

An Analytical Study on the Finger Flexion Cascade in General Population of Various Occupations

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Abstract

Background and Purpose: Finger flexion cascade (FFC) is a natural phenomenon that is observed in the hand at complete rest. It is the posture/alignment of fingers with some flexion at all the joints of digits, beginning with less flexion at the index finger, progressing to more flexion towards the little finger. The FFC may vary in individuals of different occupations as occupational activities performed over a prolonged period may have an influence on the finger flexion ROM thereby influencing the normal FFC. Understanding the variations may serve as a valuable tool to manage rehabilitation following hand injuries, which may include improving the finger flexion joint ROM suited to the need of the individual. The purpose of this study was to observe, measure and document the FFC in individuals belonging to different occupations and to analyze whether a significant variation may be seen within the occupations and between the occupations.

Methods: One hundred twenty five healthy individuals with an age ranging between 20 to 60 years who met the inclusion criteria participated in the study. Occupations included were electricians, maintenance workers and desk workers. The participants completed a performa related to their occupation prior to the study. Goniometry was used to measure the MCP, PIP and DIP flexion ROM of the dominant and non dominant hand. Composite finger flexion a gross method of measuring finger ROM was also measured using a geometric ruler. The values obtained were recorded and analyzed.

Results: To find variations within an occupation paired t test was used. ANOVA was used to analyze of variations between the 3 groups. The results between the groups were found to be statistically significant at p value < 0.05

Conclusion: The finger flexion cascade was found to vary in individuals belonging to different occupations therefore occupation has an influence on the normal FFC which suggests that following hand injuries rehabilitation program can be aimed at achieving hand function depending upon the demand the occupation places over the hand.

Keywords: Cascade; Range of motion measurement; Goniometer; Hand injuries; Occupation.

Introduction

Human hand is a highly specialized instrument which serves us well in multitude of ways. It is a primary effector organ for our complex motor behaviors. Hand is intimately correlated with the brain. Our hands contribute to mental processes of thought and feelings. The functions of the hand are unique, which cannot be substituted by any other part of the human body. We use our fingers without an observation as to how they function. If you keenly observe you will be able to appreciate that the fingers of our hand at rest form an attitude which is often referred to as the flexion cascade. According to the Moby's medical dictionary 8th edition 2009, Cascade is defined as any process that develops in stages, with each stage developing on the preceding one, often producing a cumulative effect. It may also be defined as the series

of physiological processes that occur in successive stages and each of the process is dependent on the preceding one to produce a cumulating effect (Houghton Miffliz 2002).

The Finger flexion cascade (FFC) at rest is the posture/alignment of fingers with some flexion at all the joints of the digits, beginning with less flexion at the index finger and progressing to more flexion towards the little finger (Text Book Of Rosen's emergency medicine – Concepts & Clinical Practice – Marx Hock Berger Walls -7th Edition). Ideally, the 'Cascade sign' indicates natural flexion of the fingers in which the tips point to the scaphoid bone at the base of palm [1,2]. The tone and flexibility of the soft tissues in a resting hand is responsible for the cascade sign in normal subjects. When this normal phenomenon is disrupted due to any injury to the flexor tendons or digits it may

lead to an altered finger flexion cascade which may impair the function of the hand as a whole. Among the flexor tendons injures the most commonly involved tendons are flexor digitorum superficialis (FDS) and flexor digitorum profundus (FDP) leading to an abnormal FFC [3].

Earlier studies have highlighted the importance of observing the flexion cascade following hand injuries as it gives us an idea about the involvement of flexor tendons [3,1]. Though, FFC is observed and assessed for all hand injury patients there is a lack of literature on reference normative values to identify abnormal flexion cascade. Various studies have been done to measure the flexion and extension angles of resting fingers and wrist in relation to forearm and shoulder posture in normal subjects [4]. But there are no studies that have assessed the FFC.

Occupational hand injuries are commonly seen worldwide from industrial workers to carpenters, plumbers and various other occupations. A study done to find the prevalence of these injuries stated that hand and finger injuries accounted for 30% of all occupational injuries which were more common in males with maximum involvement of hand and finger tendons [5]. The FFC may vary with different occupations in which the hand may be used with various degrees of finger flexion, occupational activities performed over a prolonged period of time may lead to a change in the resting hand position based on the type of hand grip used, since some occupations require more of precision handling while some involve prehension activities and few others may involve using both. And therefore occupation may have a significant influence in the formation of normal FFC. The FFC at rest has been assessed across various parameters for patients who suffer flexor tendon injuries/ hand injuries, in terms of patient's history, mechanism of injury, position of hand and digits at the time of injury, any deformities and skeletal trauma [6].

