

# HUMAN PERCEPTION OF HAND PAIN FOR ACTIVITIES COMMON IN DAILY LIFE

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## ABSTRACT

The hand is one of the essential parts of the body for carrying out Activities of Daily Living (ADLs). Individuals use their hands and fingers in everyday activities either in the workplace or at home. Hand-intensive tasks require diverse and sometimes extreme levels of exertion, depending on the action, movement or manipulation involved. Good design product especially using hand and finger should consider factors such as simplicity ease to learn, efficiency and pleasure of use and should be suitable for general application for all user categories including those with disabilities. Hence, improved understanding of hand pain is important for the study of ADLs and particular attention should be drawn to the type, cause, frequency and degree of pain.

Our primary objective was to determine the level and frequency of pain in the hands and fingers during common ADLs and the associated hand actions. The actions investigated were gripping, pinching, twisting, manipulating of digits and lifting. A survey totaling 626 participants was collected using an online survey, with respondents ranging between 22 to 58 years old. 616 subjects fully completed the survey with a response rate of 98.9% with 209 (34%) male and 407 (66%) female. The result shows that gripping produced the highest frequency of pain, but twisting produced the highest degree of pain, followed by pinching. Gripping and lifting actions showed the same degree of average pain rating. Serious pain feeling is ache recording higher percentage (28% - 35%), while tender, sharp, cramp, tingling are within the same range for every action. These results and proposes further work is to improve the design, environment and method to manipulate object.

**Keywords:** *ADLs (Activities Daily Living), Pain Feeling, Pain Rating and Gripping*

## 1. INTRODUCTION

Pain is one of the human body's natural defence mechanisms, causing a reflex action to stop a harmful activity and encouraging a modification in behaviour to prevent it from being repeated in the future [1]. Therefore, people instinctively tend to behave in ways that avoid or minimise painful sensations during activities of daily living. They will tend to adopt postures that are the most comfortable for them. Hand-intensive tasks require diverse and extreme levels of exertion depending on the action, movement or manipulation that is being undertaken. Hand and finger force capabilities should be considered when products are designed in an effort to minimize discomfort and injuries of the upper extremities when carrying out associated tasks for their use. The upper extremities consists of, the shoulder, upper arm, elbow, forearm, wrist and hand. For instance, movements and exertions such as reaching, gripping and pinching, combined with repetition in a forceful and/or awkward manner is a known contributing factor to the precipitation and aggravation of CTS (Cumulative Tunnel Syndrome)[2].

It is extremely difficult to quantify pain, since it is not possible to measure it directly and the personal experience of the individual must be relied on instead. In addition, the experience of pain varies between individuals (possibly due to genetic reasons and the fact that people may react very differently to the same stimulus). Although it is difficult to measure pain, it can be classified into different types. The most common of which are acute and chronic. Acute pain is of the most relevance to the current study, since it is that which is experienced due to an injury or some malfunction of the body. Chronic pain is more likely to be caused by a developing disease or even be psychosomatic. It is therefore unlikely to cause an individual to cease an activity, although it may prevent them from attempting it in the first place.

Previous studies on hand comfort has generally focused on the use of hand tools, for example, screw drivers, pneumatic drills, grinding tools and chipping hammers, etc. [2 - 4], evaluate hand tool muscle activity (EMG) [5,6], grip force level and distribution [1, 7-9] and hand-wrist postures [2-8], but less work has been carried out on Activities of Daily Living (ADLs), such as sweeping, carrying objects, wiping, painting and decorating. Hence, the factors for determining comfort and discomfort during ADLs are still to be fully understood. Therefore, a more comprehensive approach to measuring human comfort whilst undertaking ADLs is needed. The physical, cognitive and emotional feeling of the user should be considered to create an optimal human-product interaction. The primary objective of this study is to examine the frequency, level and degree of hand and finger pain experienced by adults when carrying out actions related to common daily activities based on survey study. The actions considered in this study are gripping, pinching, twisting, manipulating of digits and lifting.

