Measuring Requisite Force for Pain Compliance Techniques

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Introduction

Pain compliance is promoted as a component to self defense and implemented in law enforcement with subjects that demonstrate physical resistance. The purpose is to direct or control an individual through the judicious application of painful stimulus. In an attempt to positively affirm the feasibility of pain compliance techniques in self-defense, I will isolate a number of pain compliance points on volunteer subjects. Doing so will allow me to record the requisite force for the subject to “tap out” or to indicate that a compliant level of force was applied. Assuming that a minimum amount of force was required to result in such a “tap out”, these techniques may still be applicable towards self-defense instruction.

A number of institutions promote the use of pain compliance as a form of self-defense, these include but are not limited to hapkido, jujitsu, and the US Marines. These techniques require little force relative to the pain it produces in the subject; they’re one approach to minimizing an aggressor’s size and strength advantage. When executed correctly, this approach will often contort the aggressor’s body and allow one to keep a safe distance. But one should also keep in mind that these are not all-encompassing perfect techniques. They require a certain level of proficiency and dexterity to apply correctly, and these strategies are often aimed at those in an abnormal state of mind. If the individual is unreasonable, in an elevated state of mind or under the influence of drugs, pain infliction does not guarantee compliance. Drugs may inhibit the normal neuromuscular feedback and so the reaction to pain may be delayed or not felt at all; this can be dangerous for all parties involved!

Methods

For the purpose of this research paper, the pain compliance techniques will be limited in scope to a few joint locks and pressure points. Pressure points are sensitive areas of the human body that respond with significant pain when relatively weak pressure is applied. The reaction is a result of concentrated nerve endings in these areas and psychological aversion towards painful stimuli. I will be stimulating the philtrum with the aid of a rod to apply even pressure to the subject. Joint locks are applied through the hyperextension or hyperflexion of joints to cause pain and/or the fear of injury in the form of muscular damage or dislocation. The tests will attempt to isolate the middle finger saddle joint, the wrist and its carpal bands, the elbow-joint, and the second toe saddle joint.

Prior to testing each subject, I interviewed the subject for gender, height, weight, age and martial arts experience. Throughout the measurements, a Chatillon 30K/50LB Spring Scale was used to record the requisite force. For each subject, pain compliance points would be measured in the following order: finger bar, wrist Z-lock, armbar, philtrum pressure, and lastly a toe bar.

I first measured the point's resistance to the measuring tool followed by the force required for a subject to tap out. Subjects indicated a tap out either verbally or by physically tapping a surface to indicate that they had felt enough pain. Between each of the measurements, subjects also answered three questions about the pain they experienced. These were to qualitatively measure the location, the onset, and the intensity of the pain experienced. In addition to recording more data about the trial, this pause also introduced a refractory period in order to get the subject's mind off of the task at hand: feeling more pain.

The first pain compliance point tested was the finger bar. The subject placed their right forearm on a flat surface to maximize skin contact from the tips of their fingers to their elbow. Their arms would be placed across their body in line with both of their shoulders. All of the subjects used their right hand for the measurement, to assist with this, they placed their left hand over their fingers except for the middle finger to isolate its saddle joint and maintain contact with the flat surface. Figure 1 below depicts this test position.

Figure 1: Isolating the middle finger joint.

Once the joint was isolated and the subject comfortably positioned, I began to take measurements using nylon rope to loop around the middle finger's interphalangeal joint to transfer the force from the spring scale. I maintained a grip on the subject's elbow as they held their fingers to maintain isolation throughout the measurement. As force increased, I adjusted the angle of pull to maintain as close to a 90 degree pull on the target. Figure two depicts application of this test to a subject.

Figure 2: Maintaining joint isolation as force is applied

For the wristlock I asked the subject to maintain the same arm and body position as the finger bar. Then from their perspective, the hand was turned so that the thumb pointed away from their chest and then the palm was rotated counter clockwise. The subject then applied pressure to the top of their wrist to prevent the wrist from rising from the table. Each subject was also instructed to apply pressure to their middle knuckle towards their elbow to minimize the slack in their wrist. Figure 3 shows a subject in this position. Nylon rope was then fed between their last two digits (ring and little fingers) at their interphalangeal joints. I braced their elbow to again maintain isolation and pulled back on the nylon rope increasing the angle as the force increased.

