ORIGINAL ARTICLE

Evaluation of the pain threshold and tolerance of pain by martial arts athletes and non-athletes using a different methods and tools

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Abstract

Background & Study Aims: Control of pain by athletes and the quest for control over pain is an integral part of sports, but is also one of the most important skills in combat sports and large part of martial arts (direct contact with the opponent). Due to systematic exposure to brief periods of intense pain during training or competition, athletes need to learn how to effectively deal with these experiences. The aim of our research was the perception of pain in a group of martial arts athletes and non-athletes using different diagnostic methods involving thermal stimuli and mechanical, and the equivalence of these tests.

Material & Methods: The study involved 321 healthy men, aged 18 to 28 years. The martial arts group consisted of 140 athletes aged 18 to 28 years. The control group consisted of 181 students of the Faculty of Physical Culture, University of Szczecin, not involved in any sport at a professional level, aged between 18 and 26 years. Measurement of the pain threshold and pain tolerance was performed using Cold Pressor Test (CPT) and Pressure Pain Test (PPT).

Results: The study showed that the martial arts athletes had a different sensitivity to pain compared to non-athletes. This was reflected by both significantly higher tolerances to harmful cold and mechanical stimulation as well as a significantly higher mechanical pain threshold ($p < 0.001$).

Conclusions: It seems that both tools and methods, CPT and PPT, can be accepted as adequate and equivalent in relation to the evaluation of tolerance to pain, but not for the pain threshold. The discrepancies in pain threshold results between these tests indicate the need for a few more tests.

Key words: algometer • combat sports • pressure Cold Pressor Test • Pressure Pain Test (PPT)

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Combat sport – *noun* a sport in which one person fights another, e.g. wrestling, boxing and the martial arts [34].

Martial arts – *plural noun* any of various systems of combat and self-defence, e.g. judo or karate, developed especially in Japan and Korea and now usually practised as a sport [34].

Main relationship between combat sport and martial arts – every combat sport is martial arts but not vice versa [1].

Cold Pressor Test (CPT) – a widely used experimental pain procedure to determine a person's pain threshold and pain tolerance, defined as the elapsed time until voluntary withdrawal of the hand.

Pressure Pain Test (PPT) – a tool of method to determine person's pain threshold using a pressure algometer.

Pressure algometer – a calibrated device that can apply painful stimuli of graded intensities used to evaluate deep tissue pain threshold.

Pain threshold – an entirely subjective phenomenon followed an increasing perception of a stimulus at which pain begins to be felt.

Pain tolerance – the maximum stimulus intensity, or the maximum time of continuous painful stimulation that a subject is willing to endure.

Introduction

Nowadays, an increasing number of sports disciplines, characterized by so-called high risk degree gains increasing acceptance mainly among young people. Especially combat sports belong to this group because the essence of rivalry is the direct confrontation of two competing sportsmen [1]. The necessity of doing enormous training work as well as the character of discipline, which imposes the direct contact with the opponent, causes sports injures and pain affliction.

In athletes, pain has diverse functions and a complex aetiology. Its role is not limited to indicating the limits of the body, especially in areas that are exposed to maximal forces and stresses and consequently vulnerable to damage or injury. Pain is also a unavoidable part of the sport experience, regardless of whether the discipline involves contact with other athletes or not. In addition, changes in the intensity of pain from an injury may be used in the assessment of the effectiveness of applied therapies [2].

In theory and clinical practice physical activity is considered as one of the important elements of prevention and treatment of pain. Numerous studies indicate the reduction in intensity of pain in people doing regular exercise [3-5]. However, at the same time pain may be an obstacle in the process of regeneration and rehabilitation [6].

Studies on athletes show an increase in the pain threshold and a higher tolerance to pain compared to physically inactive people [7-9]. This reduced sensitivity to pain among athletes can be considered a factor that increases the chance of achieving success in sport, but at the same time it can pose a potential threat to health, and in extreme cases, even to an athlete's life.