## 2. METHOD

Initially, to add to the knowledge on pain and comfort levels from previous studies on hand tools [2],[7] a preliminary study was undertaken, whereby all possible factors of pain or discomfort were collected by interviews with University of Sheffield staff (lecturers, students, technicians and cleaners). The aim of this study was to establish which activities

and actions are connected to hand pain, pain rating level, type of hand pain and location of hand pain. Initially, 15 volunteers (8 female and 7 male; aged 23 - 38) participated in an interview, discussing their hand and finger pain/discomfort experiences during common daily activities (ADLs). The results from the unstructured interviews were then used to develop of a more detailed online survey questionnaire, capable of producing objective, scaled data that could be collated from a large number of participants. Specific issues covered by the online survey included:

- What ADLs do people generally undertake and which ones lead to give discomfort in the hand?
- What hand actions are used during ADLs that cause pain?
- At what frequency does pain occur while doing these activities and actions?
- Where is the location of the hand pain and what is its type e.g. muscle, joint or a combination?
- How often are the ADLs carried out (daily/ weekly/ monthly/ infrequently or never)?
- How often does the pain occur (every time / most time or a few times)?
- When specifically does the pain occur (during or after ADLs)?
- How severe is the pain that is felt?

The survey was separated into two parts. The first part examined activities that people undertake everyday, for example: using the computer, manual lifting using both hands (e.g. carrying a box), manual lifting using a handle (e.g. shopping bag), sweeping activities (e.g. hoovering, mopping etc.), wiping activities (e.g. polishing, dusting etc.), painting and decorating, DIY using hand tools (e.g. hammering, screwing etc.), DIY using power tools (e.g. drilling, sanding etc.), kitchen activities (e.g. chopping, can opening etc.) and finally pushing, (e.g. a shopping trolley, pushchair or lawnmower). This also included hobbies and interests for example, gym / fitness machines (e.g. weights, cardio work-out), mountain biking / cycling, "Racket-type" sports (e.g. tennis, hockey, cricket), skiing, martial arts (using hand-held weapons), sailing, gardening (e.g. digging, weeding) and knitting and sewing. The second part concerned peoples' experiences of pain and discomfort on the hand and finger when carrying out the activities.

For the online survey, a total of 633 responses were collected from participants ranging between 22 to 58 years old. 616 participants fully completed the survey, made up of 209 (34%) males and 407 (66%) females, giving a response rate of 98.9%. The total number of respondents experiencing a hand pain problem was found to be approximately 68% (206) female and 32% (186) male. Data from the survey was used to categories the activities into more specific actions or combination of actions including gripping, twisting, pinching, lifting and manipulation of digits.

### 3. HYPOTHESIS

Hence, from the data the authors were able to produce a set of formulae to determine the pain responses for the actions outlined in the survey. From the data, the total number of instances for each specified action, along with the number of times pain was experienced during that action can be extracted. It is possible to use the survey data to calculate pain for every action and to define which action is linked to the highest frequency of pain whilst undertaking ADLs. The formula uses data from the survey questions, "during what action did you feel pain?", "how often did the action cause pain to the hand?" and "how often does the pain occur?". It is then possible to calculate the action frequency and pain frequency as follows:

$$\text{Total Instances of Pain for a particular Action (TPA)} = \text{Action Frequency (AF)} \times \text{Number of times Pain Occured (np)} \times \text{Fraction of instances that produced pain (up)} \quad (1)$$

$$\text{Action Frequency Per Person (AFP}_p) = \frac{\sum (AF)}{\text{Total Number of Responses (TRn)}} \quad (2)$$

$$\text{Pain Frequency Per Person (PFPP)} = \frac{\sum (TPA)}{\text{Total Number of Responses (TRn)}} \quad (3)$$

Hence, a measurement of how strongly a particular action is linked to pain can be given by,

$$\text{Pain Likelihood} = \frac{\text{number of times action is carried out (N)} \times \text{number of responses (R)} \times \text{number times of pain occurred (np)}}{\quad} \quad (4)$$

Another measurement to assess the severity of pain when experienced is given by,

$$\text{Average pain rating (APR)} = \frac{[(\text{Number of responses on each action (R)} \times \text{Pain rating scale (S)})]}{(\text{Number of painf ul responses (P)})} \quad (5)$$

Using these formulae the activities and actions can be examined further to evaluate which give the highest levels and frequency of pain.