The Range of Motion (ROM) is used as an assessment tool and an outcome measure to evaluate the joint motion and the impact of medical, surgical and therapeutic interventions on it by clinicians [7]. There are many different methods employed to measure hand and finger ROM which include goniometry, composite finger flexion to distal palmar crease, visual estimation, torque ROM. Goniometry has been found to have a higher intra-rater reliability and can be thereby used to measure finger ROM, while composite finger flexion has been found to have a higher intra- rater reliability [8,9].

Following a hand injury involving the flexor tendons, surgery and rehabilitation protocols may be designed based on the occupation of the individual, and henceforth the decision regarding termination of supervised rehabilitation and return to regular activities may be based on the patient achieving the required finger flexion cascade specific to their occupation, for which the need of the hour is to establish baseline normative values of the cascade sign in various occupations. Hence this study was done with intent to observe and documents the finger flexion cascade values in the different occupations which could prove useful in clinical decision making in rehabilitation following hand injuries.

Materials and Methods

Methodology

This Observational cross sectional study was conducted in three different departments of Sri Ramachandra University which included the electrical, maintenance, and medical record departments. Subjects, both males and females who met the inclusion criteria were explained in detail about the nature and the purpose of the study. An informed consent in the regional language (Tamil) was obtained from all those subjects who were willing to participate in the study. Subjects of both the genders and different occupations were included in the study. Any subjects with injury to upper limbs or congenital malformation and deformities of hand were excluded.

The present study was conducted on 125 subjects, among which 106 were males and 24 were females with an age ranging between 20-60 years. Prior to the study all the subjects completed a Performa that included questions about the hand dominance, duration of working hours, nature of work, lifting weights, history of hand injury, mode of transport and demographic data

Subject recruitment: Ethical committee clearance was obtained from the ethics committee for student's proposal, Sri Ramachandra University (REF: csp\14\oct\37\198).

Instrumentation

- a. Baseline finger goniometer
- b. Ruler

Procedure

The subjects were made to sit comfortably on a chair with the dominant hand well supported on a table of comfortable height and the feet flat on the floor. The upper extremity to be tested was positioned with the shoulder by the side, elbow flexed to midrange, forearm supinated, and wrist in functional position (15°-20° extension) and hand in a complete resting position placed at the edge of the table. The therapist sat adjacent to the patient in order to take the readings. The patient was clearly instructed not to move his upper extremity or the fingers during the course of assessment and to stay completely relaxed. First a baseline finger goniometer was used to measure the resting flexion ROM of the MCP joint of index finger. The goniometer was placed on the dorsal aspect of the hand to be tested, such that the stable arm lied parallel to the metacarpal of second digit and the midpoint of the goniometer corresponded to the joint axis of the second MCP joint, the movable arm of the goniometer from a position of zero degrees was then moved till it lied parallel to the proximal phalanx of the index finger, this reading was then noted down as MCP 2nd digit. The flexion ROM of the PIP joint of the same digit was then measured by placing the goniometer such that the stable arm lied parallel to the proximal phalanx of the second digit with the midpoint of goniometer corresponding to the PIP joint axis, the movable arm from zero degrees was then moved till it lied parallel to the middle phalanx of the same digit and this reading on the goniometer was noted down as PIP 2nd digit. The flexion resting ROM of the DIP joint of the same digit was then measured with the goniometer placed such that the

stable arm lied parallel to the middle phalanx with the midpoint of goniometer corresponding to the DIP joint axis, the movable arm was then moved from zero degrees till it lied parallel to the distal phalanx and this reading on the goniometer was noted as DIP 2nd digit [10]. Similarly the resting flexion ROM of the middle, ring and little finger was measured and labelled 3rd, 4th, 5th (MCP, PIP and DIP) respectively. The whole procedure was carried out three times for the same hand during which a short interval of five minutes was given between each trial. The flexion ROM of all the digits was then measured for the other hand.

