UiT THE ARCTIC UNIVERSITY OF NORWAY

Institute of Psychology, Faculty of Health Sciences

Elevated Pain Threshold Levels in Elite Athletes

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Thesis in Clinical Psychology

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Foreword

The present study is the final written assignment for the course of Clinical Psychology at the University of Tromsø, The Arctic University of Norway. Professor Per Aslaksen was the main supervisor of this thesis, while associate professor Svein Arne Pettersen and professor Joar Vittersø were supervisors. The data was obtained through an experimental study conducted at Alfheim Research and Exercise lab. The participants were comprised of soccer players, cross-country skiing athletes, long distance runners and a control group. All participants were Norwegian citizens. The athletes who were inquired to join the study were all elite athletes, among the best ranked in Norway. The author operated as the experimenter for most of the subjects (95%), while the remaining subjects were tested by a male professor. The author also recruited 95% of the subjects. Statistical analysis was done in collaboration with professor Per Aslaksen. The supervisors contributed with the formulation and structure of the thesis. Research articles were obtained through the search engines “PubMed” and “PsychInfo”, in addition to the articles recommended by the supervisors. A special appreciation to Per Aslaksen, for support and engagement in this project, Svein Arne Pettersen for kindly providing us with facilities for the experiment and Anna Dahl Myrvang for help and support throughout the writing process.

Susann D. Pettersen, Tromsø, May 2019.

Abstract

The aim of this study was to examine the difference in pain perception between elite-athletes and non-athletes. The data previously obtained within this field of study is sparse and showing a significant variation in results. 52 healthy volunteers (18 females and 34 males) participated in an experimental study in which personality traits, fear of pain and grit (perseverance and passion for long-term goals) were measured prior to induction of experimental pain. Soccer players (*n = 15),* cross country skiers *(n* = 4) and long-distance runners (*n* = 2) made up the athlete group. Grit was measured by the Grit-S scale, personality traits by the Big-Five Inventory-10 and fear of pain by the Fear of Pain Questionaire-III. Heat pain was induced by a PC-controlled thermode and measured by a computerized visual analog scale. To measure pain tolerance, a cold pressor test was applied. The results showed that athletes had a significantly higher pain threshold level, but not pain tolerance, compared to the control group. The two groups did not differ in fear of pain, grit or the Big-Five personality traits. Furthermore, there was no significant difference in pain perception when comparing soccer players and endurance athletes. These findings are supported by some previous research, although results from this field of study is somewhat inconsistent. The largest concern was the control group, which proved not to be representative of a normal population. This may have affected the results and consequently more research with larger population sizes, in addition to a representative control group, needs to be conducted to improve the understanding of pain perception in athletes.

Pain is an integral part of exercise and sports (O'Connor & Cook, 1999). When engaging in exercise, pain emerges as a natural consequence of intramuscular pressure, muscle distortion and a build-up of deleterious metabolites in the muscle. Elite-athletes expose themselves to exercise-related pain almost daily, but it is unclear how this affects their perception of acute laboratory induced pain and whether it subsequently alters their general pain perception. For a better understanding of this, it is important to add knowledge to the field.

Studies have shown that pain perception may differ in athletes compared to normally active controls. A meta-analysis from 2012, conducted by Tesarz, Schuster, Hartmann, Gerhardt and Eich, showed that athletes possessed consistently higher pain tolerance than normally active controls, when ischemic stimuli and cold pain stimuli was applied. However, the data available on pain threshold were less uniform. Over all, the field of pain perception in athletes show inconsistent and partially contradictory scientific findings (Guieu, Blin, Pouget, & Serratrice, 1992; Ord & Gijsbers, 2003; Ryan & Kovacic, 1966; Tajet-Foxell & Rose, 1995).

Some studies have shown that athletes who compete in contact sports rated their pain as less severe and possessed a greater pain tolerance than non-contact sport athletes (Raudenbush et al., 2012; Ryan & Kovacic, 1966; Sullivan, Tripp, Stanish, & Rodgers, 2000). However, the causality regarding this difference in pain tolerance is not properly understood, nor investigated. Some support has been given to the hypothesis of athletes becoming more tolerant to experimental pain through participation in contact sports (Thornton, Sheffield, & Baird, 2017), through developing better coping skills and reducing catastrophizing. Others have hypothesized that naturally pain tolerant individuals are more drawn to contact sports (Ryan & Kovacic, 1966). Scott and Gijsberss (1981) found that pain tolerance in professional swimmers gradually increased following a training program. Thornton *et al*. (2017) found similar results in contact-sport athletes, in addition to finding a reduction in tolerance when the athletes ceased their training. These findings have also been replicated among non-athletes, with pain tolerance increasing following aerobic exercise programs (Anshel & Russell, 1994; Jones, Booth, Taylor, & Barry, 2014; O'Leary, Collett, Howells, & Morris, 2017). This supports the possibility that pain hyposensitivity may be acquired among athletes. In addition, it is possible that fear of pain can be a mediating variable.