### 4. RESULT AND DISCUSSION

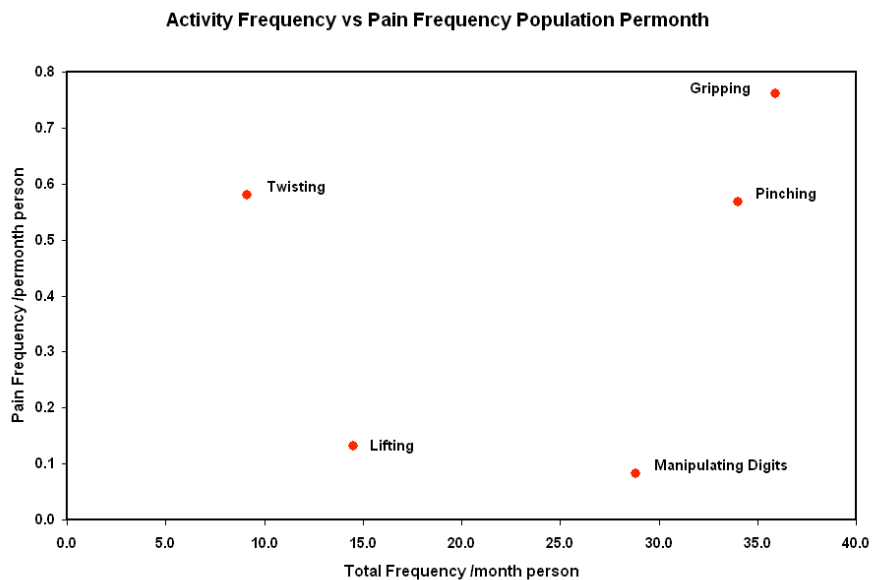
Table 1 shows the arrangement of all activities per specific action according to the answers given through the online survey. From those values, the total frequency of action per month can be calculated (total number of instances/month). The survey revealed that beside five basic actions i.e. gripping, twisting, lifting, pinching and manipulation of digit, there are four more combinations of actions which are typically used during ADLs. These combined actions are gripping/twisting, gripping/lifting, pinching/twisting, and griping/twisting/lifting. The types of action that produce the highest number of instances of pain per action per month can be obtained. An example of the necessary calculations is given in Appendix 1. Table 1 also

shows the frequency of common daily tasks for each action. Results from the survey showed that 'pure gripping' was the most commonly occurring ADLs (19974.2 per month) followed by pure manipulating (17800.5 per month), pure gripping (10338.1 per month) and pure lifting (492 per month). The most common combination action was found be gripping and twisting, as shown in Table 1. From the result 'monthly frequency per action' in Table 1 we can extract the value of total pain per month, frequency of action person per month and frequency of pain person per month. Figure 1 illustrates the relationship between the actions which are most commonly occurring and those which lead to pain. It summarizes the total common daily activities for each action such as gripping, manipulating digits, twisting, lifting and pinching and instance of occurred per month.

**Table 1:** Actions and activities reported in on-line survey

ACTION	ACTIVITY	Instances per month	Total instances per month
Pure pinching	Drumming	102	19974.2
	Playing guitar/'cello	72	
	Painting and decorating	398	
	Lab work/craftwork/machine work	94	
	Knitting and sewing	273.5	
	Gardening e.g. digging, weeding	475.5	
	Kitchen activity	1254.2	
	Writing	17305	
Pure gripping	Sweeping activities e.g. hovering, mopping etc.	3112.5	10338.1
	Pushing a 'trolley' e.g. shopping trolley, pushchair	216.9	
	Wiping activities e.g. polishing, dusting etc.	4863	
	Horse riding	28	
	Painting and decorating	398	
	Skiing	67.5	
	Kitchen activity	1254.2	
	Painting and decorating	398	
	Mountain biking / Cycling	446	
	DIY using hand tools e.g. hammer, screwdriver etc.	644	
Pure manipulating	Playing piano + accordion	150	17800.5
	Playing guitar/'cello	72	
	Using a computer keyboard + mouse	17305	
	Knitting and sewing	273.5	
Pure lifting	Painting and decorating	398	492
	Lab work/craftwork/machine work	94	
Grip + Lift	Manual lifting of objects (e.g. boxes) using 2 hands	4149	7752

