrees) was the maximum followed by the index finger (310.2 ± 27.3 degrees), ring finger (308.8 ± 29.1 degrees), and little finger (307.8 ± 25.2 degrees). The differences were statistically significant. Similar trends were noticed in all geographic zones (►**Fig. 1**).

Factors influencing ROMs were studied. Female volunteers showed a statistically significantly higher TAM and when compared with male volunteers ($p < 0.05$; ►**Fig. 2**). Factors like mother tongue and geographical location (►**Fig. 3**) showed statistically significant differences ($p < 0.05$). On analysis based on occupation, health professionals, skilled labor, clerks, and students exhibited more TAM when compared with volunteers who were unskilled laborers, housewives, and businessmen ($p < 0.05$). BMI showed an inverse correlation to TAM ($p < 0.05$). There were no significant differences based on side ($p > 0.05$), hand dominance ($p > 0.05$), and age ($p > 0.05$).

Discussion

There are a few studies that have established the ROM of fingers in the western population,[7,8] but no such studies exist for the Indian population. In many of the resources,[4–6] the ROM is reported for one digit alone and no differences in between fingers are reported. In our study, we have established the reference values for finger ROM of the index, middle, ring, and little fingers in healthy Indians based on data generated from

Table 1 Demographic data of the study population

		n	%	Mean	Standard deviation	Median	Standard error of mean
Age				32.1	10.6	29	0.762
Body mass index (BMI)				23.64	4.4	21	0.549
Age distribution	11–20	12	6.2				
	21–30	94	48.2				
	31–40	53	27.2				
	41–50	22	11.3				
	51–60	13	6.7				
Gender	Female	79	40.5				
	Male	116	59.5				
Mother tongue	Bengali	2	1				
	Dogri	3	1.5				
	Gujrati	1	0.5				
	Hindi	46	23.6				
	Kannada	2	1				
	Kashmiri	49	25.1				
	Malayalam	5	2.6				
	Marathi	40	20.5				
	Tamil	39	20				
	Telugu	8	4.1				
Hand dominance	Right	181	92.8				
	Left	14	7.2				
Occupation	Doctor	20	10.3				
	Businessman	2	1				
	Employee	32	16.4				
	Health assistant	12	6.2				
	House wife	7	3.6				
	Nursing profession	59	30.3				
	Professional	19	9.7				
	Security	4	2				
	Skilled labor	27	13.8				
	Student	13	6.7				

195 healthy participants in the age range of 18 to 60 years including participants from both genders.

We had decided on the Jamar type hyperextension goniometer for the study because of the unique challenges faced while measuring the ROM of fingers due to the dimension of the phalanges. Studies have been conducted to assess the reliability of goniometric measurements in the hand. These studies have found that measurements of all joints of the fingers that were taken using universal goniometers, and specialized finger goniometers are highly reliable.[10–13] Some studies have found that measurement of DIP flexion can be slightly less reliable than that of more proximal joints due to difficulty in placing the arms of a goniometer over the small phalanges.[14,15] Lewis et al examined the reliability of measuring active and passive ROM at the MCP, PIP, and DIP joints and reported that the reliability of active measurements was better than passive measurements.[12] These studies validate our methodology of using Jamar type hyperextension goniometer to measure active ROM. Our study demonstrated good reliability with ICC less than 0.5 in all parameters of measurement.

Measurements of the finger ROM taken by one examiner are more reliable than measurements taken by several examiners. The margin of error is generally accepted to be approximately 10 degrees for goniometric measurement of the joints in the hand, provided that standardized techniques are employed. Results from our study show a standard deviation range of 6.2 to 16.9; given the multicentric nature of the study with multiple examiners, this is a given fallacy in our study design.

Table 2 Normative data of finger range of motion in the Indian population ($p < 0.05$)