Composite finger flexion to distal palmar crease was also measured for each hand using a geometric ruler. The position of the subject and the therapist remained the same as for goniometry. To measure the CFF a geometric ruler was placed perpendicular to the palm at the level of the distal palmar crease such that the end of the ruler marked 0cm corresponded to the palmar crease and the marking on the ruler that corresponded to the tip of the index finger was noted down as 2nd digit. The therapist then measured the 3rd, 4th and 5th digits in a similar way. Three trials were done for each of the measurement with an

Table 1: Demographic data.

Variables	Electrical Department		Maintenance Department		MedicalRecord Department	
Age(years) - Mean (SD)	35.3(11.25)		42.3(11.22)		32.2(8.7)	
Gender	Male	58	Male	33	Male	12
	Female	0	Female	0	Female	22
Hand dominance	Right	58	Right	33	Right	34
	Left	0	Left	0	Left	0

Table 2: Group analysis within the Electrical department.

Joint(ROM measurement)		Electrical Department				p value
		Right hand		Left hand		
		Mean (SD)	At 95% CI	Mean (SD)	At 95% CI	
MCP	2 nd digit	32.3(7.1)	30.5-34.2	30.9(7.7)	28.9-33	0.096
	3 rd digit	36.7(7.6)	34.7-38.7	31.8(8.1)	29.7-34	0.000
	4 th digit	32.4(8.4)	30.2-34.6	27.5(7.5)	25.6-29.6	0.000
	5 th digit	28.7(10.4)	25.9-31.6	24.9(9.5)	22.4-27.5	0.002
PIP	2 nd digit	34.3(7.8)	32.2-36.4	35.0(9.9)	32.4-37.7	0.536
	3 rd digit	38.3(7.7)	36.3-40.4	38.6(10.2)	35.9-41.3	0.813
	4 th digit	43.2(8.7)	40.9-45.5	42.2(9.5)	39.8-44.8	0.443
	5 th digit	41.9(9.9)	39.3-44.5	40.5(10.3)	37.9-43.2	0.369
DIP	2 nd digit	11.7(2.8)	10.9-12.5	13.5(3.9)	12.6-14.6	0.001
	3 rd digit	13.8(3.8)	12.8-14.9	14.8(5.2)	13.5-16.3	0.049
	4 th digit	14.1(4.1)	13.0-15.2	14.6(5.3)	13.3-16.1	0.307
	5 th digit	15.6(4.8)	14.3-16.9	16.2(6.3)	14.5-17.9	0.331
CFF Measurement	2 nd digit	6.8(0.5)	6.7-7.0	6.9(0.5)	6.8-7.1	0.059
	3 rd digit	7.5(0.7)	7.4-7.8	7.9(0.7)	7.7-8.1	0.000
	4 th digit	7.0(0.7)	6.8-7.2	7.3(0.8)	7.1-7.5	0.001
	5 th digit	5.5(0.7)	5.3-5.7	5.7(0.7)	5.5-5.9	0.005

Table 3: Group analysis within the Maintenance department.

Maintenance Department						
Joint (ROM)		Right hand		Left hand		p value
		Mean (SD)	At 95% CI	Mean (SD)	At 95% CI	
MCP	2 nd digit	25.6(8.0)	22.7-28.5	23.2(9.1)	20.0-6.5	0.078
	3 rd digit	27.6(9.2)	24.4-30.9	25.0(10.3)	21.3-28.7	0.012
	4 th digit	27.1(10.6)	23.4-30.9	24.6(11.5)	20.6-28.8	0.008
	5 th digit	28.3(11.0)	24.5-32.3	23.6(12.0)	19.4-28.0	0.000
PIP	2 nd digit	36.5(8.7)	33.4-39.6	40.3(11.7)	36.3-44.6	0.037
	3 rd digit	43.9(11.1)	40.0-47.9	42.8(10.2)	39.2-46.4	0.506
	4 th digit	44.0(10)	40.5-47.6	43.9(11.4)	39.9-48.0	0.953
	5 th digit	42.1(13.0)	37.5-46.7	40.3(10.1)	36.8-44.0	0.497
DIP	2 nd digit	12.3(3.1)	11.3-13.5	12.1(2.1)	11.4-12.9	0.645
	3 rd digit	12.8(2.7)	11.9-13.8	13.4(2.1)	12.7-14.2	0.012
	4 th digit	12.5(2.1)	11.8-13.3	12.8(2.3)	12.1-13.7	0.559
	5 th digit	12.9(3.8)	11.6-14.4	13.4(2.7)	12.5-14.5	0.502
CFF Measurement	2 nd digit	6.5(0.6)	6.3-6.7	6.8(0.6)	6.6-7.0	0.009
	3 rd digit	7.1(0.9)	6.8-7.5	7.4(0.7)	7.2-7.7	0.006
	4 th digit	6.7(1.1)	6.4-7.2	7.1(0.8)	6.9-7.5	0.002
	5 th digit	5.4(1.0)	5.1-5.9	5.8(0.7)	5.6-6.1	0.048

interval of five minutes between each trial.

