

## GENDER ORIENTED VARIATIONS IN THE FINGER FLEXION CASCADE IN NORMAL INDIVIDUALS

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## ABSTRACT

**Background:** A normal Finger Flexion Cascade (FFC) is formed by the fingers of the hand when the hand is in a relaxed position. Usually, the fingers of the hand assume a flexed position; gender may influence the normative values of the resting hand due to differences in the anatomical structure of hand and frequency of usage of joints of hand in their respective occupation and habitual activities of daily living. Hence the study aims to find the difference in the FFC between men and women in power grip and nonpower grip occupational activities.

**Methods:** A cross-sectional study was conducted in a mixed population of five hundred active individuals aged between 25 and 40 years belonging to various occupations of industrial work and individuals working with software companies. Individuals who fulfilled the inclusion criteria participated in the study. After completing a questionnaire based on occupation, the subjects were grouped into power grip users and nonpower grip users. The range of motion of the joints of all the fingers, namely, metacarpophalangeal, proximal interphalangeal, and distal interphalangeal joints of both dominant hand and nondominant hand was measured using universal finger goniometer, and the composite finger flexion was recorded using a geometric ruler. The results were analyzed, and Un-paired T-test was used to compare the FFC between the power grip and the nonpower grip group.

**Results:** The FFC variations in both the hands of male and female subjects in power grip users (PGU) and nonpower grip users(NPGU) were recorded. In the dominant hand, it was found that the DIP joint of 5th digit in female subjects had a greater ROM values than male subjects, but greater ROM values in MCP joints of the hand in males were found. The comparison between the range of values of both groups revealed that the values in the PGU group were more than the NPGU group with a statistical significance of  $p < 0.001$ .

**Conclusion:** The finger flexion cascade was found to be more closed in female subjects than males in both the dominant and nondominant hands of in the power grip users than in the nonpower grip users.

**Keywords:** Finger flexion cascade, power grip, nonpower grip, goniometer, composite finger flexion.

## INTRODUCTION

The human hand is subjected to various tasks in the modern world, from activities in the industry to manipulate modernized electronic gadgets like mobile phones, electronic notebooks, and computers. Few authors even refer to the hand as one of the most important functional organs of the human body [1]. By Mosby's medical dictionary 8<sup>th</sup> edition 2009, a cascade is defined as any process that develops in stages, with each stage developing on the preceding one, often producing a cumulative effect [2]. At rest, the fingers form a flexion cascade (FFC) which is indicated by the tips pointing to the region of scaphoid at the base of the palm. The finger flexion cascade is the resting ROM of the fingers which can be altered according to the occupation that the respective job demands from the worker.

The present study is focussed on finding the FFC of hand, as significant hand joints are involved in the manipulation of objects in daily living in both male and female subjects according to the occupational demands.

The demographic profile of the hand injuries among industrial workers reveals that 50% of males were affected by hand injuries in the dominant hand in the economically viable population.

Alternatively, any industrial work is liable to cause accidental injury to the workers using their hand primarily for maneuvering of heavy machinery. This study is in agreement with the recent evidence-based research [3] in the general population with traumatic and non-traumatic injuries of the hand, which is on the rise. In a prospective study conducted in India, among 436 subjects, 67.21 % had laceration and incision wounds, 74.4% of patients had associated tendon injuries, and 25.61% had fractures of the small bones of the hand [4].

There is a significant difference between the male and female concerning the hand dimension. Conventional studies done on the length of each of the radial three fingers found a greater difference in the ratio of the relative length of index and ring finger. There is a greater difference in the hand breadth and hand length of about 1cm and 1.5cm, respectively greater in male than female subjects (Khaled E Aboul in 2011). The average hand index was more than 44% in males and less than 44% in female subjects [5].

In a study conducted to find the work-related musculo-skeletal disorders (WMSDs) among information technology professionals reveals that wrist and hand pain were reported and accounted for 14% and 13% of MSD pain respectively among the female population. Work-related musculoskeletal including studies based on functional usage of hand for daily living activities with a power of 80% and a

injuries are caused due to risk factors like mechanical overload, awkward posture for a prolonged period, like wrist deviation, flexion, hyperextension of wrist, and finger pinching, and monotonous, repetitive task which induces strain on the soft tissues like muscles, causing inflammation of tendons, compression of peripheral nerves of hand [6]. These injuries can result in medical expenses, financial loss, and also result in deformities and dysfunctions of hand [7].

Hence a need for restoring the normal finger flexion cascade is required and as a part of hand rehabilitation goals to since rehabilitation goals may vary among male and female in their role for restoring their normal functional activities, both for activities of daily living and also for accomplishing the job requirements and prevent further days of leave at work.

The current study has proved that occupation has an influence on finger flexion cascade and was found to be more closed in females than males, as the digits of the hand have to modify to numerous requirements of grasp in power grip users and nonpower grip users.