Finger	Joint	Movement	National (mean ± SD), degrees	East (mean ± SD), degrees	South (mean ± SD), degrees	West (mean ± SD), degrees	North, (mean ± SD), degrees
Index	MCP	Flexion	86.0 ± 9.2	88.3 ± 6.0	90.2 ± 7.6	87.8 ± 8.8	78.4 ± 9.1
		Extension	25.7 ± 6.8	28.6 ± 2.2	28.2 ± 3.8	28.3 ± 3	18.6 ± 8.9
	PIP	Flexion	97.2 ± 16.9	103.4 ± 5.9	107.5 ± 6.7	101.9 ± 19.3	101.1 ± 6.1
		Extension	13.7 ± 7.8	12.7 ± 6.4	16.4 ± 7.9	12.9 ± 8.2	12.2 ± 7.8
	DIP	Flexion	81.6 ± 13.9	72.6 ± 7.2	78.1 ± 7.7	76.3 ± 7.1	73.4 ± 10.2
		Extension	6.0 ± 6.0	2.7 ± 3	7.5 ± 7.3	6.7 ± 5.8	6.7 ± 5.6
	TAM		310.2 ± 27.3	308.2 ± 13	327.9 ± 21.3	313.8 ± 27.7	290.3 ± 27.2
Middle	MCP	Flexion	86.6 ± 10.4	87.6 ± 5.9	91.5 ± 7.6	87.7 ± 9.8	79.8 ± 12.6
		Extension	24.7 ± 6.7	28.5 ± 2.3	26.4 ± 5.5	26.0 ± 5.3	19 ± 7.6
	PIP	Flexion	96.2 ± 15.8	102.7 ± 5.6	106.6 ± 5.2	100.1 ± 16	99.8 ± 10
		Extension	15.6 ± 8.1	16.1 ± 7.9	17.3 ± 8.3	16.6 ± 7.8	12.5 ± 7.7
	DIP	Flexion	84.5 ± 13.1	73.3 ± 7.5	81.7 ± 8.0	80.3 ± 7	77.4 ± 12.7
		Extension	8.4 ± 6.7	3.4 ± 3.3	10.8 ± 6.9	10.4 ± 6.8	8 ± 6.2
	TAM		315.9 ± 31	311.5 ± 14.2	333.6 ± 24.3	321.2 ± 31.3	296.3 ± 34.3
Ring	MCP	Flexion	84.2 ± 8.6	89.2 ± 5.7	86.0 ± 7.0	84.2 ± 7.6	78.3 ± 9.5
		Extension	22.3 ± 7.1	24.5 ± 2.2	21.9 ± 7.1	22.6 ± 6.2	17.7 ± 6.7
	PIP	Flexion	96 ± 15.9	101.9 ± 6.0	105.8 ± 6.1	100.0 ± 16.2	99.1 ± 11.2
		Extension	16.2 ± 8.0	15.1 ± 8.3	17.3 ± 8.0	19.4 ± 6.7	12.8 ± 7.6
	DIP	Flexion	82.1 ± 14.6	73.9 ± 8.2	80 ± 8.8	77.4 ± 9.3	73.7 ± 13.8
		Extension	8.1 ± 6.8	3.7 ± 4.4	11.5 ± 7.1	9.4 ± 6.6	6.7 ± 6.1
	TAM		308.8 ± 29.1	312.2 ± 14.8	322.5 ± 21.1	313.0 ± 28.1	288.2 ± 34.3
Little	MCP	Flexion	85.0 ± 8.4	89.1 ± 6.4	86.2 ± 6.7	83.6 ± 9.3	82.1 ± 9.1
		Extension	26.3 ± 6.2	28.5 ± 2.5	28.4 ± 4.1	28.8 ± 3.2	20 ± 7.7
	PIP	Flexion	91.8 ± 12.7	101.4 ± 6.5	99.3 ± 6.8	94.5 ± 12.8	94.9 ± 8.5
		Extension	13.2 ± 8.4	11.8 ± 5.3	14.8 ± 8.6	15.8 ± 9.4	10.1 ± 8
	DIP	Flexion	84.6 ± 12.9	74.7 ± 8.8	82.6 ± 8.1	80.6 ± 8.8	77.5 ± 11.6
		Extension	6.8 ± 6.7	2.9 ± 2.8	9.5 ± 7.6	8.1 ± 6.8	5.9 ± 6.1
	TAM		307.8 ± 25.2	308.4 ± 13.1	321 ± 20.6	311.4 ± 25.9	290.4 ± 26.2

Abbreviations: DIP, distal interphalangeal joint; MCP, metacarpophalangeal joint; PIP, proximal interphalangeal joint; TAM, total active motion.