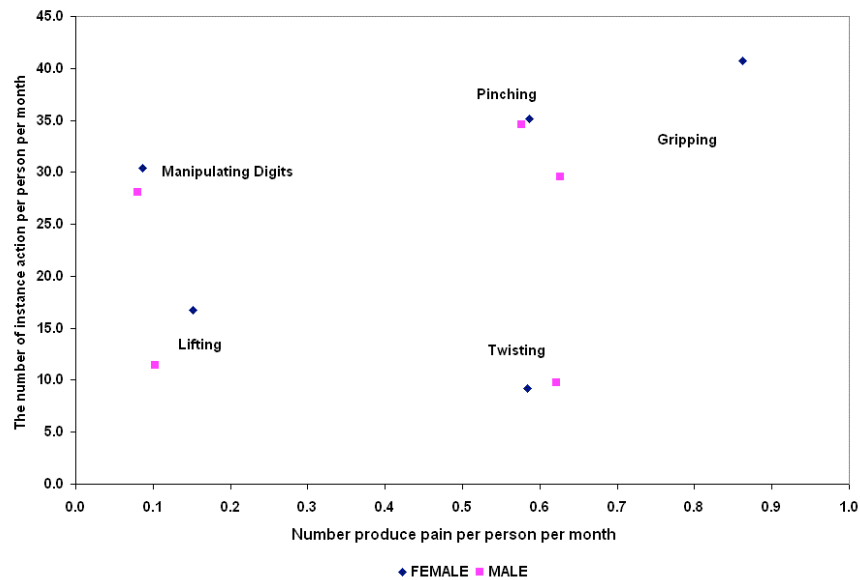
	Manual lifting using a handle e.g. shopping bag	7132	
	Fishing	6	
	Ironing	72	
	Rock climbing	70	
	DIY using power tools e.g. drill, sander etc.	472	
Grip + Twist	Martial arts (using objects) e.g. taekwando	89.5	3254.2
	Lab work/craftwork/machine work	94	
	Extracting teeth/oral surgery	240	
	Gardening e.g. digging, weeding	475.5	
	Kitchen activity	1254.2	
	"Racket" sports e.g. tennis, hockey, cricket	400	
	Sailing	57	
	DIY using hand tools eg. hammer, screwdriver etc.	644	
Grip + Mani	Mountain biking / Cycling	446	446
Pinch + Twist	Extracting teeth/oral surgery	240	1551.2
	Kitchen activity	1254.2	
	Sailing	57	
Grip+ Twist +Lift	Gym-weight, cardio	956.5	956.5



**Figure 1:** Number of instances that actions are carried out on average, per person per month plotted against the number that produces

Based on 616 responses, gripping is the action that produced the most pain on the hands. The calculation of the total number of instances of pain occurring per month is calculated using equation 2 and an example of the calculation is given on Appendix 1.

Gripping is also the most detrimental action in terms of producing pain in the hand and finger. On average each person carries out 36.3 gripping actions per month and 2.4 of these gripping actions lead to pain being experienced. If this data is separated by gender, as shown in Figure 2, it reveals that most actions show similar results. However, gripping is a more significant action amongst females, leading to 0.86 pain instances per person per month compared to 0.63 for males.



**Figure 2:** Number of instances that actions are carried out on average, per person per month plotted against the number that produces pain, separated by gender.