Research on pain in sport when approached only in terms of pain sensation and clinical evaluations of its consequences does not deal with the objective circumstances nor the complexity of pain. In addition, despite a recent significant growth in the number of studies on the physiological and psychological aspects of pain among athletes, research on pain in sport mostly focuses on the assessment of pain experienced by players or non-sporting individuals during physical activity or intense exercise.

For example, one of the important motives and effects of long-term practising of martial arts is aiming for complete possibility of action, and more effective copying with different weaknesses and limitations. For combat sports athletes, one of the potential barriers during trainings and fighting is the feeling of ailments and pain [10, 11].

Most authors ignore the impact of pain on the structure and features of the nociceptive system, suggested by papers showing significantly lower sensitivity to pain or lack of that sensitivity in physically active persons compared to inactive individuals [12, 13]. However, a thorough analysis of available data in literature in the field of pain perception in athletes shows some considerable inconsistencies [14, 15]. These differences can be traced back to the type and method of applicating noxious (nociceptive) stimuli and the heterogeneity of the studied groups of athletes representing endurance sports, team games, as well as martial arts. There is also a lack of conclusive data on differences between the sexes, despite some evidence that men may have a higher pain threshold and tolerance to cold compared to women [16].

Control of pain by athletes and the quest for control over pain is an integral part of sports, but is also one of the most important skills in combat sports and large part of martial arts (direct contact with the opponent).Due to systematic exposure to brief periods of intense pain during training or competition, players need to learn how to effectively deal with these experiences.

Individual sensitivity to pain and predicting pain processes, including chronic pain, can be measured by sensory tests, based on mechanical (touch, pressure, vibration), thermal (heat, cold) and other stimuli (chemical, electro). The tests allow us to evaluate responses to pain, including the pain threshold (the minimum value of the stimulus resulting in the sensation of pain), supra threshold (rating discrete pulses of pain), and tolerance to pain (the maximum intensity of the stimulus that the subject is able to tolerate). A major limitation in quantifying pain, both in terms of quantity and quality, is the difficulty of performing necessary procedures, expensive instruments and the long duration of study.

Therefore, developing effective and unambiguous methods for assessing pain perception by athletes, as well as establishing individual profiles, appears to be an important issue at all stages of a sports career for the sake of prevention, rehabilitation regeneration and medical treatment in sport [17, 18].

Accordingly, the aim of our research was the perception of pain in a group of martial arts athletes and non-athletes using different diagnostic methods involving thermal stimuli and mechanical, and the equivalence of these tests.

Material and methods

Participants

The study involved 321 healthy men, aged 18 to 28 years. The martial arts group consisted of 140 athletes aged 18 to 28 years (21.1 ±2.4) with at least five year long experience, including: boxing (n = 81), karate (n = 31) to a minimum level 1 KYU and different martial arts (n = 28). The control group consisted of 181 students of the Faculty of Physical Culture, University of Szczecin, not involved in any sport at a professional level, aged between 18 and 26 years (21.1 ±1.8).

For all subjects, body height was measured on an anthropometer and weight on electronic scales (Radwag, Poland), to an accuracy of 1 cm and 0.1 kg respectively. They showed no statistically significant differences between the two groups using the criteria of age, body weight and body mass index (BMI). Only the height of the martial arts athletes was slightly but significantly lower than the non-athletes 2.5 cm on average) (Table 1).

Cold Pressor Test (CPT)

The Cold Pressor Test is a tool of method popular in science labs in order to determine pain and pain endurance limitations. It is highly reproducible and uses a natural stimulus to induce pain. Furthermore, CPT works well in the evaluation of perception of pain supra threshold or pain tolerance [19]. While testing, the participants submerged their right hand below the wrist into a container with water at 37°C agitated by a pump for 2 min to acclimatize the skin [20]. Subsequently, the participants then relocated their hand into a glass container with a freezing-cold water mixture between 0°C to 0.5°C, with an installed thermometer to observe the temperature. The hand was kept in the ice-water until they were not able to withstand the pain any longer. The participants were asked to say "pain" when they faced the first physical sensation of pain in the hand. There were required to specify the sensation of pain as it began (pain threshold) and again when the pain began to be unbearable (pain tolerance threshold/pain endurance limitations). The upper limit of time during which the hand could be left in the container was 120 seconds, but the participants had not been informed about the cut-off moment. The tolerance of pain was calculated in seconds.