## MATERIALS AND METHODS

An observational cross-sectional study was conducted among the mixed population with subjects in different occupations handling and manufacturing heavy equipment at various industries, tire manufacturing companies, and software companies. The participants were divided into power grip users and nonpower grip users group based on their inclusion and exclusion criteria. Both male and female subjects between the age group of 25 years and 40 years and active in their occupation working for minimum of three years participated in the study. Early retired individuals, any congenital or acquired ailments of the hand, swelling of the wrist and digits, any recent or past trauma to an upper extremity, and pain at any part of the body with a Visual Analogue Scale (VAS) of 5 or above were excluded from the study. Subjects working in heavy industries are grouped in power grip users. Measurements of ROM of resting-state of all the individual four digits of both the dominant and nondominant hand were recorded using a universal goniometer, and composite finger flexion of all the four digits was measured using a ruler. Subjects working in software companies were included in this non-power grip users group. Measurement of ROM of resting stage of all the individual four digits of both dominant and non-dominant hand were recorded using universal goniometer and composite finger flexion of all the four digits were measured using ruler. The sample size was determined using prior literature review, confidence level of 0.05. The estimated sample size was 500 individuals (250 in power grip users group

and 250 in nonpower grip users group) by power analysis on statistical software R version 3.5.1

**Methodology:** This study was accepted by the Institutional Ethics Committee, Sri Ramachandra University (IEC- NI/11/OCT/25/61). Both male and female subjects between the age group of 25 years and 40 years and active in their occupation working for a minimum of three years participated in the study. This age variation was selected to include only the subjects active in their profession and to exclude any medical illness that affects the hand and finger resting positions, which is a common scenario beyond 40 years of age. Out of the 510 participants who were screened,

ten were excluded from this study due to factors like earlier injuries to the hand, severe callosities, and one participant due to a crack in the skin on the fingertips.

**Assessment Protocol:** Before the study, a questionnaire was given to all participants who were included in the study. The questionnaire assessed for their profile, hand dominance, nature of work, and a number of years in the same occupation. VAS score was recorded to determine any pain in the hands. Each subject, after fulfilling the requirements of the inclusion and exclusion criteria, was placed in any one of the groups based on the occupation. They were taught self-stretching to the flexors and extensors of the wrist and digits to avoid the effects of any recent activities performed, such as carrying a heavy bag, holding the handle of the two-wheeler, etc.

**Outcome tools:** The first outcome measure was done using a goniometer. The joint range of motion of a limb is considered as a measurable and reliable identity used as an assessment tool. Many clinicians contemplate it as a reliable and valuable measure for medical, surgical, and therapeutic interventions [8]. The ROM values obtained using goniometer is considered as the fundamental results of hand functions mainly ROM of Metacarpophalangeal joint (MCP), Proximal interphalangeal joint (PIP) and distal interphalangeal joint (DIP) of both the dominant and nondominant hand [9].

The second outcome measure is recorded using the composite finger flexion method, which assesses the finger range of motion, measured as the distance from the fingertip to a fixed point in the palm, using a ruler [10]. The subject attempts to make a fist. Composite finger flexion is an easy and simple method and provides a measure which both therapist and patients can use as an identity of improvement [11]. This measurement gives an approximation of the total digital motion in flexion and is more comprehensible to most individuals than motion measured in degrees. Centimeters or inches can be used to record the

distance with zero indicating full flexion to the distal palmar crease.

#### **Measurement of ROM of MCP, PIP, DIP Joints**

**[9]:** The participants included in the study were positioned comfortably in a chair with their hand well supported and feet flat on the floor. The range of motion of distal joints of all fingers, namely MCP, PIP and DIP joints of the dominant hand was taken initially followed by measurements for the nondominant hand. The hand to be tested was positioned with shoulder by the side of the body in adduction, forearm supinated, wrist in a functional position at 15-20° of extension and fingers in a fully relaxed position placed at the edge of the table. The therapist sat near to the subject, and the readings were recorded. The participants were instructed not to move and to remain completely relaxed throughout the procedure. Finger goniometer was used to measure the flexion range of motion of the 2<sup>nd</sup> MCP joint. The stationary arm of the goniometer was placed parallel to the 2<sup>nd</sup> metacarpal bone, the midpoint of the goniometer was placed at the MCP joint, and the movable

arm was moved from zero degrees to a position where it lies along with the proximal phalanx. The readings were recorded as ROM of the 2<sup>nd</sup> MCP joint. Next, the flexion resting range of values of the 2<sup>nd</sup> PIP joint of the same digit was measured with a stable arm parallel to the 2<sup>nd</sup> proximal phalanx, the axis of goniometer at the PIP joint and the movable arm was moved from zero such that it lies parallel to the middle phalanx. The readings were recorded as flexion ROM of the 2<sup>nd</sup> PIP joint. Subsequent flexion range of values of the DIP joint of the same digit was measured with immovable arm parallel to the 2<sup>nd</sup> middle phalanx, the axis of goniometer at the DIP joint, and the movable arm was moved from zero such that it lies parallel to the distal phalanx. The readings were recorded as flexion ROM of the 2<sup>nd</sup> DIP joint. Similarly, flexion ROM of all the distal joints of the 3<sup>rd</sup>, 4<sup>th</sup>, and 5<sup>th</sup> digit was also recorded by the therapist.

#### **Composite finger flexion to find flexion of all four digits**

**[10, 11]:** Composite finger flexion (CFF) values of all the four digits were taken for both hands using a geometric ruler. The individual was comfortably seated and the therapist sitting near the individual, placing the gonimetic ruler perpendicular to the palm at the level of the distal palmar crease so that the end of the ruler marked 0 cm corresponding to the palmar crease and the marking on the ruler corresponding to the tip of the nail bed of index finger, which was recorded as CFF value for 2<sup>nd</sup> digit. The therapist then followed the same procedure to measure the CFF values of 3<sup>rd</sup>, 4<sup>th</sup>, and 5<sup>th</sup> digits.