Using results from the calculation data on pain instances per month per person, we found that gripping was the most detrimental action in terms of producing pain in the hand and finger. It was found that women have the highest number of instances of gripping action per person per month (40.7) and 0.86 of these lead to pain, in comparison to males having 29 instances of gripping with 0.63 leading to pain. The gap difference between male and female gripping action may be due to reasons as below:-

- Females undertake domestic activities more frequently compared to males. These include activities in the kitchen, sweeping and wiping activities which cause discomfort and pain to the hand and finger. These activities give females more pain compared to males.
- Previous studies into hand grip strength showed males to be stronger than females when doing the hand grip test. Female used higher force to grip compared to males while undertaking gripping actions. Therefore females felt pain at the hand and finger.
- Product design can effect gripping force and hand grip style. People use different styles of grip while undertaking the gripping action. It is depended on hand size and ability to do this action. Some people use one hand to grip the object, however, many older people, especially females, use both hands. This is because their hand ability has

decreased. Due to these reasons, older females feel pain while carrying out gripping actions.

The second biggest difference between males and females occurs during lifting actions. For females carrying out lifting actions, the number of instances per person per month is 16.75 and number producing pain per person per month is 0.15. While male lifting action, number of instances per person per month is 11.41 and number producing pain per person per month is 0.10. However, the gap is not as big as that for gripping actions. This pattern is similar to that for gripping actions, as females carry out this activity more often and experience pain frequently than males. This is due to female doing more ADLs than males such as lifting and carrying objects for instance shopping basket, bags.

The severity of the pain felt is shown in Table 2. The selection of pain rating on this survey is referred to as Numeric Pain Rating Scale (NPRS) [10] and Visual Analogue Scale (VAS)[11]. Rating 0 means 0% pain, rating 1 means 20% pain and rating level 2 means a little pain - 40%, level 3 – 60% pain, level 4 – 80% pain and level 5 – 100%. Table 2 shows the summary of total instances of the five different levels and action during common daily living. The twisting action has the highest average pain rating of 2.71. The calculation of the average pain rating and number standard division of instances of pain occurring per month is calculated using equation 5 and an example of the calculation is given on Appendix 1.

**Table 2:** The rating level of hand pain for each action

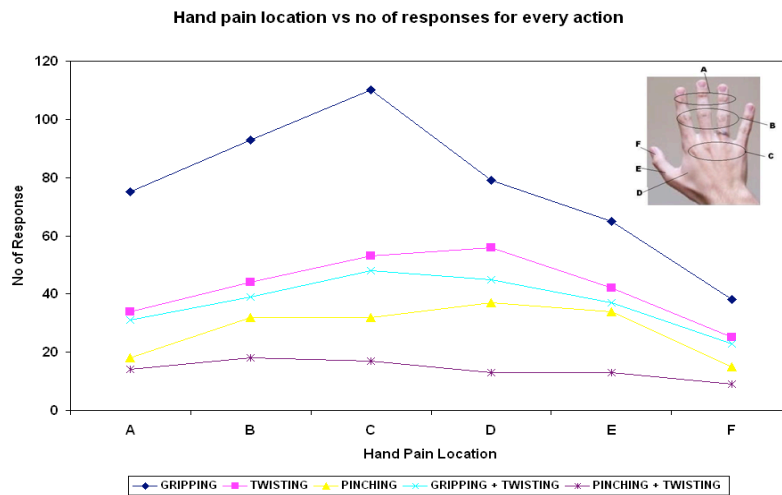
ACTION	0	1	2	3	4	5	Avg. Pain Rating	SD	Total no painful
Gripping	0	34	88	64	45	5	2.6	0.976	257
Twisting	0	17	40	44	29	3	2.71	1.021	133
Pinching	0	10	9	21	9	2	2.69	1.104	51
Lifting	0	11	31	26	15	2	2.6	1.002	85
Manipulating Digits	0	24	65	54	12	3	2.4	0.903	158

Table 2 shows the result of average pain rating against pain frequency person per month for each action. It was found that the gripping action gave the highest total number of painful occurrences in which 257 people from the total of 392 people experienced hand pain. The average pain rating for twisting recorded the highest value of 2.71, followed by pinching, gripping and lifting and manipulating digits. Base on the average pain rating and pain frequency results, it showed that the gripping and twisting actions cause the most serious pain for hand and finger during ADLs.