Parametric tests were used to analyze the data obtained with R version 3.0.2. Within group analysis for goniometric measurements of all the four digits and CFF measurement was done using a paired t-test. Between groups analysis for goniometric measurements of all four digits and CFF measurement was done using ANOVA. To find out the corresponding joint correlation across the fingers, correlation coefficient was used. Level of significance (p value) for all the tests was fixed at p < 0.

Results

Table 1 show the demographic data and hand dominance of the subjects. It shows that all the participants of the study were right dominant. It also shows mean and standard deviation for age which is significant at p value <0.05. A statistical significance was found in MCP, PIP, DIP flexion ROM between the groups.

In electrical department the resting flexion ROM of all the 4 digits in the dominant (right) and non-dominant (left) hand was found to be greatest in PIP joints followed by MCP and then DIP

joints. MCP joint ROM was found to be greater in the dominant hand compared to the non dominant hand. In contrast the PIP and DIP joint ROM in the non dominant hand was found to be greater than the dominant hand. The ROM of PIP joint within the digits was not statistically significant. While a comparison of CFF was found to be statistically significant (Table 2).

In maintenance department the resting flexion ROM of all the 4 digits in the dominant (right) and non-dominant (left) hand was found to be greatest in PIP joints followed by MCP and then DIP joints. MCP joint ROM was found to be greater in the dominant hand compared to the non dominant hand while no significant difference was found in the PIP and DIP flexion ROM between both hands while a comparison of CFF was found to be statistically significant (Table 3).

In medical record department the resting flexion ROM of all the 4 digits in the dominant (right) and non-dominant (left) hand was found to be greatest in PIP joints followed by MCP and then DIP joints. MCP and PIP joint ROM was found to be greater in the dominant hand compared to the non dominant hand. While

Table 4: Group analysis within the Medical record department.

Medical Record Department						
Joint(ROM measurement)		Right hand		Left hand		p value
		Mean(SD)	AT 95% CI	Mean (SD)	At 95% CI	
MCP	2 nd digit	28.7(8.0)	25.9-31.5	25.8(8)	23.1-28.7	0.001
	3 rd digit	34.7(9.1)	31.6-37.9	29.5(9.4)	26.2-32.8	0.000
	4 th digit	31.6(7.7)	29.0-34.4	26.9(6.8)	24.5-29.3	0.000
	5 th digit	27.4(4.9)	25.7-29.1	25.0(6.8)	22.7-27.5	0.013
PIP	2 nd digit	43.1(10.2)	39.5-46.7	41.3(10.6)	37.6-45.1	0.127
	3 rd digit	47.4(10.0)	43.9-51.0	46.5(9.5)	43.2-49.9	0.405
	4 th digit	52.3(10.2)	48.8-55.9	47.8(9.3)	44.6-51.1	0.000
	5 th digit	48.5(11.2)	44.6-52.4	44.3(9.3)	41.0-47.6	0.004
DIP	2 nd digit	12.6(3.8)	11.3-14.0	13.1(4.3)	11.6-14.7	0.417
	3 rd digit	14.6(4.2)	13.2-16.2	14.4(5.9)	12.4-16.5	0.751
	4 th digit	14.0(4.9)	12.4-15.8	13.6(5.5)	11.7-15.6	0.400
	5 th digit	15.0(5.3)	13.2-16.9	15.2(6.5)	13.0-17.5	0.695
CFF Measurement	2 nd digit	6.1(0.6)	5.9-6.3	6.3(0.8)	6.1-6.6	0.012
	3 rd digit	6.5(0.7)	6.3-6.8	6.8(0.8)	6.6-7.2	0.001
	4 th digit	6.3(0.8)	6.0-6.6	6.5(0.7)	6.3-6.8	0.008
	5 th digit	4.9(0.7)	4.6-5.2	5.1(0.7)	4.9-5.4	0.021

no significant difference was found in DIP joint ROM. The CFF measurements were found to be statistically significant (Table 4).