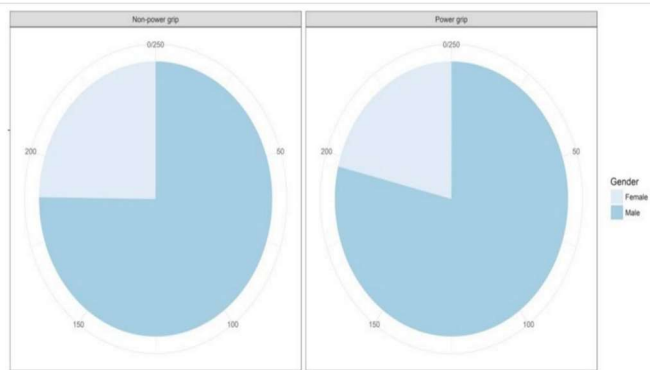
**RESULTS**

**Table 1: Gender distributions in both groups**

	Occupation involving Power Grip	%	Occupation involving Non- Power grip	%
Male	197	78.8	188	75.2
Female	53	21.2	62	24.8

Among 250 participants in power grip users, 78.8% were male, and 21.1% were female. Among 250 nonpower grip participants in Group II, 75.2% were males and 24.8% were females. A comparison between groups revealed that there were more male subjects in the power grip group and more female subjects in the nonpower grip group.

**Figure 1: Gender distribution in both groups**



**Table 2: comparison of the range of motion values of the dominant hand between the male and female among power grip users**

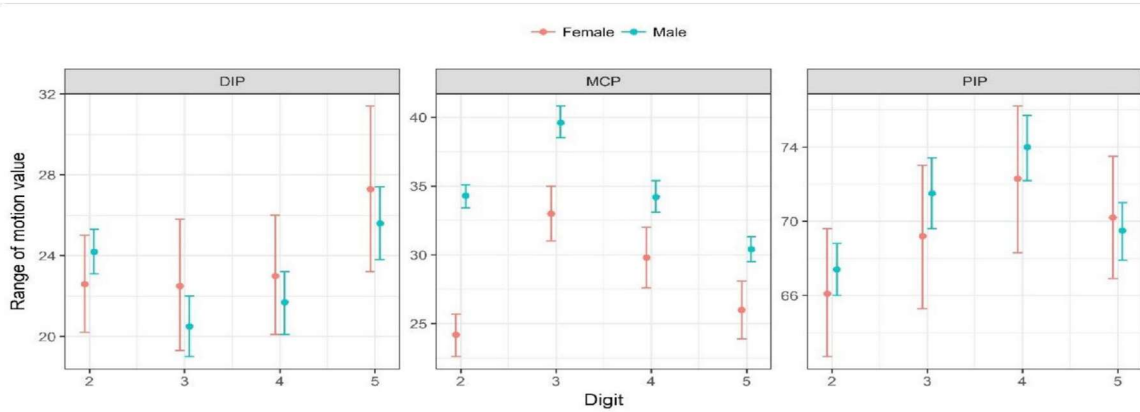
Digit	Gender	DIP			MCP			PIP		
		Mean with S.D	95% CI	p- value	Mean with S.D	95% CI	p-value	Mean with S.D	95% CI	p-value
2nd	Male	24.2± 7.92	23.1, 25.3	0.223	34.28± 6.19	33.4, 35.1	<0.001	67.36± 10.01	66, 68.8	0.510
	Female	22.58± 8.67	20, 22.5		24.17± 5.17	22.6, 25.7		66.13± 12.47	62.7, 69.6	
3rd	Male	20.52± 10.76	19,22	0.260	39.63± 8.15	38.5, 40.8	<0.001	71.52± 13.49	69.6, 73.4	0.277
	Female	22.55± 11.92	19.3,25.8		33.00± 7.26	31, 35		69.15± 14.13	65.3, 73	
4th	Male	21.67± 10.95	20.1,23.2	0.420	34.25± 8.25	33.1, 35.4	<0.001	73.98± 12.5	72.2, 75.7	0.431
	Female	23.03± 10.71	20.1, 26		29.81± 7.99	27.6, 32		72.26± 14.43	68.3, 76.2	
5th	Male	25.63± 12.87	23.8,27.4	0.462	30.43± 6.43	29.5, 31.3	<0.001	69.47± 11.25	67.9, 71	0.693
	Female	27.30± 15.04	23.2,31.4		25.98± 7.59	23.9, 28.1		70.19± 11.93	66.9, 73.5	

In the DIP joint of the dominant hand, female subjects have a greater ROM values than male subjects in the 3<sup>rd</sup>, 4<sup>th</sup>, and 5<sup>th</sup> digits.

In the MCP joint of the dominant hand, male subjects have a statistically significant ROM value (P<0.001) in all

the lateral four digits than the female subjects. In the PIP joint of the dominant hand, except the 5<sup>th</sup> digit, 2<sup>nd</sup>, 3<sup>rd</sup>, and 4<sup>th</sup> digits, males have a greater ROM values than female subjects in the dominant hand of power grip users.