Fear of pain

Fear of pain is considered a personality trait (McNeil & Rainwater, 1998) and refers to the dispositional tendency to react with negative emotions to pain and in the anticipation of pain. Fear and pain are both factors that are challenging to measure, due to their multifaceted and subjective nature. Prevailing theory suggests that pain comprises sensory, as well as cognitive, affective, and behavioural components (Asmundson, Vlaeyen, & Crombez, 2004). The experience of pain is idiosyncratic, implying that the same intensity of pain may be perceived differently depending on the individual. Fear is a present-oriented state that is designed to protect the individual from a perceived immediate threat and is often described as one of the basic emotions (Izard, 1992).

The Fear of Pain Questionnaire-III (McNeil & Rainwater, 1998) is a widely used scale, when measuring fear of pain. However, studies have shown varying levels of validity and consistency (Albaret, Muñoz Sastre, Cottencin, & Mullet, 2004; Vambheim et al., 2017), partly explained by the notion of psychosocial and cultural differences. Vambheim *et al.* (2017) suggested that country specific validation of fear of pain is recommended. In the present study, the Norwegian version of Fear of Pain-III was therefore applied.

Personality

Fear of pain has also been linked with the personality trait neuroticism (Courbalay, Deroche, & Woodman, 2016). Neuroticism reflects a sensitivity to threat, and to a range of negative emotions and cognitions that accompany experiences of threat and punishment, including anxiety, depression, anger, irritation, and self-consciousness (Costa & McCrae, 1992; Deyoung & Gray, 2009). Negative emotions increase the experience of pain (Rhudy & Meagher, 2001) and therefore it is likely that individuals with high scores on neuroticism will report more pain, compared to individuals with lower scores. To examine this notion, the Big-Five Index-10 (BFI-10) was used as an instrument in the present work.

Grit

Grit is a personality trait defined as passion and perseverance for long-term goal achievement (Duckworth, Peterson, Matthews, & Kelly, 2007). Grit is further composed of perseverance of effort, which means having stamina in working toward a goal despite obstacles, and consistency of interest, which means having sustained focus on a goal through to completion. The Grit-scale was originally developed to examine whether Grit could account for more variance in achievement in academic success, than the Big-Five personality traits (Neuroticism, Conscientiousness, Openness to Experience, Extroversion and Agreeableness). In sports too, most personality research has revolved around the Big-Five personality traits (Meyer, Markgraf, & Gnacinski, 2017). Grit has shown to be similar to other constructs of personality from the sports literature, such as hardiness and resilience, but the constructs have been deemed operationally distinguishable. To the best of the author’s knowledge, there is little to no research regarding how scores on the Grit-scale correlate with pain perception in athletes.

Pain threshold

Pain threshold is the minimum stimulus intensity that is *usually* perceived as painful, but even in controlled laboratory conditions, there is considerable intra-individual variation in perceptual responses to noxious stimuli (O’Connor & Cook, 1999). However, this variability is less than inter-individual variation.

Even though research on pain threshold is less uniform than that of pain tolerance, interesting findings have been obtained. An elegant study by Tajet-Foxel and Rose (1995) compared the pain perception of professional ballet dancers with age matched controls. They used a cold pressor test, in addition to examining personality and coping strategies. The results showed that the ballet dancers had significantly higher pain threshold and pain tolerance, compared to the controls. This could not be explained by lower neuroticism scores, because the ballet dancers had significantly higher scores on the neuroticism scale. There were no significant differences in coping strategies either, indicating that another factor or factors must be influential.

Pain tolerance

Pain tolerance is either the length of time an individual is willing to endure a noxious stimulus, or the maximal stimulus intensity that one will endure (O'Connor & Cook, 1999). Some of the existing literature conclude with athletes having consistently elevated pain tolerance compared to control groups consistently elevated pain tolerance (Ord & Gijsbers, 2003; Raudenbush et al., 2012; Tajet-Foxell & Rose, 1995; Tesarz, Schuster, Hartmann, Gerhardt, & Eich, 2012; Thornton, Sheffield, & Baird, 2017), but few studies draw conclusions on causality. Because of potential tissue damage or permanent injury, pseudo-tolerance measurements of pain tolerance are performed in experimental studies. This can be conducted with various methods, but the present study used immersing one's hand into cold water, and a thermal heat intensity test to measure pain tolerance.

Hypothesis

Cross-country skiing is relatively minor sport compared to long-distance running and soccer. Henceforth, skiing has not been subdued to the same amount of research as soccer and long-distance running. There is little to no research regarding psychological variables or pain perception variables in skiers known to the author, except research on variables related to the pain of injury and recovery.

Thus, the present study wanted to further examine the topic of elite-athletes' pain perception compared to normal controls and investigate the underlying mechanisms of why athletes seem to possess a higher pain tolerance. We expected to replicate the finding of Tajet-Foxell & Rose (1995) who showed that elite-athletes had an increased pain tolerance level compared to a control group. We did not expect a difference in pain threshold as literature on this subject has shown inconsistent results (Ord & Gijsbers, 2003; Ryan & Kovacic, 2011). We also expected that the endurance athletes would have a higher pain tolerance compared to the soccer players, if physical activity account for much of the variance in increased pain tolerance. This because endurance athletes perform continuous intense exercise for 5-50 kilometers while the main activity of soccer players, although eliciting ca 85% of maximal heart rate in match, is walking and standing (Mohr, Krustrup, & Bangsbo, 2003). In addition, we expected the athlete group to have higher scores on the Grit-S scale and lower scores on the Fear of Pain III-questionnaire compared to the control group.