Group analysis between the department shows that the resting ROM of MCP joint was found to be greatest in subjects of electrical department followed by MRD and then MD both in dominant and non dominant hand. The PIP joint ROM between the groups and both in dominant and non dominant hand was found to be greatest in MRD compared to MD with ED being the least. The DIP joint ROM of both dominant and non dominant hand was found to be greatest in MRD followed by ED and then MD. The resting ROM between the three groups showed significant p values. The CFF was found to be statistically significant between the groups for the dominant and the non dominant hand (Table 5a & 5b).

Table 6 shows that a significant correlation was found in MCP flexion ROM across 2nd, 3rd and 4th digits between the dominant and non dominant hand, except the MCP flexion ROM of 5th digit.

Table 7 shows that a significant correlation was found in PIP flexion ROM across 2nd, 3rd, 4th and 5th digit between the dominant and non dominant hand.

Table 8 shows that a significant correlation was found in DIP flexion ROM across 2nd, 3rd, 4th and 5th digit between the dominant

and non dominant hand.

A significant correlation was observed for CFF across 2nd, 3rd, 4th and 5th digit between the dominant and non dominant hand (Table 9). A correlation was found across all the four digits, in which 2nd digit correlated with the 3rd, 3rd with 4th and 4th with 5th digits. There was no correlation between the 2nd and 5th digits or 3rd and 5th digits (Figures 1 & 2).

Discussion

This study presents to analyze the influence of different occupations on the finger flexion cascade, as the fingers of the hand need to adapt to various degrees of movement suited to the requirements of different occupations. The fingers of the hand need to precisely and intricately move to carry out a variety of tasks which sets the human hand apart from any other mammal.

Injuries of the hand may prove to be very debilitating as it leads to a loss of these precise and intricate movements which is very essential to carry out day to day activities and most importantly when most people are dependent on it to earn a living. And therefore determining the need to which degree the fingers are required to move and work to the demands of an individual's occupation can serve as a valuable tool to manage rehabilitation following hand injuries, which may include improving the finger

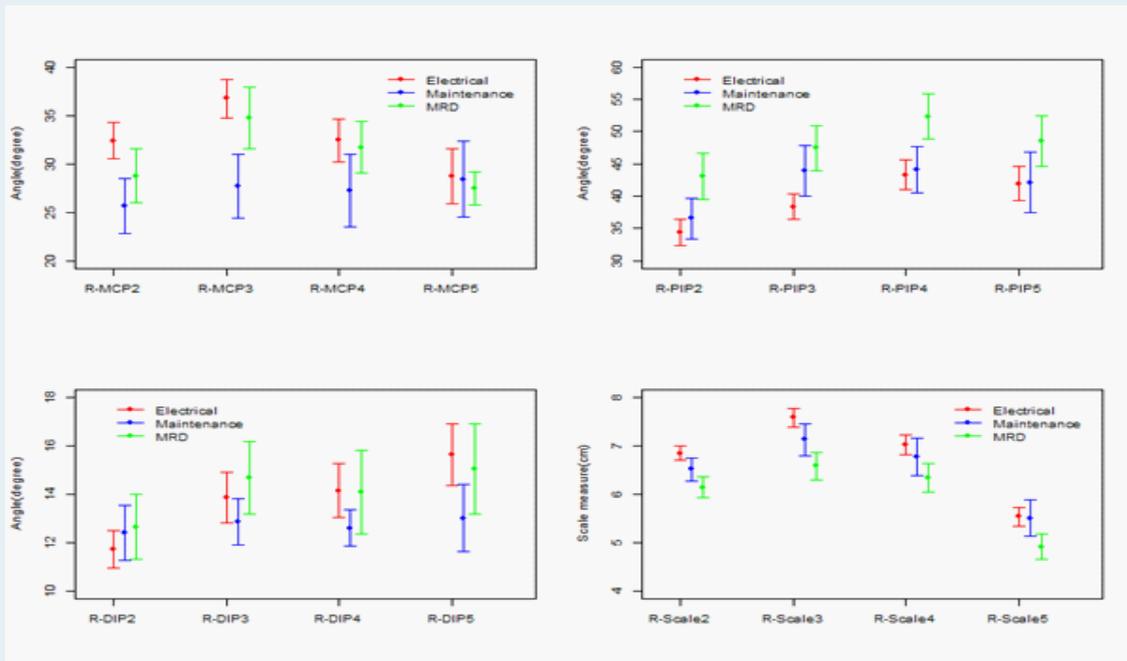


Figure 1: Forest Plot- Comparing the resting ROM of the MCP, PIP and DIP joints of the 2nd, 3rd, 4th and 5th digits among three different departments (Goniometer & CFF measurements on right side).