**Figure 2: Comparison of the range of motion values of the dominant hand between the male and female among power grip users**



**Table 3: Comparison of the range of motion values of the nondominant hand between the male and female among power grip users**

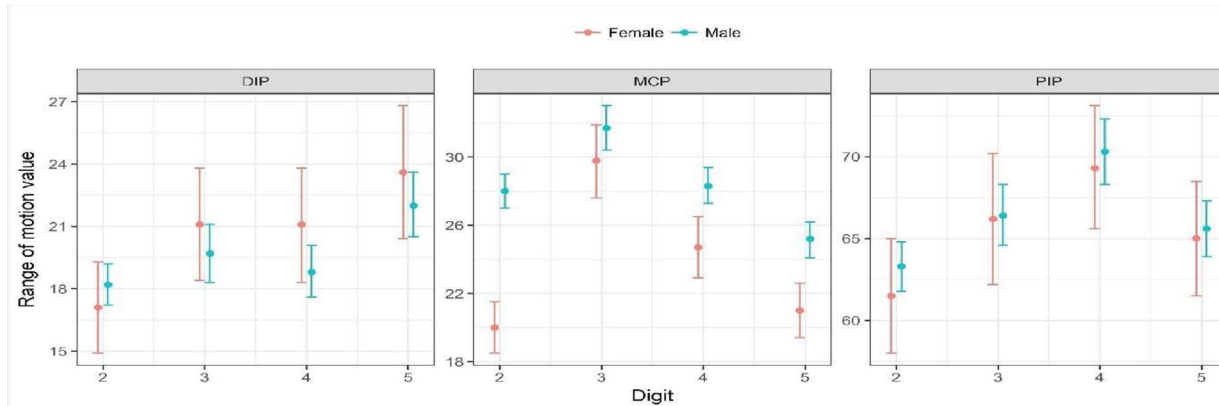
Digit	Gender	DIP			MCP			PIP		
		Mean with S.D	95% CI	P- value	Mean with S.D	95% CI	p- value	Mean with S.D	95% CI	p-value
2nd	Male	18.21±7.01	17.2, 19.2	0.349	27.99±7.4	27, 29	<0.001	63.27±10.61	61.8, 64.8	0.354
	Female	17.08±8.01	14.9, 19.3		19.96±5.43	18.5, 21.5		61.51±12.62	58, 65	
3rd	Male	19.73±9.8	18.3, 21.1	0.374	31.7±9.16	30.4, 33	0.126	66.44±14.61	64.6, 68.3	0.916
	Female	21.09±9.93	18.4, 23.8		29.75±7.84	27.6, 31.9		66.21±14.61	62.2, 70.2	
4th	Male	18.85±8.95	17.6, 20.1	0.145	28.31±7.41	27.3, 29.4	0.001	70.32±14.28	68.3, 72.3	0.639
	Female	21.06±9.89	18.3, 23.8		24.68±6.59	22.9, 26.5		69.32±13.67	65.6, 73.1	
5th	Male	22.01±11.04	20.5, 23.6	0.367	25.16±7.18	24.1, 26.2	<0.001	65.58±12.18	63.9, 67.3	0.765
	Female	23.62±11.59	20.4, 26.8		20.96±5.83	19.4, 22.6		65.00±12.67	61.5, 68.5	

In the DIP joint of the nondominant hand, female subjects have a greater ROM values than male subjects with no statistically significant difference in the 3<sup>rd</sup>, 4<sup>th</sup>, and 5<sup>th</sup> digits.

the lateral four digits than the female subjects. In the PIP joint of the nondominant hand, except in the 2<sup>nd</sup> digit, the 3<sup>rd</sup>, and 4<sup>th</sup> and 5<sup>th</sup> digits, male and female ROM values are almost equal with no significance in the nondominant hand of power grip users.

In the MCP joint of the nondominant hand, male subjects have a statistically significant ROM value ( $P < 0.001$ ) in all

**Figure 3: Comparison of the range of motion values of the nondominant hand between the male and female among power grip users**



**Table 4: Comparison of the range of motion values of the dominant hand between the male and female among nonpower grip users**