Pressure Pain Test (PPT)

Measurement of the sensitivity of tissues to compression was performed using an algometer manufactured by Quirumed (Spain). The device is a force gauge, ranging from 0 to 10 kg, fitted with a disc-shape rubber tip bearing a surface of exactly 1cm^2. The results obtained by the individuals were qualified to one of the two measurement intervals, i.e. below or above 10 kg.

Before the measurement of sensitivity to compression, each participant was in the same manner informed about the purpose and course of the study and received guidance on behaviour during the test. Before the actual measurement three test measurements were carried out so that the participant could test the compression and pain, and be able to react in a timely manner and complete the measurement of pressure.

The test was conducted in a sitting position, with the right upper limb, bent at the elbow, being placed on the table. The measurement was made on the back of the hand between the thumb and forefinger. The researcher evaluated the point of

Table 1. Demographic and anthropometric data of the martial arts athletes and non-athletes.

Variables	Martial arts athletes (n = 140) M ±SD	Non-athletes (n = 181) M ± SD	*p*-value
Age (years)	21.1 ±2.4	21.1 ±1.8	0.53
Height (cm)	179.1 ±7.2	181.6 ±7.4	0.01
Body Mass (kg)	76.5 ±12.9	77.7 ±9.6	0.22
BMI (kg/m^2)	23.9 ±3.0	23.5 ±2.1	0.46

contact by palpation, then applied the pressure head at an angle of 90° and compressed it against the body with an increasing force, at the rate of 100 g/s. The measurement results were visible only to the person conducting the test.

When pain was felt by the participant, they said 'stop', and the person performing the experiment recorded the pressure level as the pain threshold. The test was continued until the subject could not stand the strength of the stimulus, signalled the end of the measurement, which was then classified as tolerance to pain.

Statistical inference was used to determine the distribution of the pain thresholds and tolerance to pain in both the martial arts group of athletes and in the control group. Due to the limitations of the measuring instruments and the simplified methods, the results of the pain threshold test were assigned to two intervals, i.e. below or equal to 10 kg/cm^2 (limit value in the algometer scale) and measurements greater than 10 kg/cm^2.

All measurements were performed by the same investigator, in the morning hours and under the same conditions. All participants gave written informed consent to participate in the research. The study was approved by the Bioethics Committee of the Regional Medical Chamber in Szczecin, Poland (No. 09/KB/V/2013).

Statistical Analysis

Results were presented as means standard deviation (±). Comparisons of variables between the martial arts and control groups were performed using Fisher's exact test for quantitative variables and Mann-Whitney U test for qualitative variables. Differences with $p < 0.05$ were considered statistically significant.

Results

Much higher pain threshold was observed in the experimental group of martial arts athletes, where values above 10 kg/cm^2 were obtained by as many as 17.14% of these athletes, while only by 1.11% of the group of non-athletic controls. The pain tolerance values obtained by the martial arts group of martial arts athletes also differed significantly ($p < 0.001$) from the non-athletic controls, with pain tolerances > 10 kg/cm^2 found in 91.43% and 57.46% in the non-athletic group (Table 2).

The martial arts group had similar values of pain threshold compared to the control group (27.7 vs. 26.2 s, $p < 0.95$). Statistically significant differences ($p = 0.0002$) were found for pain tolerance, where the martial arts and control group means were 99.5 and 86.0 s, respectively (Table 3).

Discussion

Tolerance to pain

Our experiment showed that martial arts athletes had a higher tolerance to pain compared to non-athletes, for the first time in such a large group of subjects. Martial arts athletes showed a significantly higher tolerance to pain both during CPT (Cold Pressure Pain test) and PPT (Pressure Pain

Table 2. Pain threshold and tolerance to pain in the martial arts athletes and non-athletes , with the use of an algometer.