Some trends are quite apparent; the PIP joints have the maximum flexion, followed by the MCP and DIP joints. When looking at extension, the MCP joints have the largest amount of extension and the DIP joints have the least extension. Studies have reported an ulnar progression of MCP flexion, PIP flexion, DIP flexion, and TAM from the index to the little finger,[6,7] but in our study the national data and individual geographic zone data show a particular pattern in which the middle finger shows the highest TAM and lower TAM is found in the ring and little fingers (►**Fig. 1**). The higher TAM in the middle finger is mainly due to the higher DIP and PIP flexion, which could be attributed to the length of the phalanges and the availability of space for flexion in the hollow of the hand. The same reason could also be the reason for reduced TAM in the little finger as the observed PIP flexion is lower due to the less space available for flexion due to restriction by the hypothenar eminence. The observation of lower TAM in the ring finger could be explained by the restricted MCP extension at the ring finger due to the presence of juncturae tendinum. The juncturae restrict independent extension of the ring finger MCP joint especially when the other fingers are kept in the neutral position, which is the position for measuring MCP joint extension as per the methodology of our study. Mallon et al report that extension of the MCP joints is equal for all fingers.[7] However, Skvarilová and Plevková[8] and Smahel and Klímová[9] note that the little finger has the greatest amount of MCP extension. Our results are similar to these studies with the little and index finger MCP joints showing maximum extension. The PIP and DIP extensions show a pattern in which higher extension is noted in