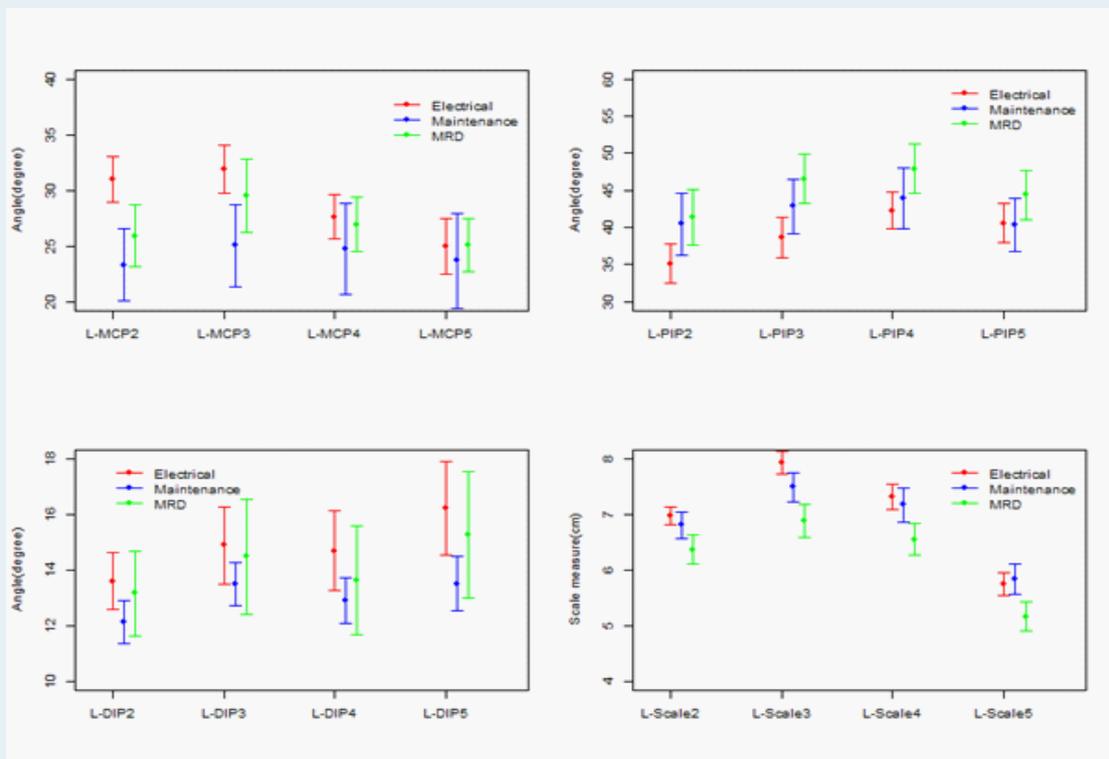


Figure 2: Forest Plot- Comparing the resting ROM of the MCP, PIP and DIP joints of the 2nd, 3rd, 4th and 5th digits among three different departments (Goniometer & CFF measurements on left side).

Table 5a: Group analysis between the departments (Right).

Joints	Right			p value
	Electrical	Maintenance	MRD	
ROM	Electrical	Maintenance	MRD	p value
MCP*	32.5(6.8)	27.2(9.0)	30.6(6.7)	0.005
PIP*	39.4(6.9)	41.6(8.6)	47.8(9.7)	0.000
DIP	13.8(3.4)	12.7(2.4)	14.1(4.2)	0.011
CFE	6.7(0.6)	6.4(0.9)	5.9(0.6)	0.000

Table 5b: Group analysis between the departments (Left).

Joints	Left			p value
	Electrical	Maintenance	MRD	
ROM	Electrical	Maintenance	MRD	p value
MCP*	28.8(6.8)	24.1(10.3)	26.8(7.2)	0.000
PIP*	39.1(8.9)	41.8(9.6)	45.0(8.9)	0.010
DIP	14.8(4.6)	13(1.7)	14.1(5.1)	0.456
CFE*	6.9(0.68)	6.8(0.6)	6.8(0.6)	0.000

*Significant at p<0.05

Table 6: Correlation coefficient between resting ROM of MCP joints across fingers in right and left hands.