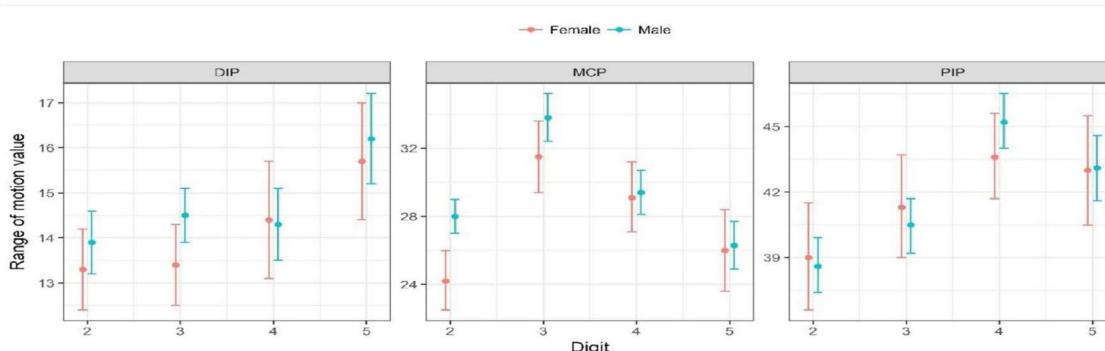
Digit	Gender	DIP			MCP			PIP		
		Mean with S.D	95% CI	p-value	Mean with S.D	95% CI	p-value	Mean with S.D	95% CI	p-value
2nd	Male	13.9±4.94	13.2, 14.6	0.307	28.02±6.85	27, 29	<0.001	38.64±8.46	37.4, 39.9	0.777
	Female	13.39±3.45	12.4, 14.2		24.24±6.75	22.5, 26		39.03±9.59	36.6, 41.5	
3rd	Male	14.46±4.24	13.9, 15.1	0.047	33.77±9.73	32.4, 35.2	0.076	40.5±8.99	39.2, 41.7	0.515
	Female	13.39±3.45	12.5, 14.3		31.5±8.28	29.4, 33.6		41.34±9.36	39, 43.7	
4th	Male	14.31±5.72	13.5, 15.1	0.919	29.41±8.85	28.1, 30.7	0.817	45.22±8.65	44, 46.5	0.176
	Female	14.39±5.08	13.1, 15.7		29.13±8.07	27.1, 31.2		43.65±7.62	41.7, 45.6	
5th	Male	16.2±6.83	15.2, 17.2	0.552	26.31±9.74	24.9, 27.7	0.841	43.1±10.49	41.6, 44.6	0.949
	Female	15.71±5.09	14.4, 17		26.03±9.52	23.6, 28.4		43.00±9.97	40.5, 45.5	

The above table shows the comparison between male and female subjects of non- power grip users in the dominant hand.

dominant hand among non –power grip users. In contrast, the MCP joint of the 2<sup>nd</sup> digit shows a significant difference, with male subjects ROM values more than female subjects, in the forefinger and middle finger, and similar values in the ring and little finger.

The is no significant difference between the male and female subjects in both the interphalangeal joints of the

**Figure 4: Comparison of the range of motion values of the dominant hand between the male and female among nonpower grip users**



**Table 5: Comparison of the range of motion values of the nondominant hand between the male and female among nonpower grip users**

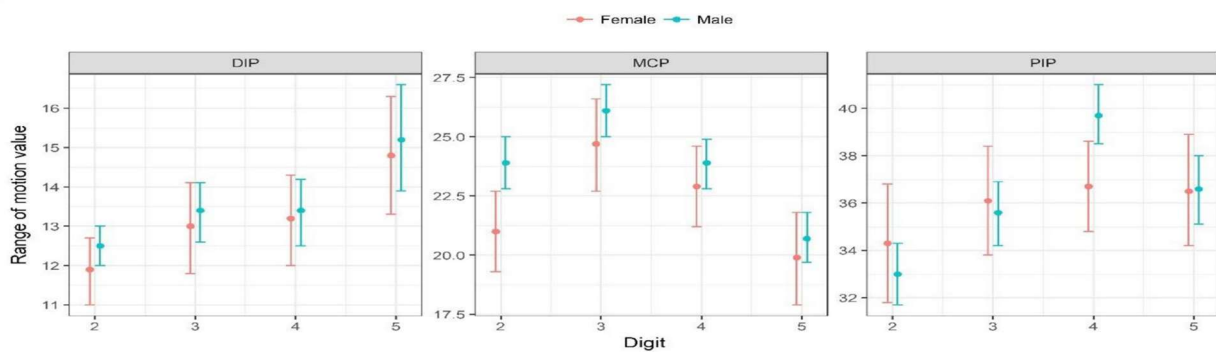
Digit	Gender	DIP			MCP			PIP		
		Mean with S.D	95% CI	p-value	Mean with S.D	95% CI	p-value	Mean with S.D	95% CI	p-value
2nd	Male	12.49±3.66	12, 13	0.208	23.91±7.66	22.8, 25	0.005	32.99±8.89	31.7, 34.3	0.357
	Female	11.87±3.26	11, 12.7		21.00±6.81	19.3, 22.7		34.29±9.83	31.8, 36.8	
3rd	Male	13.36±5.23	12.6, 14.1	0.547	26.11±7.76	25, 27.2	0.206	35.55±9.11	34.2, 36.9	0.681
	Female	12.95±4.35	11.8, 14.1		24.66±7.76	22.7, 26.6		36.1±8.97	33.8, 38.4	
4th	Male	13.36±5.70	12.5, 14.2	0.777	23.87±7.31	22.8, 24.9	0.348	39.71±8.69	38.5, 41	0.009
	Female	13.16±4.49	12, 14.3		22.92±6.76	21.2, 24.6		36.69±7.49	34.8, 38.6	
5th	Male	15.24±9.49	13.9, 16.6	0.669	20.72±7.45	19.7, 21.8	0.435	36.55±9.4	35.1, 38	0.991
	Female	14.81±5.95	13.3, 16.3		19.85±7.61	17.9, 21.8		36.56±9.97	34.2, 38.9	

The above table shows the comparison between genders in the nondominant hand among non- power grip users.

There was no significant difference between the Range of motion values of distal interphalangeal joint (DIP) joints

in the nondominant hands. In the MCP joint, only the 2<sup>nd</sup> digit has significance (p 0.005). In the PIP joint, except for the 4<sup>th</sup> digit, females exhibit more ROM values than male subjects with significance (p<0.01).