Figure 3: Right wrist locked and held by left hand

To isolate the elbow joint for the armbar, I had each subject place and keep his or her chin on the flat surface and then to roll their right shoulder forward. This let their elbows and palms face towards the ceiling at a resting state. I placed my hand at the base of their tricep and verbally checked with each subject whether it was the correct location. Then I would measure the requisite force with the nylon looped around the wrist.

The philtrum pain compliance point required each subject to be seated with their back to a wall such that their shoulder blades and head were supported as they sat straight up. However, the area above their nose was not supported by said wall. This is the only test that used a separate tool, a wooden dowel rod with a hole drilled through the diameter of the rod at either end. Metal wiring was threaded through each bore and tied off. The rod would be placed over the subject’s upper lip and below their nose. The metal wiring would feed back and be hooked by the Chatillon Scale at the center point of the subject's head width to apply even force across their philtrum. Once arranged comfortably, I could get an even pull on their philtrum courtesy of the dowel rod.

Figure 4: Philtrum setup with dowel rod in position

The toe bar was the final pain compliance point and had the subject remain seated. I had the subject place their right foot down and position their knee straight above the ankle. Their hands came down to cover and plant their foot, leaving only the second toe exposed. In some cases, flexibility was an issue and I allowed subjects to tuck their left leg underneath to still maintain a planted heel and straight shin. I measured from the toe's outermost interphalangeal joint.

While these pain compliance points are not exact replications of the recommended martial arts techniques, the set-up described above allowed consistent, simple, repeatable measurements of the amount of force applied to each point for each subject. The finer adjustments made when performing pain compliance techniques are often done so as to maximize pain while minimizing force exertion. These changes will either be to increase torsion in the subject's limbs or to introduce body contortions to break balance and maximize discomfort. The toe bar was included in the test lineup to act as a control across the subjects. The toe joints and a toe bar are often not promoted as self defense attacks and thus would likely have the least exposure to built-up pain resistance prior to these tests.

Results

Data tables for the experimental trials are provided in an appendix to this paper. These tables characterize the 15 subjects and the data collected from subjecting them to this battery of pressure point tests.

Discussion & Analysis

As stated in the methods, I questioned each subject between the pain compliance point tests to know more about the onset of the pain. Out of concerns for subject safety and liability, I consistently applied a slowly increasing amount of force to the point at hand. However, this doesn't necessarily reflect a realistic technique application. When learning, a slow and steady application of force is acceptable but when the same technique is done for effect and show, the rate of force application is likely to be nonlinear. Most techniques are executed with force that rises exponentially to spike and then remain at some plateau to hold the subject. Some subjects voiced their thoughts on the matter and explained that as the pain rose linearly, so did their tolerance and mental adjustment towards the pain. All of the voiced levels of pain were low or moderate.

Subjects were instructed to tap out when they normally would for exposure to the given technique. For some, given their aversion towards pain, this was not a problem. For others, the tapping point could still be reached through the fear of dislocation and/or biomechanical limitations. Some test subjects preferred to tap out early for safety concerns. This experiment was by no means a test on the physical limitations of pain compliance points. So all of the perceived pain levels were expected to be low to moderate.

Most of the test subjects also stated that while the force steadily increased, there was a level at which pain spiked sharply for that pain compliance point. This suggests that the targets I picked were binarily signaling for and inducing a reaction from each subject regardless of the rate of force used. Although, as previously mentioned, gradual application of static pressure would quickly dull the response. With an increased rate of force application, there may be a change wherein that critical threshold is surpassed and thus a quicker or more violent subject reaction.