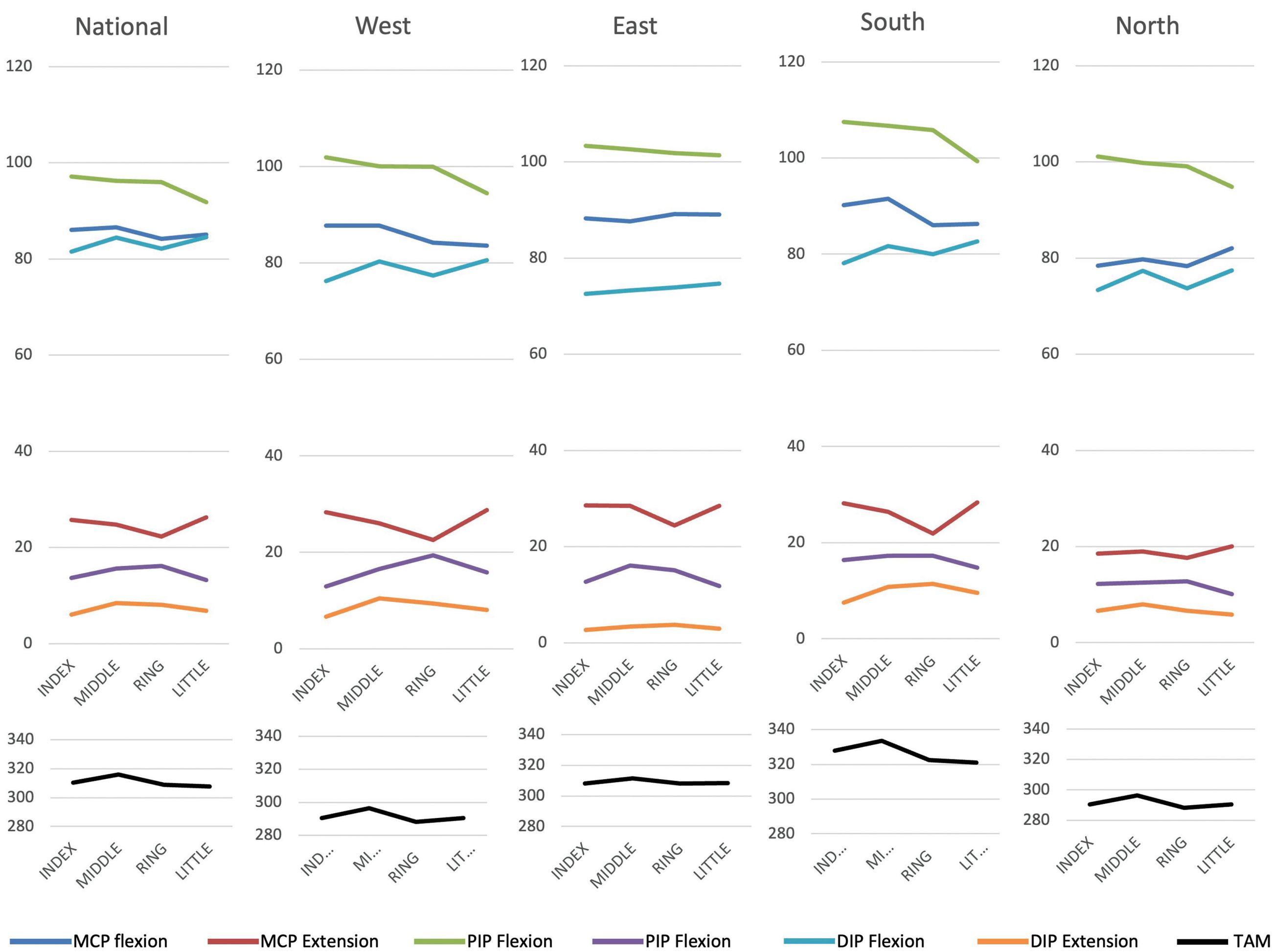

Fig. 1 Normative data of finger range of motion in the Indian population and the different geographical zones of the country ($p < 0.05$). DIP, distal interphalangeal joint; MCP, metacarpophalangeal joint; PIP, proximal interphalangeal joint.

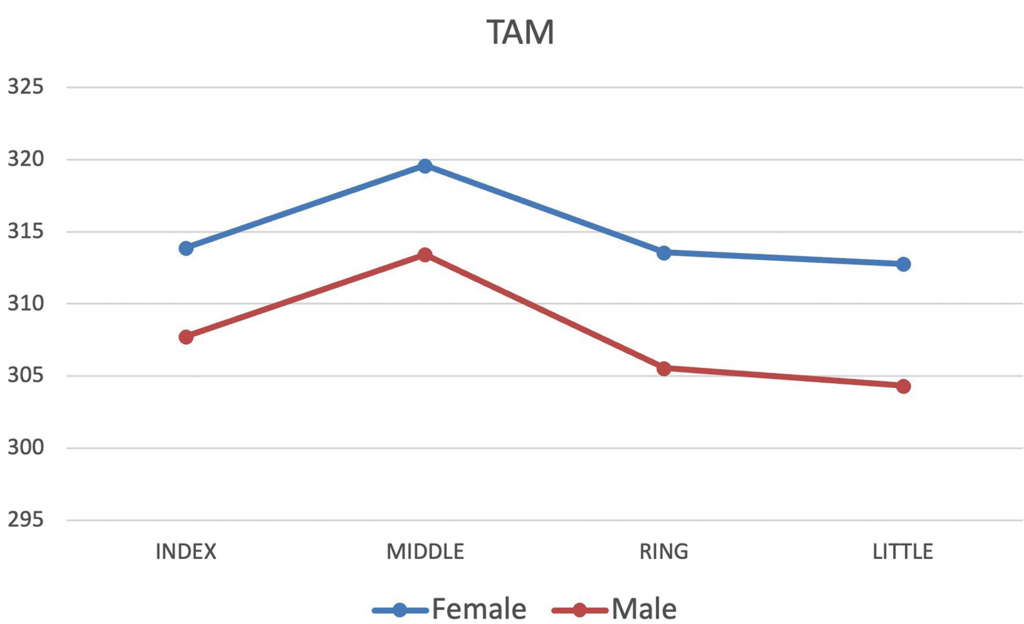

Fig. 2 Correlation of total active motion based on gender ($p < 0.05$). TAM, total active motion.