**Figure 5: Comparison of the range of motion values of the nondominant hand between the male and female among nonpower grip users**



**Table 6: Comparison of composite finger flexion of the values of both dominant and nondominant hand between the male and female power grip users**

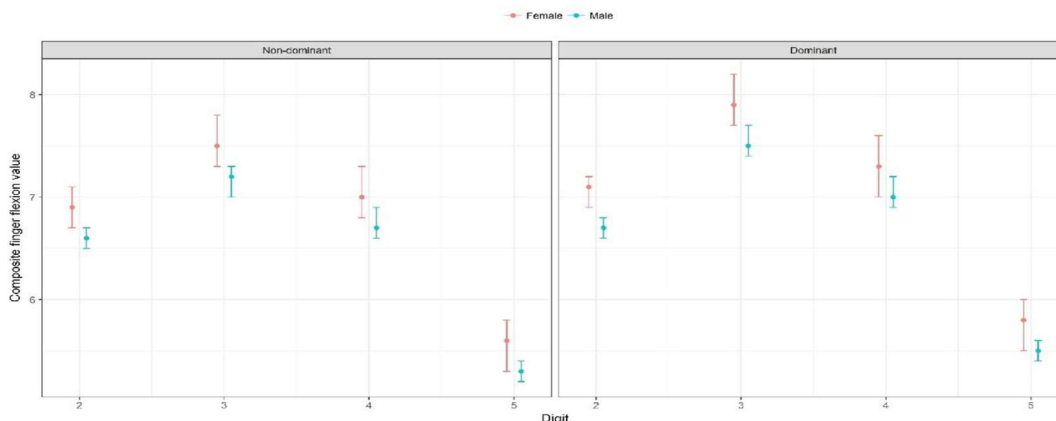
Digit	Gender	NON DOMINANT HAND IN POWER GRIP USERS			DOMINANT HAND IN POWER GRIP USERS		
		Mean with S.D	95% CI	p- value	Mean with S.D	95% CI	p-value
2nd	Male	6.56±0.7	6.5, 6.7	0.003	6.72±0.76	6.6, 6.8	0.003
	Female	6.88±0.66	6.7, 7.1		7.06±0.69	6.9, 7.2	
3rd	Male	7.18±0.98	7, 7.3	0.011	7.52±0.99	7.4, 7.7	0.008
	Female	7.54±0.88	7.3,7.8		7.92±0.92	7.7, 8.2	
4th	Male	6.74±0.96	6.6, 6.9	0.032	7.02±0.97	6.9, 7.2	0.066
	Female	7.04±0.87	6.8, 7.3		7.29±0.95	7, 7.6	
5th	Male	5.29±0.83	5.2, 5.4	0.034	5.51±0.84	5.4, 5.6	0.055
	Female	5.58±0.89	5.3, 5.8		5.79±0.95	5, 5.6	



The above table represents the comparison of CFF values between male and female subjects belonging to the power grip group in both non- dominant and dominant hand.

Female participants of group I had greater CFF values than the male participants in both the dominant and non – dominant hand.

**Figure 6: Comparison of the values of composite finger flexion of both dominant and nondominant hands between the male and female power grip users**



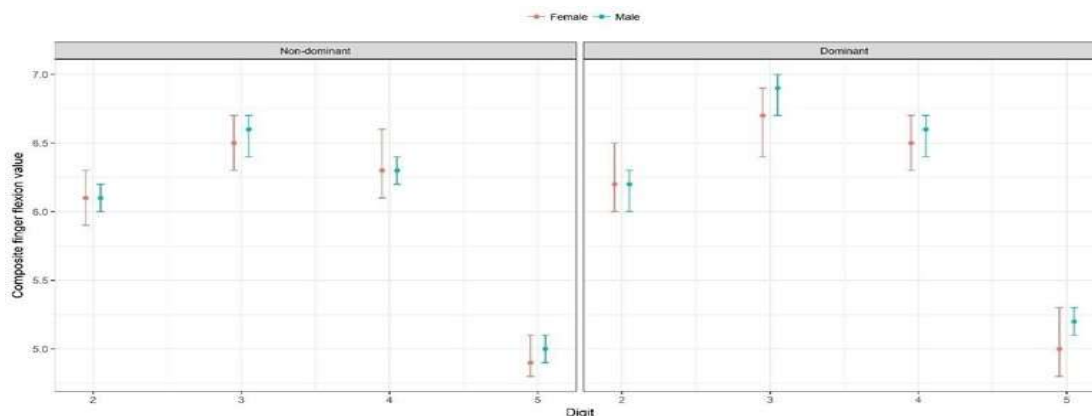
**Table 7: Comparison of the values of composite finger flexion of both dominant and nondominant hands between the male and female nonpower grip users**