Given the force application rate and pain intensity levels, I expected the critical levels to vary from person to person. I was surprised that the philtrum pain levels across multiple subjects would consistently register at or below the 4 kgF level. The philtrum was the only pressure point that I had targeted, which may explain the lack of variation across subjects. The philtrum isn’t often a typical contact point and may be able to maintain its sensitivity. The philtrum’s sensitivity may also be why the variations in requisite force may have been much smaller. Further exploration of other pressure points using a density checker or more sensitive strain gauge may illuminate whether an individual's pain tolerance goes up relative to the target or as a general bodily function.

I attempted to transpose a small slice of pain compliance techniques from martial arts into a more static form for ease of measurement, doing so may have oversimplified some of the techniques. The finger bar and toe bar may have not implemented an ideal lever. During the trials, I used the natural lever of the finger's saddle joint. Whereas during a finger bar technique implemented to maximize pain, placing the fulcrum at the midpoint of the lowest bone makes one lever arm the portion of the finger to which force is applied and the other is the remainder of the finger towards the knuckle. There are greater risks and challenges with managing this technique as well because each individual has a different sized hand and amount of flexibility. The pain is also less about the dislocation and more about the bone's integrity. The wrist z-lock may have also been short changed as flaring the wrist so that the palm continues to twist and face towards the ceiling would increase the pain and the compression. In addition to causing more pain, the measurement angle may become inconsistent across subjects. The armbar was also simplified down to attacking only the elbow joint instead of placing the fulcrum at the humerus. This allowed a number of subjects to max out the spring scale. I decided that the armbar data was rendered incomplete at best. These simplified technique forms left out a variety of force factors that impacted the technique's effectiveness and actual execution.

I plotted the data recorded from the finger bar and wrist z-lock and found that age appeared to have no bearing on an individual's pain tolerance. The rising requisite force proportional to the number of years accrued fielding bodily abuse in martial arts suggested that those more versed in the techniques had become accustomed to the exposure. This wasn't necessarily true of unpracticed pain compliance points though. Both height and weight affected the requisite force to reach compliance. I assumed that this wasn't necessarily that larger individuals have a bigger appetite for pain, but rather that it takes more force to move the same limb on a larger person when compared to the same limb on a smaller person. Generally, the larger an individual is, the larger their joints or longer their limbs may be. To compensate for the force difference, I divided all of the requisite force by the corresponding subject's BMI.

Figure 5: Recalculated finger bar pain tolerance

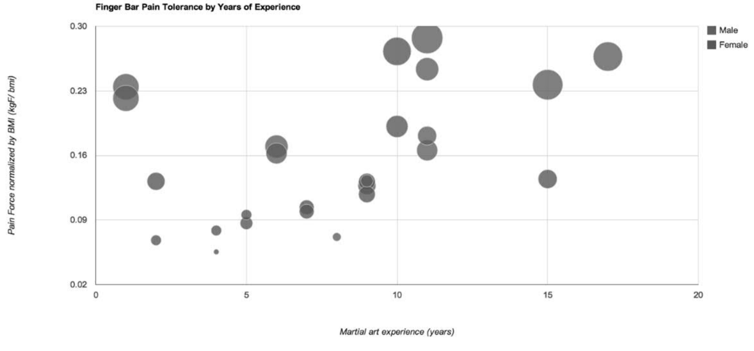
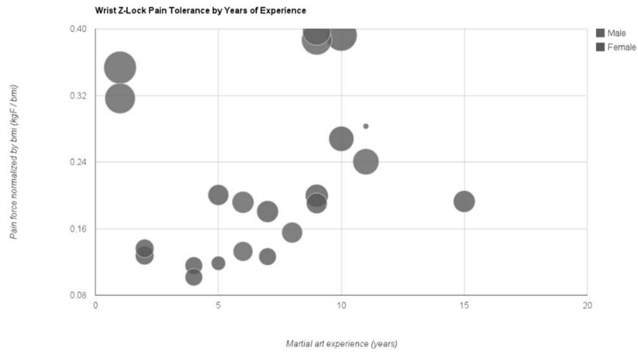