Method

Participants

The sample consisted of 52 healthy participants. The recruitment of the elite athletes (n = 22) was conducted by contacting the trainers for each individual soccer, ski and long-distance running team by mail and through a poster located at the Alfheim Research and Exercise lab. The email consisted of an inquiry for participation and information regarding the procedure of the project. The control group (n = 30) was recruited via a poster located at the university area.

The participants had a mean age of 24.4 years (range 18-37, SD = 4.4), 18 (34.6%) of whom were women. Athlete participants were comprised of soccer players (n = 15) and aerobic endurance athletes (*n* = 6). The endurance athlete group consisted of four cross country skiers and two long-distance runners. Of the 52 participants, one participant was excluded due to failed completion of the pain intensity test. The remaining 51 participants completed the study. Information regarding the study was provided both orally and in writing. All participants signed a consent form declaring their voluntary participation (appendix A). The form highlighted information regarding the right to withdraw from the study and reassurance of data anonymity. The consent form also stated that participants could not partake in the study if they had a history of ongoing disease or previous serious diseases such as heart conditions (including increased blood pressure), metabolic disorders, mental disorders, damaged skin on the forearms, neurological illnesses or brain damage, or damage in the central nervous system. Volunteers who used any type of prescribed medications could not participate, except for birth control pills and asthma medicine. Pregnant women could not participate. The subjects included in the study received a gift card with a value of 200 NOK for participating.

Experimenters

95% of the participants were tested by the author, a female studying clinical psychology at the University of Tromsø. The remaining subjects were tested by a male professor employed at the same university.

Pain Apparatus

A cold pressor pain task was accomplished using a computer-controlled water circulator (JeioTech, South Korea), which is designed to circulate water through a cooling mechanism and into a reservoir tank. The temperature was maintained at 2°C.

Heat-pain was induced by contact heat stimulation (30x30 mm aluminum contact thermode, Pathway; Medoc, Israel) attached to the surface of the left volar forearm.

Pain intensity was measured continuously during stimulation by a 0-100 Computerized Visual Analogue Scale (COVAS, Medoc, Israel) where 0 equaled no pain sensation and 100 equaled the most intense pain sensation imaginable.

Blood pressure and heart rate were measured with a standard electronic blood pressure device (Microlife, Widnau, Switzerland). Systolic/ diabolic blood pressure and heart rate were registered before and after the cold pressor test. Participants who displayed a systolic blood pressure over 170 mmHg were excluded due to risk factors associated with rapid changes in blood-pressure under the cold pressor task that may cause dizziness or fainting.

Procedure

The experiment took place at Alfheim Research and Exercise lab (https://uit.no/om/enhet/artikkel?p_document_id=388560&p_dimension_id=247534), in a room shielded from sound. The room temperature was kept stable at 21 degrees. Upon arrival the participants received information about the experiment. They were told that the purpose of the study was to examine how physical exercise and personality affect the experience of physical pain. We recorded age, gender, level of finished education and hourly exercise per week. They then signed the former described consent form and filled out the BFI-10, FPQ-III and Grit-S scale, before being placed in a comfortable chair. Once in the chair, blood pressure, heart rate and the hands skin-surface temperature were measured.

We then applied a cold pressor test (CPT) and a MEDOC Pathway somatosensory stimulator apparatus to conduct quantative sensory testing (QST). Participants were instructed to submerge their right hand up to and including the wrist into cold water (2°C). Because this can be experienced as very uncomfortable, subjects were told to keep their hand in the water as long as possible and that they could remove their hand at their discretion, but at a certain point they would be instructed to remove their hand. Those who kept their hand in the water for three minutes were at that point instructed to remove their hand. Upon finishing the test, blood pressure, heart rate and the hands skin-surface temperature measurement was repeated.

Heat-pain threshold (HPth) was measured using a MEDOC Pathway somatosensory stimulator. We used the classical procedure "method of limits", where the pain intensity level is set below pain threshold and subsequently increased until the stimuli is perceived as painful. The thermode was attached to the left volar forearm for all participants, except two subjects who had tattoos on the left arm who undertook heat pain testing on the right volar forearm. Tattoos contain traces of iron oxide which can cause burns. The thermode had a baseline temperature of +32°C when applied to the arm. The temperature increased by 1°C per second and an upper safety limit was set at 52°C. Participants were instructed to press a button on a pc-mouse when the sensation changed from warmth to pain. Upon clicking the pc-mouse button, temperature was registered and the temperature returned to baseline with a fall rate of 8 °C/s. The measurement was repeated five times and HPth was calculated as the mean of the five measurements.

Participants then went through a pain intensity test. They were told the test would be painful, but harmless. Subjects were asked to rate their pain continuously on a computerized visual analogue scale on a scale of 0-100, 0 being no pain perception and 100 being the most painful sensation imaginable. The test started at baseline temperature (32°C), rapidly increased (10°C/second) to and kept a stable temperature of 47,5°C for 30 seconds, before returning to baseline. Upon finishing the two thermode tests, the thermode was moved 2 cm from the original spot towards the elbow, to avoid hyperalgesia. The pain threshold and pain intensity test were then repeated and the thermode was later removed. The total duration of the experimental procedure was approximately 25 minutes for each participant.