Figure 3 shows the location of hand pain while performing different actions. Hand Pain in Location C is the most severe during a gripping action. 110 responses claimed that they feel hand pain during their daily activities. Location B gave 93 responses, and locations A & D gave 75 responses. This means that a large percentage of hand pain during a gripping action



is experienced at locations C, B and A. As a conclusion, we have to agree that location C (flexor tendon sheath) is the most common location for hand pain while carrying out gripping and gripping/twisting actions. However location D (carp metacarpal) was the most frequent location for hand pain during twisting, pinching, twisting/pinching action. However, this study is unable to determine whether this was on the Flexor Tendon Sheath for tendons or proximal phalanges for bone and metacarpophalangeal (MCP) for the joint.



**Figure 3:** Graph location hand pain for every action reference the hand model

The evaluation of ADLs which include those who have difficulty in performing activities is mostly related to painful experiences. There are many common hand problems that can interface with activities of daily living such as arthritis, carpal tunnel syndrome, hand joint, ganglion cysts and tendon. Previous studies include much research undertaken on the hand problem for people doing the ADLs such as repetitive motion with the hand and finger, like typing on a computer keyboard, using a computer mouse, using a hand tool, using a knife etc.

The effect of the gripping and lifting actions create problems for the hand. Carpal Tunnel Syndrome is one type of hand pain caused by gripping and lifting actions. The list of experienced hand pain recorded by online surveys are referred to by previous studies [12, 13] McGill Short Form Pain Questionnaire. The findings from the survey section that link to pain experience were used to categories the types of pain. Table 3 shows the results from the questionnaire.

**Table 3:** The pain feeling for each action

Pain Feeling	Gripping	Twisting	Pinching	Gripping + Twisting	Pinching + Twisting
SHARP	34	21	11	5	7
THROBBING	34	14	9	3	5
ACHE (Arm)	122	52	27	16	16
CRAMP	35	9	6	5	4
STIFNESS	36	2	10	4	8
STABBING	16	9	5	2	3
TENDER	39	18	10	6	4
TINGLING	38	20	11	3	7
BURNING	3	1	2	4	3
Total Pain	357	146	91	48	57
% Pain (Per Action)	51%	21%	13%	7%	8%

The results on the experience of hand pain indicate that gripping actions show the higher percentage, 51% with 357 responses. Twisting comes second at 21% with 146 responses, followed by pinching 13% with 91 responses. Gripping and twisting at 7% with 48 responses and pinching and twisting at 8% with 57 responses. Aching records the highest number of painful experiences. Many respondents feel aches while performing their common daily activities. However, the pain types; sharp, throbbing, cramping, stiffness, and tenderness have values very close to each other. Gripping is the most painful activity compared to twisting and pinching actions. This means that people struggle more when carrying out gripping actions. It was also discussed in the previous studies that gripping caused pain and injury especially when using equipment such as manual hand tools and power hand tools.

## 5. CONCLUSION

The results of the study contribute to the discussion of the Activity Daily Living relationship between pain rating and pain feeling. We argued that in ADLs especially related to gripping actions give discomfort and pain at the hand and fingers, either during or after ADL. By grouping subjects with respect to pain feeling and pain rating, we found that the pain level and feeling varies between genders although they are undertaking a similar task. This is due to several factors such as lower hand strength and smaller hand size. This finding offers an explanation as to why women report more pronounced higher pain rating and higher number pain feeling than men. The study proved that females have a higher number of hand problems compared to males. Hence, the appropriate use to constructive approach, which is keen to improve the design, environment and method to manipulate object. Further work is underway to look the distribution of hand grip force and hand manipulative movement during gripping actions to determine and examine the location of the highest grip force and relate this to discomfort or pain at the hand and finger. The eventual aim would be

to aid in the more ergonomic design of these types of appliances, reducing instances of pain and discomfort and hence the likelihood of the onset of any more serious illness.