Correlation Coefficients across fingers							
Right	R-MCP3	R-MCP4	R-MCP5	Left	L-MCP3	L-MCP4	L-MCP5
R-MCP2	0.74*	0.55*	0.10	L-MCP2	0.82*	0.57*	0.24
R-MCP3	-	0.76*	0.36	L-MCP3	-	0.75*	0.43
R-MCP4	-	-	0.70*	L-MCP4	-	-	0.72*

Table 7: Correlation coefficient between resting ROM of PIP joints across fingers in right and left hands.

Correlation Coefficients across fingers							
Right	R-PIP3	R-PIP4	R-PIP5	Left	L-PIP3	L-PIP4	L-PIP5
R-PIP2	0.65*	0.41	0.45	L-PIP2	0.85*	0.74*	0.60*
R-PIP3		0.63*	0.56*	L-PIP3		0.84*	0.62*
R-PIP4			0.52*	L-PIP4			0.78*

* - above 0.05 are considered to be highly correlated.

flexion joint ROM suited to the need of the individual and early return to work rather than an intensive rehabilitation program that may take a long time to achieve nearly full functions of the hand pre injury. This study may prove useful for framing goals after hand rehabilitation and to monitor prognosis based on the occupation.

Based on this study a significant difference was observed in the finger flexion cascade among three different occupations, the differences noticed in the resting ROM of different joints in the hand can be attributed to the anatomical variations in the alignment of hand from one individual to another, the tension of the soft tissues in the hand, and the day to day activities. The ECRL transfer for finger flexor restoration is more simple alternative method and is done to achieve normal cascade of the fingers [11]. The two flexor tendons responsible for flexing the finger are Flexor digitorum Superficialis (FDS) and Flexor digitorum Profundus (FDP). FDS acts at PIP joint and FDP at DIP joint. These

tendons function in coordinated fashion and independently [12]. The only relation to flexor tendons and the flexor sheath is through the vinculae. Vinculae are located on phalanx, dorsal surface of and in between two tendons [13]. Mallon et al. [14] conducted a study to find out the gender differences in the measuring the finger joint ROM. The results showed that no significant effect of gender on amount of flexion in any joints of the fingers [14].

A study conducted on seven specialized testers to assess the reliability of three different goniometers measuring the MCP, PIP, DIP joints of hand, placing the goniometer on lateral and dorsal to the joint showed that there is no significant difference between the three different types of goniometer [15].

The results of the study show that for all the participants of the study shows that the resting flexion ROM of both the dominant and non dominant hand was found to be greatest in the PIP joint followed by MCP joint with the least in DIP joint. This observation can be attributed to the natural resting position of the hand in general wherein the MCP joint remains in the functional position while the PIP and DIP show more flexion due to passive insufficiency. What is worth noting is the differences that were found between the flexion ROM of the joints based on hand dominance and how it varied with different occupations. It was coincidental that all the participants of the study were observed to have right hand dominance. A study conducted on the variation of ROM in Bengali healthy adult subjects to find out the influence of age and gender on ROM and gradation of ROM among healthy adults using digital goniometer for measuring ROM in most of the body joint angles. The results showed that there was no difference in ROM between right and left sides of body, in both genders and among different age groups [16].

For within group analysis of each department on comparison between the dominant and non dominant hand it was seen that in ED the subjects were found to have greatest MCP flexion ROM on the dominant side, as their occupation requires using instruments like screw drivers, spanners and wiring activities which involves strong prehension grip activities. Because of greater prehension grip activities, the ROM of PIP joints is higher than other joints in both right and left hands. Within the group there is less significant between values of all the three joints. Even though there is a less significance in the analysis within the group, between the groups it shows considerable significance.

In subjects who belonged to the MD, again the MCP flexion ROM was found to be greater on the dominant hand while PIP flexion ROM was found to be greater when compared to the ED as the nature of this occupation involves handling larger sized objects like hammers and drilling machines in which biomechanically the PIP joints tend to go for a greater flexion range and force generation from the flexor tendons.