The experimental protocol was conducted in accordance with the Helsinki Declaration and was approved by the Regional Committee for Medical Research in North Norway (REK) project number 2018/1333.

Instruments

Grit is a personal quality defined as perseverance and passion for long-term goals (Duckworth et al., 2007). Grit was measured by an eight item self-report questionnaire (Grit-S) (appendix D). The items were rated on a five-point Likert scale from 1 = not at all like me to 5 = very much like me. The Grit-S scale was translated from the English/ American version into Norwegian by professor Joar Vittersø, department of psychology, University of Tromsø and colleagues from the Norwegian School of Sport Sciences. The technique used was parallel blind technique (Behling & Law, 2000).

BFI-10 is a short scale version of the Big Five Inventory, which consists of 44 items (Rammstedt & John, 2007) (appendix B). The BFI-10 is a 10-item self-report measure containing short items assessing the Big Five factors (Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism). Items are answered using a five-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree. BFI-10 is often used in research settings with time constraints (Rammstedt, 2007).

FPQ-III (Fear of Pain Questionnaire-III) (McNeil & Rainwater, 1998) contains 30 items consisting short phrases depicting painful situations (appendix C). The items are rated on a five-point Likert scale ranging from 1 = no pain to 5 = severe pain. The questionnaire consists of three 10-item subscales: fear of severe pain (e.g., “Breaking your arm”), medical pain (e.g., “Having a blood sample drawn with a hypodermic needle”), and minor pain (e.g., “Getting a paper-cut in your finger”). Respondents were instructed to rate the degree of anticipated pain related to each item. It is established that the questionnaire has a good internal consistency (total score, $\alpha = .92$; severe pain, $\alpha = .88$; minor pain, $\alpha = .87$; and medical pain, $\alpha = .92$) and good test–retest reliability (total scale, $\alpha = .74$; severe pain, $\alpha = .69$; minor pain, $\alpha = .73$; and medical pain, $\alpha = .76$) (McNeil & Rainwater, 1998). FPQ-III was translated from the original English/ American version into Norwegian by two

Norwegian Ph.D. students at the Department of Psychology, University of Tromsø (Lyby, Aslaksen, & Flaten, 2010). This was later back-translated into English before concluding upon a final version.

Statistical analysis

The statistical analysis was performed with SPSS version 25.0 (SPSS, Inc, Chicago, Illinois, USA). Group differences in demographic variables, pain perception and questionnaires were investigated by one-way analysis of variance. Pearson product-moment correlation coefficient was used to investigate the correlation between the pain measurements and the total score on the fear of pain questionnaire. A Pearson product-moment correlation coefficient was also used to investigate the correlation between grit, fear of pain and the Big Five personality traits. A between-groups multivariate analysis of variance was performed to investigate whether the athletes differed from the control group in pain threshold and pain intensity, in addition to examining whether the athletes differed from the control group in traits of personality. We performed tests of normality by inspecting Q-Q plots and box plots for all variables. One violation of assumptions for parametric tests were discovered, the time variable for the cold pressor test. A Mann-Whitney U test was therefore conducted to investigate whether there was a significant difference in time spent in the cold pressor test. It was also used to examine if there was a significant difference in pain perception between soccer players and endurance athletes.

In order to adjust p-values for multiple testing and reducing the probability of type I errors, p-values were adjusted with the False Discovery Rate (FDR) procedure with $q = 0.05$ (Hochberg, 1995; Yekutieli & Benjamini, 1999). After FDR adjustments performed with a script for SPSS (http://www-01.ibm.com/support/docview.wss?uid=swg21476447) the level of significance was $p < .014$ for the between-groups multivariate analysis of variance performed to investigate whether the athletes differed from the control group in pain threshold and pain intensity (table 2). Elsewhere, *p*-values < .05 were considered significant.

Results

Descriptive statistics

51 participants completed all tests, 65.4% men and 34.6% women, with a mean age of 24.7 years. The sample consisted of 42.2% athletes divided into groups of soccer players (n = 15), cross country skiers (n = 4) and long-distance runners (n = 2). The cross-country skiers and the long-distance runners were combined into one group in analysis comparing in-group effects. The control group spent an average of 5.20 hours per week exercising, whilst the elite athlete group spent an average of 16.5 hours per week. The elite athlete group had significantly higher scores on the second test for pain threshold.

Table 1

Descriptive statistics. Mean, standard deviation (SD), F-value and p-value.