Figure 6: Recalculated wrist Z-lock pain tolerance



As with the finger bar, the trend to tolerating more and more pain apparently correlates with more martial arts experience. It's strange that at the 10 year mark, there is a sudden rise in the amount of pain an individual was willing to put up with. Prior to adjusting for BMI, the trends suggested that males require more force to reach compliance than females. However, once adjusted for BMI to account for mass differences, the critical pain thresholds were more evenly distributed. I'm not sure what it is that happens at the 10th year of martial arts exposure, but the subjects' pain tolerance spiked along there and appeared to plateau after that mark. Despite the spike in requisite force to tap a subject out, these joints do not appear to require super human strength to coerce compliance.

There are a number of things that I'd like to improve upon in future pain compliance point tests. The subjects I used for the test provided a nice spread of data, but there was a lack of representation of experienced females and inexperienced males.

I hypothesize that they'd continue to reinforce the trend of martial art experience increasing a subject's pain tolerance. But without clear representation, it's difficult to make a guess at the impact it has. The tools of the experiment could also be sharpened in order to more accurately collect data. While the same tools were used throughout the test, it may be worth noting that the spring scale's last calibration date is unknown. Using a digital scale instead of an analog one may be able to better map the onset of force as well as to precisely identify the peak force applied in the test. It'd be nice to see a curve for the rate of force that was applied and to determine (safely) whether or not rate of force application mattered. That may be an entirely different test instead of an extension of the current one.

The factor of human error is also present throughout the test. Relying on subject yelps or verbal acknowledgment has its limitations. Each subject may harbor a different scale of pain that they used given the situation. Regardless of a subject's history of exposure, a 3 on one's scale may be a 5 on another's pain scale. Each subject also had a different level of flexibility. There wasn't exactly one setup for every joint that worked for every subject. A lot of tests required tweaking the height of the flat surface or asking for assistance to isolate a joint on larger individuals. I had to compromise technique accuracy for ease of measurement and doing so, may have lost the effectual components to the technique. Yet without isolating particular points to measure, it's impossible to aggregate enough consistent data. For some of the tests like the wrist z-lock and armbar, it was difficult to maintain a consistent angle of attack across all of the tests. In the future, I'd like to approach the joint isolation in new ways. Some of the methods used may have not been appropriate or necessarily correct and could use further testing.

Conclusion

As subjects gained experience or exposure to pain compliance techniques, subjects had a proportional gain in the required force to reach a critical threshold of pain. Force adjusted for individual's BMI reflected that this property was independent of an individual's size, but that generally a greater size means that more force is required to manipulate the body into a compliant state. Pressure points and joints that do not get regular exposure to force suffer universally throughout the subjects. This suggests that pain tolerance may grow only for targets that have been repeatedly exposed to force. While uncertainty in pain compliance point isolation and technique execution suggests some caution, the data recorded also implies that finger bars and philtrum attacks are easily within self-defense's reach.

References

MCRP 3-02B. Marine Corps Reference Publication: Marine Corps Martial Arts. Washington DC: Department of the Navy, 1999: p75. Available at http://www.marines.mil/Portals/59/Publications/MCRP%203-02B%20PT%201.pdf Accessed March 29 2012.

Appendix: Data Tables

Table 1: Basic Subject Data

ID	Gender	Height (in)	Weight (lb)	BMI
1	Male	70	165	23.7
2	Male	67	162	25.4
3	Male	69	133	19.6
4	Female	62	120	21.9
5	Female	63	118	20.9
6	Female	67	150	23.5
7	Female	68	145	22.0
8	Female	67	138	21.6
9	Male	76	203	24.7
10	Male	72	200	27.1
11	Male	68	160	24.3
12	Female	64	130	22.3
13	Male	71	200	27.9
14	Male	70	175	25.1
15	Female	69	150	22.1