Subject	Pain tolerance		*p*-value
	≤ 10.0 kg/cm^2	> 10.0 kg/cm^2	
Martial arts athletes Non-athletes	12 (8.57%) 77 (42.54%)	128 (91.43%) 104 (57.46%)	< 0.00001
	Pain threshold		
	≤ 10.0 kg/cm^2	**> 10.0 kg/cm^2**	
Martial arts athletes Non-athletes	116 (82.86%) 179 (98.89%)	24 (17.14%) 2 (1.11%)	< 0.0001

Table 3. Pain threshold and tolerance to pain in martial arts athletes and non-athletes, using CPT.

Variable	Martial arts athletes (n= 140) M ± SD	Non-athletes (n= 181) M ± SD	*p*-value
Pain threshold (s)	27.74 ±28.71	26.20 ±3.83	0.95
Pain tolerance (s)	99.51 ±30.75	86.03 ±34.82	0.00020

Test), compared to the control group consisting of non-sporting students. There are only a few studies that evaluate the sensitivity of pain in martial arts athletes at rest.

CPT was used to measure tolerance to pain in 26 dancers [9], 36 runners [21] and 50 combat sports athletes [22]. Thus obtained results indicated that athletes tolerated significantly more pain than normally active persons.

Subjective assessment of pain on numerical scales or in questionnaires describing pain confirms that tolerance to pain is strongly modulated by psychological and psychosocial factors [23, 24]. It can be assumed that skilful coping with stress increases pain control, and experience in pain management reduces athletes' sensitivity to pain compared to physically inactive people [14]. According to Azavedo et al. [25], athletes who have developed successful strategies for coping with stress can tolerate much higher levels of pain compared to non-athletes.

In our study, the selected group of martial arts athletes had a significantly higher tolerance to pain compared to non-athletes (CPT $p = 0.0002$; PPT $p < 0.00001$). That higher tolerance to pain among athletes demonstrated better adaptation and perhaps more efficient protective reactions, not only during the "murderous" sport activities but also at rest. As a consequence, increased tolerance to pain among athletes predisposes them to greater physical endurance and better results, but on the other hand may not reflect the real consequences of injury. It can also be an important factor limiting the regeneration of damaged tissue, leading to permanent physical overload [19] which in turn can lead to much more serious injuries and even dysfunction of the musculoskeletal system.

Pain threshold

Examination of the pain threshold at rest on a manual algometer showed that the martial arts athletes had a significantly higher pain threshold compared to non-athletes. The same characteristic during CPT showed no statistically significant difference. The examined martial arts athletes and students of the control group, informed about the pain in their hand almost at the same time. The observed differences between the CPT and PPT were probably due to the type of stimulus. These findings indicate the need for allowing for the specificity of tests when planning research in the area of pain in athletes.

Reports on pain threshold in athletes are not conclusive [8, 12, 13, 26]. Most studies using CPT or PPT to determine pain threshold assessed the sensitivity to pain during physical exercise or ten minutes after completion. Those data cannot be used directly to establish differences in the perception of pain between physically active and inactive subjects [21, 27, 28].

Studies similar to our experiment (resting values), Tesarz et al. [15] did not show significant differences between endurance athletes and non-athletes in the PPT and CPT. The study by Tayet-Foxell [9] showed athletes achieving higher pain thresholds during CPT compared to the control group. Significantly higher pain threshold in the PPT was found in athletes when compared with the control group in the study by van der Heijden et al.[29], which is consistent with our own findings.

In our study the pain threshold was similar for martial arts athletes and non-athletes in the CPT, despite the fact that the control group comprised of students are usually subjected to much lower stress loads, and hence less exposure to noxious stimuli. This suggests that in each of the participants (athletes and physical education students) the activation of thermoreceptors in the upper limb, results in similar activation of brain centres, devoid of modulation effects generated under conditions of anxiety, fear or threat. Furthermore, contact with cold water is known and encoded in the minds of participants as harmless, and sometimes even positive (e.g. when overheated), especially in comparison to other experimental stimuli, such as electrical stimulation or ischemia caused by an elastic band.