Clinical Measures	Athlete group (*SD*)	Control group (*SD*)	*F*-value	*p*-value
N	22	30		
Age	24.18 (4.90)	24.50 (4.17)	0.06	.80
Weekly exercise	16.50 (3.07)	5.20 (4.29)	110.67	**.001**
Grit	24.27 (3.34)	25.12 (2.58)	0.69	.30
Minor pain	18.09 (6.80)	17.70 (5.47)	0.05	.20
Severe pain	35.36 (5.71)	32.93 (7.29)	1.69	.82
Medical pain	22.95 (7.75)	21.17 (6.34)	0.84	.37
FPQ total	76.41 (16.90)	71.80 (16.79)	0.95	.33
Extroversion	3.77 (0.83)	3.80 (0.94)	0.01	.91
Agreeableness	3.75 (0.57)	3.83 (0.75)	0.19	.66
Conscientiousness	3.95 (0.63)	3.72 (0.96)	1.02	.32
Neuroticism	2.39 (0.79)	2.47 (0.84)	0.12	.73
Openness	3.18 (1.15)	3.33 (0.78)	0.32	.57

CPT*	129.55 (69.00)	131.80 (63.29)	0.02	.90
Threshold I**	47.99 (1.93)	47.05 (2.10)	2.71	.11
Intensity I**	49.90 (23.14)	53.73 (30.40)	0.24	.62
Threshold II**	48.24 (1.27)	47.27 (1.33)	6.84	**.012**
Intensity II**	44.38 (24.26)	49.40 (31.64)	0.37	.54

Note: Statistics: One-way ANOVA. CPT: Cold Pressor Test; Threshold: Mean value of five measurements; Intensity: Highest value on visual analogue scale. *Non-parametric test applied. **Athlete group $n = 21$. p-values in bold type are significant ($p < .014$) after FDR-corrections.

Pain perception

A between-groups multivariate analysis of variance was performed to investigate whether the athletes differed from the control group in pain threshold and pain intensity (table 2). Preliminary assumption testing was conducted to check for normality, linearity, univariate and multivariate outliers, homogeneity of variance-covariance matrices, and multicollinearity. One serious violation was noted, regarding the variable cold pressor test, consequently a non-parametric test was later applied. Four dependent variables were therefore used: threshold I, intensity I, threshold II and intensity II. The independent variable was athlete or non-athlete. Participants age, gender, systolic blood pressure pre-testing and their scores on the Grit-S scale and FPQ-III were used as the covariates in the analysis.

There was no statistically significant difference between athletes and non-athletes on the multivariate test for the dependent variables, $F = 1.86$, $p = .14$; Wilks' Lambda = .85; partial eta squared .15.When the results for the dependent variables were tested univariate, two variables reached statistical significance: Threshold I, $F = 5.28$, $p = .026$; partial eta squared .11 and Threshold II, $F = 7.17$, $p = .010$; partial eta squared .14, indicating that the athlete group had an elevated pain threshold compared with the control group. There was also a significant relationship between total score on the FPQ-III and Intensity II: $F = 5.34$, $p = .026$; partial eta squared .11.

Table 2

Multivariate linear analysis of variance

	Threshold I			Intensity I			Threshold II			Intensity II		
	F	η^2	*p*	F	η^2	*p*	F	η^2	*p*	F	η^2	*p*
Groups	5.29	.11	**.026**	.73	.02	.40	7.17	.14	**.010**	0.66	.02	.42
BLPR	0.86	.02	.36	1.58	.22	.04	2.00	.04	.16	1.36	.03	.25
FPQ	0.62	.01	.44	3.20	.07	.80	0.67	.02	.42	5.34	.11	**.026**
Grit	0.01	.00	.99	0.01	.00	.99	1.94	.04	.17	0.24	.01	.63
Age	0.11	.00	.74	0.25	.01	.63	0.01	.00	.98	1.24	.03	.27
Gender	0.01	.00	.97	0.12	.00	.73	0.56	.01	.46	0.01	.01	.95

Note: BLPR = Blood pressure. Groups = Athlete or non-athlete. *p*-values in bold are significant at $p < .05$ levels.

To test whether there was a significant difference in time spent in the cold pressor test, a Mann-Whitney U test was conducted. There was no significant difference in pain tolerance for the cold pressor test, between the athletes and the non-athletes, $U = 331.00$, $z = 0.21$, $p = .983$.

To test whether there was a significant difference in pain perception between the soccer players and the endurance athletes, a Mann-Whitney U test was executed. There was no significant difference between the soccer players and the endurance athletes in the five pain perception variables.

Personality traits

A between-groups multivariate analysis of variance was performed to investigate whether the athletes differed from the control group in traits of personality. Preliminary assumption testing was conducted to check for normality, linearity, univariate and multivariate outliers, homogeneity of variance-covariance matrices, and multicollinearity. No violations were found. Six dependent variables were used: extroversion, agreeableness, conscientiousness, neuroticism, openness to experience and grit. The independent variable was athlete or non-athlete.

There was no statistically significant difference between athletes and non-athletes on the multivariate test for the dependent variables, $F = 0.389$, $p = .88$; Wilks' Lambda = .95; partial eta squared .05. There were no statistical differences when the results for the dependent variables were considered separately.

The relationship between grit or fear of pain and the Big-Five personality traits, was investigated using Pearson product-moment correlation coefficient. Preliminary analysis were performed to ensure no violation of the assumptions of normality, linearity and homoscedasticity. There was no significant relationship between grit and fear of pain, and extraversion, agreeableness, conscientiousness, neuroticism and openness (table 3).