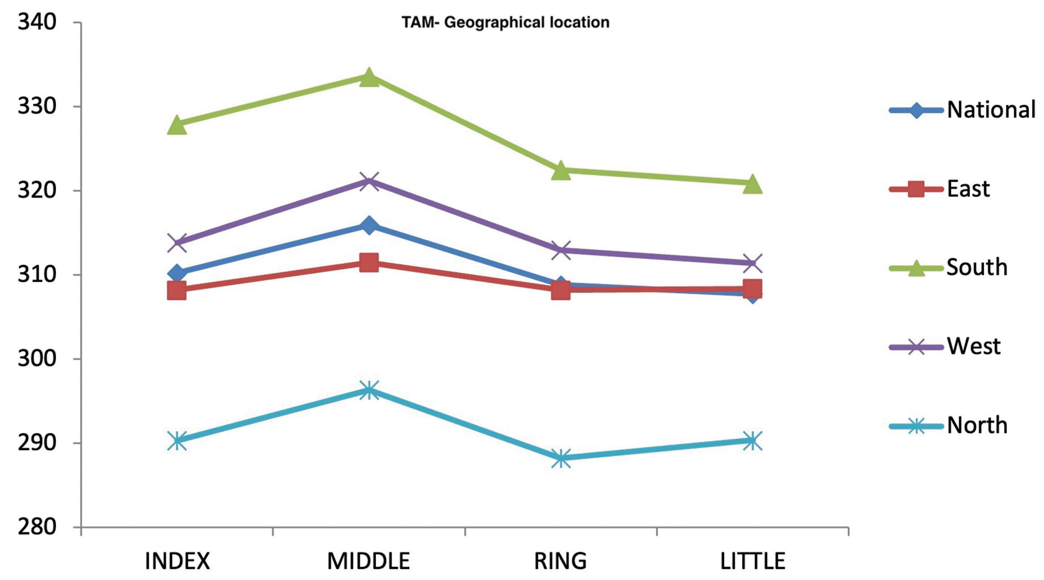

Fig. 3 Correlation of total active motion and geographical location ($p < 0.05$). TAM, total active motion.

the middle and ring fingers, which is in contrast to the pattern reported in the literature.[7]

Studies have found a significant inverse correlation between flexion ROM and age.[9,16,17] We did not observe any significant correlation between joint motion and age. Significant associations were noticed with gender. Female participants had higher TAM on all fingers, which could be attributed to higher extension in all joints and higher PIP and DIP flexion as observed in other studies.[7,9,17] Correlation between BMI and joint ROM has been noted in the upper limb joints.[18] We observed an inverse correlation between BMI and finger ROM in our study.

Studies comparing ROM in the right and left hand fingers have generally found no significant difference between sides or only a small increase in motion on the left side.[7,8] We did not observe any significant differences between the right and left sides and also between the dominant and nondominant hands.

Mother tongue is an integral part of cultural and ethnic identity; hence, mother tongue can be considered an indicator of ethnicity or ancestry.[19] Our study included volunteers speaking 10 different mother tongues from four geographical regions of the country. We have noticed significant variations in the finger ROM based on the mother tongue of the individual. This could be attributed to the difference in anthropometry between various ethnic groups. In addition, the ROM of the fingers showed significant differences between geographical areas; this could also be due to the above-mentioned ethnic and racial differences among the population in different regions of the country. We believe these differences add value to the study as a highly varied study population would yield a more robust normative data for the general population.

On analyzing the ROM on the basis of occupation of the study population, manual laborers, housewives, and businessmen reported lower TAM compared with healthy professionals, clerks, and students. One reason for this could be the difference in usage pattern among various occupations. Previous studies have demonstrated a similar association.[20,21]

Limitations

As mentioned earlier, goniometer measurement by multiple investigators is inherently prone to error, but we have tried to mitigate this inherent deficiency by designing a standardized methodology for measuring finger ROM. In addition, our study population has few female participants compared with males and the age distribution is skewed toward the younger age group. The reason is due to the random sampling technique used while recruiting participants.

Finger ROM is an essential clinical parameter in hand surgery. The application and usage of these measurements in clinical practice is vast, from evaluation after tendon reconstruction or repair to asses recovery after hand trauma and joint replacement following arthritis, and to identify ideal positions for finger joint arthrodesis, to assessment of stiffness after hand surgery to monitor progress in rehabilitation and quantify recovery after nerve surgery in the designing of modern prosthetic hands, just to name a few. The finger ROM normative data for the Indian population do not exist, but for a few studies that have reported finger flexion cascade or ROM of individual fingers.[20,21] The observed finger ROM and certain trends in TAM contrasts with the previously reported literature. Our study will help clinicians establish guidelines and outcome measures tailormade for the Indian population in hand surgery.

Conclusion

We have reported normative data of the finger ROM and TAM for the index, middle, ring, and little fingers in the Indian population and for four geographical zones of the country. Finger ROM in Indian population is highly variable. The PIP joint flexion is the highest followed, by the MCP and DIP flexion. The MCP joint has the highest extension followed by the PIP and DIP joints. The observed TAM in the Indian population is higher than what is reported earlier. Gender, BMI, geographical location, mother tongue, and occupation were factors affecting the ROM in the study population.

Note

Institutional review board clearance was obtained for the study individually at the four participating centers where the study was performed and the study protocols conformed to the Declaration of Helsinki.

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None.

Conflict of Interest

None declared.

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