Digit	Gender	NON DOMINANT HAND IN NON POWER GRIP USERS			DOMINANT HAND IN NON POWER GRIP USERS		
		Mean with S.D	95% CI	p- value	Mean with S.D	95% CI	p-value
2nd	Male	6.12±0.66	6, 6.2	0.829	6.17±0.94	6, 6.5	0.590
	Female	6.1±0.67	5.9, 6.3		6.24±0.83	6, 6.3	
3rd	Male	6.57±0.87	6.4, 6.7	0.513	6.86±0.86	6. 7, 7	0.155
	Female	6.49±0.89	6.3, 6.7		6.66±0.96	6.4, 6.9	
4th	Male	6.29±0.91	6.2, 6.4	0.826	6.57±0.9	6.4, 6.7	0.582
	Female	6.32±0.98	6.1, 6.6		6.5±0.91	6.3, 6.7	
5th	Male	4.99±0.89	4.9, 5.1	0.693	5.19±0.71	5.1, 5.3	0.184
	Female	4.95±0.7	4.8, 5.1		5.01±0.94	4.8, 5.3	

In the non- dominant hand, male subjects have a higher CFF value than female subjects in 3<sup>rd</sup> digit. Only in the 4<sup>th</sup> digit, females have a greater CFF value than male subjects of Nonpower grip group. On the dominant hand, male subjects have higher CFF values than females in the 3<sup>rd</sup> and

5<sup>th</sup> digit. Only in the 2<sup>nd</sup> digit, females exhibit a greater CFF value than male subjects. Both the gender have equal CFF values in the 2<sup>nd</sup> and 5<sup>th</sup> digit of the nondominant hand and 4<sup>th</sup> digit of the dominant hand.

**Figure 7: Comparison of the values of composite finger flexion of both dominant and nondominant hands between the male and female nonpower grip user**



## DISCUSSION

### Comparison of the range of motion values of the dominant and nondominant hand between the male and female among power grip users

Table 2 shows the comparison of the range of motion values of the dominant hand between the male and female subjects in the power grip group. In the DIP joint of the dominant hand, female subjects have a greater ROM values than male subjects in the 3<sup>rd</sup>, 4<sup>th</sup>, and 5<sup>th</sup> digits. Among female subjects, the resting ROM values of the DIP joint were found to progressively increasing from radial to ulnar side digits with the highest value on the 5<sup>th</sup> digit.

All the subjects in the study were right-handed, and more participants were aged between 35–40 years. As age increases, the manual workload also increases as professionals. Mostly the female subjects were employed in the manufacturing sector and power-driven handling tools, drilling, cutting, and boring tools like drillers, screwdrivers, which requires more repetitive and fine gripping motions. Mostly female subjects were also housewives and used their dominant hand for cutting ingredients using a knife. Repeated gripping and pinching activities demand more flexion of the DIP joint of all the lateral four digits and therefore contribute to increasing resting ROM in the DIP joints of the dominant hand than their male counterpart. The DIP joint is found to have larger functional ROM but smaller active ROM. It works in synergy with the PIP joint in performing precision movements via the intrinsic muscles, extensor hood, and the oblique retinacular ligament [12]. In an investigation done to find hand deformation among professional cooks of 5719 subjects (Miwako Nagasu in 2011), found that 36.5% of females and 11.7% males had reported on hand deformation in the 5<sup>th</sup> digit of DIP joint of the dominant hand [13]. The AROM of the DIP joint is 70°. In our study, the DIP joint of the 5<sup>th</sup> digit has the highest ROM of 27° and the least of 22° in the DIP joint of 2<sup>nd</sup> digit. The values were progressively found to increase from the radial towards the ulnar side. This explains that the DIP joint of the 5<sup>th</sup> digit contributed fine gripping in females than in males. Hence to avoid musculoskeletal disorders of the joints of the hand, improvement in the work conditions can be enhanced by modifying the tools to the resting ROM values found in this study which can help to rehabilitate even individuals (who had an injury) to their preinjury level instead of achieving full AROM of joints of hand which is time-consuming. As there were more female participants between the ages of 35–40 years, they use their nondominant hand for lifting heavy utensils, tongs, slippery and fragile household items, and other larger tools apart from handling heavy tools little finger. In the nonpower grip group, the subjects were mostly employed to incorporate the

requiring power grip due to their occupation. Hence consequently, it contributes to an increased resting ROM of distal joints among female subjects in the nondominant hand also.

In the MCP and PIP joints of the dominant and nondominant hand, male subjects have a statistically significant ROM value ( $P < 0.001$ ) in all the lateral four digits than the female subjects. The MCP joint is intended to increase the extent of the hand and has a comparatively larger active ROM, but a small functional ROM in grasping objects. In this study, the MCP joint is required for pre grasp activities and for grasping larger objects like precision tools, electric power-driven tools, pneumatic compression air tools with a diameter of more than 35 mm. As the MCP joint flexes to grasp, the collateral ligaments lock the MCP joint, preventing the abduction and adduction of fingers.

In the PIP joint of the dominant hand, except the 5<sup>th</sup> digit, 2<sup>nd</sup>, 3<sup>rd</sup>, and 4<sup>th</sup> digits, males have greater ROM values than female subjects in the dominant hand of power grip users. In our study, in the power grip group, 78.8% of subjects were male. Majority of participants were aged between 25–30 years and a corresponding increase in strength in gripping the prehensile tools for power grip, an observation that was reported earlier (Fraser T.M. 1980) [14]. While holding precision tools with wrist extension and ulnar deviation, it further contributes to flexion of MCP and PIP joints. In our study PIP joint has larger resting ROM values than MCP and DIP joint as men were engaged in grasping and lifting heavier tools requiring more power and hence flexion of fingers at MCP and PIP joints.