Table 3

Correlations among study variables

	Extraversion	Agreeableness	Conscientiousness	Neuroticism	Openness	FPQ	Grit
Extraversion							
Agreeableness	.07						
Conscientiousness	.10	.26					
Neuroticism	-.16	**.352***	.07				
Openness	.22	-.15	**-.319***	-.20			
FPQ	.01	.06	.00	.18	-.17		
Grit	.16	.13	-.01	.03	.16	-.26	

Note: *Correlation is significant at .05 level.

Fear of pain

The relationship between the total score of fear of pain and four of the pain variables was investigated using Pearson product-moment correlation coefficient (table 4). The level of pain intensity measured by a visual analogue scale was significantly related to the total score on the Fear of Pain III questionnaire (*r* = .32, *n = 51*, *p = .021).*

Table 4

Correlations among study variables

	FPQ	Threshold I	Intensity I	Threshold II	Intensity II
FPQ	1				
Threshold I	-.14	1			
Intensity I	.27	**-.392****	1		
Threshold II	-.15	**.772****	-.21	1	
Intensity II	**.322***	**-.340***	**.869****	**-.334***	1

Note: *Correlation is significant at .05 level, ** correlation is significant at .01 level.

Discussion

The main finding in the present study was that the elite athletes possessed significantly higher heat pain threshold than the control group. This finding match some of the existing literature (Flood, Waddington, Thompson, & Cathcart, 2017; Granges & Littlejohn, 1993; Guieu et al., 1992; Raudenbush et al., 2012; Roberts, Tchanturia, Stahl, Southgate, & Treasure, 2007). However, other studies have found no such difference (Ryan & Kovacic, 1966) while one study found a lowered pain threshold in athletes (Ord & Gijsbers, 2003).

The most recent meta-analysis on pain perception in athletes performed by Tesarz *et al.* (2012) found a wide variety in methods used for pain induction and results obtained. It also emphasized the lack of large sample sizes, with all 15 eligible studies containing population sizes of *N* = <105, with an average of *N* = 60. Methods used to measure pain perception was pressure, ischemic, heat, CPT, electrical stimulation and finger flexion. Taking these aspects into consideration, it is difficult to conclude whether athletes have a higher pain threshold than the normal population, and which mechanisms may be influential.

Further research should focus on providing larger sample sizes and testing athletes from several sports with the same pain apparatus, to add knowledge to the specific field.

A remarkable finding was that there was no difference in pain tolerance between the athlete group and the control group. This contradicts most of the results from previous research within this field, concluding that athletes have consistently elevated pain tolerance (Ord & Gijsbers, 2003; Raudenbush et al., 2012; Tajet-Foxell & Rose, 1995; Tesarz, Schuster, Hartmann, Gerhardt, & Eich, 2012; Thornton, Sheffield, & Baird, 2017). One possible explanation could be the confounding effect of a more than normal physically active control group. The control group was recruited through posters at the university area and on average the control group had either started studying or already finished a university degree. Previous research has shown that level of exercise increases with level of education (Trost, Owen, Bauman, Sallis, & Brown, 2002; Vaage, 2004). A study conducted in 2007 showed that 83% of the Norwegian population were classified as inactive, meaning they engaged in less than 3,5 hours of weekly physical activity (Ommundsen & A. Aadland, 2007). The present study's control group averaged 5.2 hours of weekly physical activity. The fact that the control group was substantially more physically active than the normal population, generate a non-representative control group. This may be a contributing factor to why the athlete group and the control group did not differ in differ in grit, fear of pain or pain tolerance.

There is little to no research on pain perception in cross country-skiers, and even though we did not find a difference in pain perception between soccer players and the endurance athletes, the sample size is too small to draw any conclusions. Because the sample size is small, it increases the possibility of a statistical type II error, giving a non-significant difference in the results although a pain perception difference might be present.

The athletes did not report any less fear of pain than the normal population group. This result was based on the total score of the FPQ-III and not the subscales. It is contradicting compared to previous findings, which showed that athletes had decreased fear of pain (Assa, Geva, Zarkh, & Defrin, 2018; Geva & Defrin, 2013). One possible explanation is athletes relating pain to injuries, which in their profession can affect their career or be career changing. Another explanation is that the formulation and content of the questions is not specific enough to differentiate the athletes from the control group, because the questions are not related to pain experienced in sports, moreover acute pain experienced in daily life situations – and some extreme situations. We also know that the control group is not a representative sample of the Norwegian population, which makes it difficult to conclude that athletes and non-athletes have the same levels of fear of pain.

The total score on fear of pain was positively correlated with the level of pain intensity reported on the visual analogue scale. In other words, heightened pain-related fear equals higher sensitivity of pain. This result match previous findings. For example, George, Dannecker and Robinson (2006) found that fear of pain significantly predicted acute pain intensity levels, more so than pain catastrophizing. A follow-up study conducted by Hirsh, George, Bialosky and Robinson (2008) replicated this exact finding. Also, a review paper conducted in 2007, suggested that pain-related fear is associated with catastrophic (mis)interpretations of pain, hypervigilance, increased avoidance behaviors, as well as intensified pain intensity and functional disability (Leeuw et al., 2007).