Subjects from the MRD exhibited a greater flexion ROM of PIP and DIP when compared to ED and MD as their job most significantly involves typing and other activities include writing and arranging files during which biomechanically the PIP and DIP joints go in for repeated flexion movements while the MCP and wrist remains almost in the same position. The resting flexion ROM of 4th and 5th digits is greater compared to 2nd and 3rd digits

Table 8: correlation coefficient between resting ROM of DIP joints across fingers in right and left hands.

Correlation Coefficients across fingers							
Right	R-DIP3	R-DIP4	R-DIP5	Left	L-DIP3	L-DIP4	L-DIP5
R-DIP2	0.67*	0.56*	0.52	L-DIP2	0.63*	0.59*	0.53*
R-DIP3	-	0.78*	0.69*	L-DIP3	-	0.83*	0.77*
R-DIP4	-	-	0.83*	L-DIP4	-	-	0.89*

Table 9: Correlation coefficient between composite finger flexion measurement across fingers in right and left hands.

Correlation Coefficients across fingers							
Right				Left			
	3 rd digit	4 th digit	5 th digit		3 rd digit	4 th digit	5 th digit
2 nd digit	0.70*	0.59*	0.59*	2 nd digit	0.77*	0.67*	0.57*
3 rd digit	-	0.90*	0.78*	3 rd digit	-	0.92*	0.78*
4 th digit	-	-	0.82*	4 th digit	-	-	0.85*

*- above 0.05 are considered to be highly correlated.

because clinically the 2nd and 3rd digits are less mobile compared to 4th and 5th digit.

In the analysis of medical records department, the resting ROM of PIP joint is greater followed by MCP and then DIP joints. On comparison of the resting ROM of MCP and PIP joints in right is greater than left hand. This could be possibly because the right is the dominant hand and is used more frequently for functional activities.

In between group analysis the resting ROM of MCP joint is higher in ED followed by MRD and then MD both in right and left hand, because of their different activities involved in their occupations. In PIP joint the resting ROM is greater in MRD followed by MD and then ED. The difference in resting ROM of PIP joint of right and left hand in between the three groups shows that the electrical and maintenance departments were very similar but in MRD the difference is little higher (almost 2 degrees). The resting ROM in DIP joint in the right hand shows higher value in MRD group followed by electrical and then maintenance department and in the left hand it shows similar value in both electrical department and medical record department followed by maintenance department. This shows that there is a major difference in finger flexion cascade among the three occupations.

The Composite finger flexion when analyzed was found to be greatest in ED followed by MD and least in the MRD with proved to have a statistical significance which suggests that CFF can also be used as an alternative tool for the measurement of FFC.

All the subjects involved in the study worked for 8 hours per day. Extraneous variables were also considered while including the subjects in this study. All of them stayed within 5 kilometers of the hospital and few were hostel inmates and staff quarters residents. So the question of the hand being influenced by the hand grip commonly used during travel was ruled out. In this study, the statistical analysis shows that the finger flexion cascade is near similar within the same occupation and that there

is a difference in the finger flexion cascade between the different occupations. Though the normative values are not suggested, this calls for the attention of the concerned specialists to draw their attention towards the finger flexion cascade and its relation to the various occupations.

Limitations

The limitations of this study shows that there are less female subjects and hence the gender differences was not been addressed. This study has not considered the Diurnal variations.

Conclusion

The occupation of an individual has been found to have an influence on the finger flexion cascade of the hand which suggests that the FFC will differ from one individual to another. An occupation based analysis proved to be helpful as it emphasizes on the different activities that can alter this phenomenon. It is also observed that there is a similarity in the FFC in the subjects within the individuals. Thereby there is a need to analyze the FFC based on occupation so as to categorize patients following hand injuries for rehabilitation suited best to the functional needs of their hand. Those groups of people working in electrical jobs and maintenance showed a more closed pattern when compared to those working with the medical records. This is valuable information in the rehabilitation perspective. While rehabilitating the injured hand, excessive stretching of the digits beyond the required ranges can also compromise on the grip strengths of the individuals thereby affecting the performance at occupation.

This study was done with a smaller sample size and suggested that a significant variation exists and henceforth it provides future scope for studies with a larger sample size including many different occupations with diurnal considerations. There has been no study till date that was done to analyze the FFC although it has a clinical significance in the diagnosis of flexor tendon injuries. The current study adds to the literature by focusing on the significance of FFC measurement following hand injuries for diagnosis as well as prognosis of these patients and their rehabilitation.

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