The perception of the pain threshold and tolerance to pain in an extremity involves both objective and subjective processes. The processing of information taking place from nociceptor stimulation to the sensation of pain generally indicates the lack of a simple relationship between the degree of nociceptor stimulation and the intensity of pain, particularly under load or stress [30]. We must not forget that the actions of various stimuli lead to the activation of various nociceptive innervated structures. Thermal and electrical stimuli selectively activate skin nociception whereas pressure stimuli target both skin and deep tissue nociceptors with a relative preponderance of the latter [31, 32]. Also information from deep tissue nociceptors is processed differently in the spinal cord than the information from superficial tissue nociceptors. Moreover, the information from nociceptors of deep tissues is subjected to a stronger inhibitory effect than the skin nociceptors [33].

The results obtained in a large population of subjects by one researcher shows clearly that the perception of pain was modified by physical activity. An elevated threshold of tolerance to noxious stimuli may result in a situation where repeated injuries, especially those suffered by martial arts athletes, may be perceived as increasingly weaker and less troublesome. As a consequence, it might cause a potential health hazard and in extreme situations it may even pose a life threat. The modulation of pain threshold and tolerance to pain is also of great importance in the application of non-invasive methods in rehabilitation, regeneration, assessment of the effectiveness of therapy, not only for athletes but also people with certain medical conditions.

Conclusions

The study showed that the martial arts athletes had a different sensitivity to pain compared to non-athletes. This was reflected by both significantly higher tolerances to harmful cold and mechanical stimulation as well as a significantly higher mechanical pain threshold ($p < 0.001$). However, the athletes and non-athletes did not differ in terms of cold-induced pain threshold.

It seems that both methods, CPT and PPT, can be accepted as adequate and equivalent in relation to the evaluation of tolerance to pain, but not for the pain threshold. The discrepancies in pain threshold results between these tests indicate the need for a few more tests to objectify pain threshold in the tested subjects.