This increase in the MCP and PIP joints of the nondominant hand in males is due to usage of hand for various requirements at a job for power grip purposes to satisfy their job demands as in holding the object in position (nails) using the nondominant hand which requires more of MCP and PIP joints functionally [15].

### Comparison of the range of motion values of the dominant and nondominant hand between the male and female among non- power grip users

Table 4 shows the comparison between genders in the dominant hand among non- power grip users. No significant difference was observed between the male and female genders in DIP and PIP joints of the dominant hand among non-power grip users. In contrast, the MCP joint of the 2<sup>nd</sup> digit shows a significant difference, with male subjects ROM values more than female subjects, in the forefinger and middle finger, and similar values in the ring and

information technology industry; hence repetitive clicking and grasping activities were predominantly

done using the dominant hand contributed mainly by MCP joint while maintaining for an increased span of Observingly, both the interphalangeal joints were held in only mild flexion as found in our study of resting ROM values of  $16^{\circ}$  at the DIP joint of 5<sup>th</sup> digit and  $43^{\circ}$  at the PIP joint of 5<sup>th</sup> digit against the AROM of flexion of  $100^{\circ}$  of PIP joint. This shows that if ergonomically designed keyboard and mouse are used relating to the resting ROM values of the hand found in, it will be useful for the software professionals as it comparatively causes the least strain on these joints.

Table 5 shows the comparison between genders in the nondominant hand among non- power grip users.

Comparison between genders in non-dominant hand has no significant difference in the DIP joint. In the MCP joint, only 2<sup>nd</sup> digit has significance ( $p < 0.005$ ). In the PIP joint, except the 4<sup>th</sup> digit, female subjects exhibit more ROM values than male subjects with significance ( $p < 0.01$ ) as the nondominant hand is used for typing activities on the keyboard and additionally gripping activities for household work like lifting utensils, washing clothes and cleaning which requires more functional ROM on the PIP joint. The PIP joint has the greatest functional ROM and is functionally important to the finger. It has a comparatively large active ROM and large functional ROM, which is flexed. Two long flexors control the PIP joint and the extensor hood. The interosseous muscles provide controlled extension, while the lumbricals facilitate a unique interaction between the flexors and extensor hood [17].

#### **Comparison of the values of composite finger flexion of both dominant and nondominant hands between the male and female power grip users and nonpower grip users**

Table 6 represents the comparison of CFF values between male and female subjects belonging to the power grip group in both non- dominant and dominant hand. CFF values always reflect the functional mobility of the hand. Female participants of the group had greater CFF values than the male participants in both the dominant and non-dominant hand as females require to perform the additional functional task at home for household work compared to male workers.

Table 7 represents the comparison of CFF values between male and female subjects in non- power grip group. In the non- dominant hand, male subjects have a higher CFF value than female subjects in 3<sup>rd</sup> digit. Only in the 4<sup>th</sup> digit, females have measurements such as hand dimensions influence on recommended for further studies in the future.

#### **CONCLUSION**

hand for grasping objects like double button mouse [16].

a greater CFF value than male subjects of nonpower grip group. On the dominant hand, male subjects have a higher CFF value than females in the 3<sup>rd</sup> and 5<sup>th</sup> digit. Only in the 2<sup>nd</sup> digit, females exhibit a greater CFF value than male subjects. Both the genders have equal CFF values in the 2<sup>nd</sup> and 5<sup>th</sup> digit of the nondominant hand and 4<sup>th</sup> digit of the dominant hand.

#### **Clinical implications**

The study was done to find the normative finger flexion cascade (FFC) of the dominant and non-dominant hands in both power grip and nonpower grip users with gender perspective. The range of motion values is beneficial to find the impairments of joints of the hand and to establish effective rehabilitation protocols. All the resting range of values reveals that the values were increasing from radial to ulnar side of fingers in both dominant and nondominant hand. The values of the DIP joint were found to be more in females than in males in the power grip user group. It is associated with age factors, smaller arm dimensions (T.M. Faser, 1980) type of work done in the work station and at home. The flexibility of the joints, muscle mass, and hand dimensions can be a factor contributing to the difference which further needs to be elucidated. The values of the dominant hand are found to be more than the non-dominant hand. The values of MCP and PIP joints are found to be more in males than in females as the nature of the job demands in both power grip and non- power grip users. As Finger flexion cascade is comparatively less than the AROM values and the functional ROM values, they are effective in formulating the ergonomically designed tools and other types of equipment, which puts the least strain on the joints of hand with least muscle force generated for movement. The finger flexion cascade can be of value for rehabilitation after sustaining hand injuries, which can vary according to the occupation of the individuals. The difference in the FFC between male and females are suggestive that occupation, activities of daily living and anatomical variations contribute to individual differences in resting ROM values and hence contribute to the prevention of joint injuries and improvement in one's activities of life.

#### **Limitations of the study**

A smaller number of female participants were included in the study. The hobbies of the subjects were not taken into account. Hand anthropometric finger flexion cascade can be

The present study concludes that there is an actual difference in the finger flexion cascade between the male and female subjects in both dominant and

nondominant hand with the occupation of power grips than individuals with the occupation of nonpower grips. The study suggests that hand rehabilitation can be aimed to achieve the predetermined normative values of finger flexion cascade values required by the occupational demand placed on the hand.

**Conflict of interest:** The authors do not have any conflict of interest to declare.

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