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## APPENDIX 1

### Example Equation

Gripping for example, the first action is to sum all the pure gripping activities.

$$\text{Total Action Frequency (TAF}_{\text{(GRIP)}}) = \text{pure grip} + (\text{grip \& lift}) + (\text{grip \& twist}) + (\text{grip \& manipulating}) + (\text{grip \& twist \& lift}) \quad (6)$$

Hence from Table 1,

$$\begin{aligned} \text{TAF}_{\text{(GRIP)}} &= 10338.1 + 7752 + 3254.2 + 446 + 956.5 \\ &= 22,746.8 \text{ frequency/ month} \end{aligned} \quad (7)$$

The calculation of the total number of instances of pain per month is calculated using equation 1 and an example of the calculation is given below;

$$\begin{aligned} \text{Total Instance of Pain for a particular Action (TPA)} = \\ \text{Action Frequency (AF)} \times \text{Number of times Pain Occur (np)} \times \text{Fraction of instance that} \\ \text{produce pain} (\mu p) \end{aligned} \quad (1)$$

$$\begin{aligned} \text{TPA}_{\text{(GRIP)}} = (\text{TAF}_{\text{(GRIP)}} \times \text{np}) + (\text{TAF}_{\text{(GRIP + TWIST)}} \times \text{np}) + (\text{TAF}_{\text{(GRIP + PINCH)}} \times \text{np}) + \\ (\text{TAF}_{\text{(GRIP + MANIPULATING)}} \times \text{np}) + (\text{TAF}_{\text{(GRIP + TWIS + LIFT)}} \times \text{np}) \end{aligned} \quad (8)$$

Hence  $\text{TAP}_{\text{(GRIP)}}$  can be calculated using data including that found in Table 8 (related to pure gripping only in this case).

**Table 4:** The data for pure gripping

Action	Fraction of produce pain	Daily -30	Weekly -4	Monthly -1	Infrequently -0.5
Pure Gripping	every time = 1	4	5	3	2
	most time = 0.6	7	9	4	2
	a few time =0.4	14	10	6	4
Total Response		25	24	1	8
Total Pain		414	57.6	7.8	2.4

So,

$$\begin{aligned} \text{TAF}_{\text{(GRIP)}} \times \text{np} &= (4 \times 30 \times 1) + (7 \times 30 \times 0.6) + (14 \times 30 \times 0.4) + (5 \times 4 \times 1) + (9 \times 4 \times 0.6) + (10 \times 4 \times 0.4) \\ &\quad + (3 \times 1 \times 1) + (4 \times 1 \times 0.6) + (6 \times 1 \times 0.6) + (2 \times 0.5 \times 1) + (2 \times 0.5 \times 0.6) + (4 \times 0.5 \times 0.4) \\ &= 120 + 126 + 168 + 20 + 21.6 + 16 + 3 + 2.4 + 3.6 + 1 + 0.6 + 0.8 \\ &= 481.8 \text{ instance pain action per month} \end{aligned} \quad (9)$$

From equation 2 and equation 3, we can calculate action frequency per person and pain frequency per person as below.

$$\text{Action Frequency Per Person (AFP}_p) = \frac{\sum (AF)}{\text{Total Number of Responses (TRn)}} \quad (2)$$

$$\text{Pain Frequency Per Person (PFP}_p) = \frac{\sum (TPA)}{\text{Total Number of Responses (TRn)}} \quad (3)$$

$$\begin{aligned} \text{AFP}_p &= 22,746.8 \text{ frequency/ month / 616 response} \\ &= 36.93 \text{ action instance person per month} \end{aligned} \quad (10)$$

$$\begin{aligned} \text{PFP}_p &= 481.8 \text{ pain / 616 response} \\ &= 0.78 \text{ pain instance per person per month} \end{aligned} \quad (11)$$

The average pain rating for grip action can be calculate using equation 10 which

$$\text{Average pain rating (APR)} = \frac{[(\text{Number of responses on each action (R)} \times \text{Pain rating scale (S)})]}{(\text{Number of painf uresponses (P))} \quad (5)$$

Hence, for gripping the Average Pain Rating can be calculated;

$$\begin{aligned} \text{APR}_{(\text{GRIP})} &= [(34 \times 1) + (88 \times 2) + (86 \times 3) + (45 \times 4) + (4 \times 5)] / 257 \\ &= 2.60 \end{aligned} \quad (12)$$