Table 2: Subject Age and Experience Data

Subject ID	Age (Years)	Years of Martial Arts Experience
1	16	11
2	30	11
3	15	9
4	22	5
5	16	10
6	20	2
7	15	9
8	23	4
9	34	17
10	24	6
11	26	1
12	37	15
13	47	15
14	31	8
15	25	7

Table 3: Finger bar resistance and pain trial data

ID	Resistance Trial 1 (kgF)	Pain Trial 1 (kgF)	Resistance Trial 2 (kgF)	Pain Trial 2 (kgF)
1	2.0	6.0		6.8
2	2.0	4.6	0.8	4.2
3		2.5	1.2	2.6
4	0.9	2.1	0.4	1.9
5	0.4	4.0		5.7
6	0.4	1.6	0.6	3.1
7	0.6	2.9	0.4	2.6
8	0.6	1.7	0.6	1.2
9	0.7	6.6		
10	1.1	4.4	0.7	4.6
11	0.6	5.4	0.8	5.7
12	0.4	3.0		
13	0.4	6.6		
14	0.9	1.8		
15	0.4	2.2	0.4	2.3

Table 4: Wrist Z-lock resistance and pain trial data

ID	Resistance Trial 1 (kgF)	Pain Trial 1 (kgF)	Resistance Trial 2 (kgF)	Pain Trial 2 (kgF)
1		6.7		
2			1.2	6.1
3	0.7	7.6	2.0	7.8
4	1.4	2.6	1.3	4.4
5	1.1	5.6	0.9	8.2
6	0.6	3.0	0.8	3.2
7	1.1	4.2	0.6	4.4
8	0.4	2.5		2.2
9	1.1	maxed		
10	1.7	5.2	0.9	3.6
11	0.8	7.7	0.7	8.6
12	0.8	4.3		
13				
14	0.7	3.9		
15	0.7	4.0	0.6	2.8

Table 5: Arm bar resistance and pain trial data

ID	Resistance Trial 1 (kgF)	Pain Trial 1 (kgF)	Resistance Trial 2 (kgF)	Pain Trial 2 (kgF)
1	2.0			11.4
2	2.0	12.0		11.6
3	1.7	6.9	1.4	6.1
4		5.4		
5	1.2	6.6	0.9	7.8
6	0.7	4.5	1.1	5.7
7	0.8	7.2	1.2	6.9
8	0.7	5.2	1.2	4.6
9	1.6	max		
10	1.1	8.9		6.8
11	0.9	max		
12	1.1	5.1		
13	1.1	10.1		
14		6.8		
15	1.1	9.6	0.9	7.9

Table 6: Philtrum resistance and pain trial data

ID	Resistance Trial 1 (kgF)	Pain Trial 1 (kgF)	Resistance Trial 2 (kgF)	Pain Trial 2 (kgF)
1		6.5	1.0	6.2
2	2.0	4.2	1.6	1.8
3	1.4	2.4	0.5	3.6
4		1.9	0.4	1.6
5	1.4	2.4	0.6	3.1
6		3.1	0.4	2.8
7	0.4	3.6	0.4	3.5
8	0.3	2.4	0.3	2.6
9	0.8	13.6	0.6	6.7
10	0.6	2.6	0.6	3.0
11	0.4	8.8	0.4	12.0
12	0.4	2.4		
13	0.6	3.6		
14	0.6	4.3		
15	0.7	2.6	0.4	3.0

Table 7: Toe bar resistance and pain trial data

ID	Resistance Trial 1 (kgF)	Pain Trial 1 (kgF)	Resistance Trial 2 (kgF)	Pain Trial 2 (kgF)
1		6.2		
2	1.4	3.6	2.0	5.7
3	0.9	4.4	0.7	4.6
4		4.8		
5				
6	0.7	5.6	0.6	4.4
7	0.4	5.2	1.3	5.3
8	0.3	4.9	0.8	4.3
9	1.1	8.0		
10		6.5	0.7	7.5
11	1.1	13.4		
12	1.1	7.3		
13	0.6	4.8		
14	1.1	2.6		
15	1.1	3.5	1.1	4.4