The two groups did not differ in scores on the Grit-S scale. This result is contradictive of previous research on the field (Meyer et al., 2017). Furthermore, a recent meta-analysis has provided a question of the merit of grit construct in performance realms, suggesting a need to investigate grit theory and measurement validity in sport before assuming construct relevance in athlete samples (Credé, Tynan, & Harms, 2017). Another possible explanation of this finding is the inherent difference between sports achievement (often a voluntary endeavor), and academic achievement (often an obligatory endeavor) (Meyer et al., 2017). Meyer, Markgraf & Gnacinski (2017) recommend avoiding terms like grit in sports, because little to any evidence supports the existence of the construct or its significance in the sports domain. Further research is needed to understand the merit of grit as a personality trait among competitive athletes.

Additionally, grit did not correlate with fear of pain, or any of the big-five personality traits. Previous research has shown grit to be highly correlated with the trait of conscientiousness (Duckworth et al., 2007; Ivcevic & Brackett, 2014; Reed et al., 2014; Reed, Pritschet, & Cutton, 2013). However, neither of these studies used the BFI-10 and all studies had sample sizes $N > 200$, which may be an explanation of why we did not find a correlation between grit and conscientiousness. There is also a possibility of a statistical type II error, because of the small sample size.

Regarding personality traits, there was no significant difference observed between the athletes and non-athletes. Previous research has been inconsistent, with some studies finding that athletes have higher scores on conscientiousness (Malinauskas, Dumciene, Mamkus, & Venckunas, 2014) or extroversion (Colley, Roberts, & Chipps, 1985; Egloff & Gruhn, 1996), or openness to experience (Hughes, Case, Stuempfle, & Evans, 2003; Kajtna, Tušak, Barić, & Burnik, 2004). However, in a comprehensive meta-analysis regarding personality and physical activity, Rhodes and Smith (2006) concluded that physical activity involvement has a medium positive association with extraversion, a medium positive association with conscientiousness, and a small negative association with neuroticism. Taken into consideration that the control group in the present study on average engaged in 5.2 hours of physical activity a week, it is not remarkable that the two groups did not differ in personality traits.

Sports training is increasingly being recommended for pain management and health benefits (Geneen et al., 2017; Krustrup et al., 2018), and having specific knowledge about how different types of sports and psychical activity affect pain responses, can prove valuable to pain management. Therefore, future research of the interaction between sport type and pain responses can prove important to pain management across different patient groups. However, previous findings suggest that participating in professional sports also can lead to challenges with chronic pain. A study conducted by Drawer and Fuller (2001) showed that 80% of former professional soccer players reported pain in one lower extremity joint during one or more daily activities. They also concluded that the risk of developing osteoarthritis in at least one of the lower extremity joints was significantly higher for the athletes, than for the general population. Another study, conducted with NFL-players in the United States, reported that 93% of former athletes experienced pain in their daily life (Cottler et al., 2011). In the normal population, chronic pain has a weighted mean prevalence in adults of 20% (Geneen et al., 2017). Nonetheless, it is not uncommon to experience chronic pain after injury, and while injuries vary among sports, the risk of injury is inevitable when being an athlete (DiGiovanni, Fraga, Cohen, & Shereff, 2000). With most former athletes reporting pain having experienced injury, it is likely that this is a result of injuries experienced in their sporting career and not a correlation of normal physical activity and chronic pain. This is supported by an overview study of physical activity and exercise for chronic pain in adults (Geneen et al., 2017). They included 381 studies in their overview and concluded with favorable effects of reduction in pain severity and improved physical function, although the quality of evidence was low due to small sample sizes.

Strengths

There are many strengths in the present study, including the use of well tested pain inducing methods like the cold pressor test and the heat pain apparatus to conduct quantative sensory testing. QST is considered a reliable method for psychophysical assessment of cold and heat pain (thermoalgesic) perception (Verdugo & Ochoa, 1992; Yarnitsky, Sprecher, Zaslansky, & Hemli, 1995).

In addition to the instruments being validated through multiple studies, we also applied several types of pain measurements. This is of high importance, since different experimental pain inducing methods, have shown divergent results (Flood et al., 2017; Jones et al., 2014; Raudenbush et al., 2012; Ryan & Kovacic, 1966; Scott & Gijsbers, 1981; Sullivan et al., 2000; Thornton et al., 2017). Furthermore, this is the first study who has compared pain measurements and specific personality traits, like grit and fear of pain, in elite athletes. With most other studies only using a singular pain modality (Tajet-Foxell & Rose, 1995), examining only grit (Meyer et al., 2017), personality traits in athletes (Egloff & Gruhn, 1996; Hughes et al., 2003; Malinauskas et al., 2014), or fear of pain in athletes (Geva & Defrin, 2013) , this intricate study combined all the variables above.

Limitations

Although the present study presents novel data, several limitations should be considered. First, we did not examine the participants' history of exposure to painful experiences. A study conducted in 2004 found that 14 of the 30 items in the FPQ-III, had a moderate to strong exposure effect (e.g., receiving an injection in your arm). Other items, like receiving an injection in your arm, only had a marginally significant effect, while others (e.g. biting your tongue while eating) had a non-existing exposure effect. The remaining items were not compatible since participants had not been exposed to them (e.g. breaking your neck) (Albaret et al., 2004). The results supported the previous findings of Linton and Vlaeyen (2000). Future studies should examine participants' previous pain experience, in addition to other factors that may affect pain perception and modulation in athletes, including competitiveness, self-efficacy, catastrophizing and coping styles.