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References

1. Kalina RM. Teoria sportów walki. Warszawa: Centralny Ośrodek Sportu; 2000 [in Polish]
2. Pawlak M. Aspects of pain in sport. TSS 2013; 3(20): 123-134
3. Ellison K, Freischlag J. Pain tolerance, arousal, and personality relationships of athletes and non-athletes. Res Q 1975; 46: 250-255
4. Anshell MH, Russell KG. Effects of aerobic and strength training on pain tolerance, pain appraisal and mood of unfit males as a function of pain location. J Sports Sci 1994; 12: 535-547
5. van Middelkoop M, Rubinstein SM, Kuijpers T,Verhagen AP, Ostelo S, Koes BW, van Tulder MW. A systematic review on the effectiveness of physical and rehabilitation interventions for chronic non-specific low back pain. Eur Spine J 2011; 20: 19-39
6. Heil J. Psychology of Sport Injury. Champaign, IL: Human Kinetics Publishers; 1993
7. Guieu R, Blin O, Pouget J, Serratrice G. Nocciceptive threshold and physical activity. Can J Neurol Sci 1992; 19: 69-71
8. Granges G, Littelejohn GO. A comparative study of clinical signs in fibromyalgia/fibrositis syndrome, healthy and exercising subjects. J Rheumatol 1993; 20: 344-351
9. Tajet-Foxell B, Rose FD. Pain and pain tolerance in professional ballet dancers. Br J Sports Med 1995; 29: 31-34
10. Ortenburger D, Wąsik J, Szerla M et al. Does pain always accompany martial arts? The measurement of strategies coping with pain by taekwondo athletes. Arch Budo Sci Martial Art Extreme Sport 2016; 12: 11-16
11. Struhár I, Dovrtělová L, Reguli Z. Influence of two years study in Special Education of Security Sections on the body posture. Arch Budo 2015; 11: 359-364
12. Ryan ED, Kovacic CR. Pain tolerance and athletic participation. Percept Mot Skills 1966; 22: 383-390
13. Ord P,Gijsberg K. Pain thresholds and tolerances of competitive rowers and their use of spontaneous self- generated pain-coping strategies. Percept Mot Skills 2003; 97: 1219-1222
14. Chen AC, Dworkin SF, Haug J, Gehrig J. Human pain responsivity in a tonic pain model: physiological determinants. Pain 1989; 37: 143-160
15. Tesarz J, Gerhardt A, Schommer K et. al. Alterations in endogenous pain modulation in endurance athletes: An experimental study using quantitative sensory testing and the cold-pressor task. Pain 2013; 154: 1022-1029
16. Manning EL, Fillingim RB. The influence of athletic status and gender on experimental pain responses. J Pain 2002; 3: 421-428
17. O'Connor PJ, Cook DB. Exercise and pain: the neurobiology, measurement, and laboratory study of pain in relation to exercise in humans. Exerc Sport Sci Rev 1999; 27: 119-166
18. Hasselstrom J, Liu-Palmgren J,Rasjo-Wraak G. Prevelence of pain in general practice. Eur J Pain 2002; 6: 375-378
19. Freund W, Weber F, Billich Ch. Ultra-Marathon Runners Are Different: Investigations into Pain Tolerance and Personality Traits of Participants of the TransEurope FootRace 2009. Pain Practice 2013; 13 (7): 524-532
20. Keogh E, Bond FW, Hanmer R, Tilston J. Comparing acceptance-and control- based coping instructions on the cold-pressor pain experiences of healthy men and women. Eur J Pain 2005; 9: 591-598
21. Janal MN, Glusman M,Kuhl JP, Clark WC. Are runners stoical? An examination of pain sensitivity in habitual runners and normally active controls. Pain 1994; 58: 109-116
22. Egan S. Acute pain tolerance among athletes. Can J Sport Sci 1987; 12: 175-178
23. Buchanan HM, Midgley JA. Evaluation of pain threshold using a simple algometer. Clin Rheumatol 1987; 6: 510-517
24. Streator S, Ingersoll CD, Knight KL. Sensory information can decrease cold-induced pain perception. J Athl Train 1995; 30: 293-296
25. Azevedo DC, Samulski M. Assessment of psychological pain management techniques:

a comparative study between athletes and non-athletes. Rev Bras Med Esporte 2003; 9; 214-222

26. Scott V, Gijsbers K. Pain perception in competitive swimmers. Br Med J 1981; 137: 245-256
27. Kemppainen P, Hamalainen O, Kononen M. Different effects of physical exercise on cold pain sensitivity in fighter pilots with and without the history of acute in-flight neck pain attacks. Med. Sci Sports Exerc 1998; 30: 577-582
28. Sternberg WF, Bailin D, Grant M, Gracely RH. Competition alters the perception of noxious stimuli in male and female athletes . Pain 1998; 76: 231-238
29. van der Heijden D, de Vries Msc. J. Pressure pain threshold response to aerobic exercise in elite rowers with actual low back pain. Master Sports Physical Therapy; 2009
30. Pawlak M. Biologiczne uwarunkowania bólu. Poznań: Akademia Wychowania Fizycznego; 2010 [in Polish]
31. Kosek, E, Ekholm J, Hansson P. Pressure pain thresholds in different tissues in one body region. The influence of skin sensitivity in pressure algometry. Scand J Rehabil Med 1999; 31: 89-93
32. Rollman GB, Lautenbacher S. Sex differences in musculoskeletal pain. Clin J Pain 2001; 17: 20-24
33. Mense S. Nociception from skeletal muscle in relation to clinical muscle pain. Pain 1993; 54: 241-289
34. Dictionary of Sport and Exercise Science. Over 5,000 Terms Clearly Defined. London: A & B Black; 2006

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