Second, the present study had a limited sample size (*N* = 51). A larger sample size could have strengthened the results and improved the reliability and validity of the obtained results.

Finally, the study faces the challenge of ecological validity. Even though consensual pain induction techniques can be administered in a controlled and safe environment, individuals know that the induced pain can be terminated at any time. This does not replicate the same nature of the pain experienced in training or competition by the athletes. The same challenge applies for the type of pain induced, in this case heat and cold pain. The soccer players experience periods of pain associated with short bouts of supramaximal intensity and receiving blows from opponents or the ball (Mohr et al., 2003). The endurance athletes experience a prolonged interoceptive pain caused by persistent activity close to maximal oxygen uptake (Sagelv et al., 2018). In addition, the pain athletes' experience is often in situations with elevated levels of adrenaline. The challenge for future research is to find useful procedures for distinguishing what mechanisms underly pain perception, in a real-world sport situation.

Conclusions

The data obtained in the present study showed that athletes had significantly higher pain threshold levels, but not pain tolerance, compared to the control group. This finding is supported by some of the existing research, although other results have been somewhat inconsistent. The athlete and non-athlete group did not differ in fear of pain, grit or the Big-Five personality traits, which may be a consequence of a control group which proved not to be representative of a normal population. Furthermore, there was no significant difference in pain perception when comparing soccer players and endurance athletes, which again could be a type II error caused by a lack of participants competing in endurance sports. Additional research with larger population sizes and a representative control group needs to be conducted to provide a better understanding of pain perception in athletes.

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1 Forespørsel om deltakelse i forskningsprosjektet

Påvirker personlighet og fysisk trening smertesensitivitet og smertetoleranse?

Dette er et spørsmål til deg om å delta i et forskningsprosjekt for å undersøke hvordan fysisk trening og personlighet påvirker opplevelse av fysisk smerte. I denne studien søker vi friske personer mellom 18-40 år. Vi søker personer som driver med idrett på topp nasjonalt nivå, og personer som trener mindre eller ikke trener til daglig. Denne studien er en del av et større forskningsprosjekt der formålet er å undersøke hvordan fysiologiske faktorer og personlighet påvirker hjernens respons på smerte. Du forespørres derfor om å delta i denne studien for å inngå i den kontrollgruppen som består av friske frivillige. Institutt for Psykologi, Universitetet i Tromsø, er ansvarlig for denne studien. Du kan ikke delta i denne studien dersom du har eller har hatt behandlingstrengende sykdommer som hjerte/kar lidelser (inkludert påvist høyt blodtrykk), kreft, stoffskiftesykdommer, psykiske lidelser, skader på huden på armene, eller nevrologiske sykdommer eller skader på hjerne eller sentralnervesystemet. Du kan ikke delta dersom du får reseptbelagte medikamenter utenom p-piller, astmamedisin eller dersom du er gravid.

1.1 Hva innebærer PROSJEKTET?

Studien innebærer at du gjennomfører eksperimentell smertetesting og fyller ut flere skjemaer som måler personlighetstrekk. Smertetestingen gjøres ved at du får påført varme ved en metallplate på huden, og at du må holde en hånd i et bad med kaldt vann. Underveis vil du bli bedt om å rangere når varmen eller kulden går over til å bli smerte, samt at du vil bli bedt om å rangere hvor smertefullt du opplever varmen eller kulden. Data som innhentes fra personlighetsmålene og smertetestingen skal kun brukes til forskningsformål, og er ikke egnet til å si noe om verken din psykiske eller fysiske helsetilstand. Hele eksperimentet tar ca en time å gjennomføre.

1.2 Mulige fordeler og ulemper

Smertetestene som gjennomføres er ubehagelige og smertefulle, men innebærer ingen risiko for hudskader eller andre langvarige bivirkninger. Enkelte kan oppleve at huden blir rød i opptil to dager på armen der vi påfører varmesmerte. Dette er ufarlig, men kan oppleves som ubehagelig. Enkelte kan oppleve svimmelhet ved å ha hånden i kaldt vann. Dette gjennomføres derfor mens du sitter og under overvåkning av personell som har opplæring og erfaring med å gjennomføre smertetesting. Alle smertetestene er ufarlige for friske personer, men medfører intens smerte som går over når forsøket er over. Å fylle ut skjema om personlighet kan oppleves som ubehagelig, men denne informasjonen behandles anonymt i prosjektet. Det er ingen åpenbare fordeler ved å delta i dette prosjektet.

1.3 Frivillig deltakelse og mulighet for å trekke sitt samtykke

Det er frivillig å delta i prosjektet. Dersom du ønsker å delta, undertegner du samtykkeerklæringen på siste side. Du kan når som helst og uten å oppgi noen grunn trekke ditt samtykke. Dersom du trekker deg fra prosjektet, kan du kreve å få slettet innsamlede opplysninger, med mindre opplysningene allerede er inngått i analyser eller brukt i vitenskapelige publikasjoner. Dersom du senere ønsker å trekke deg eller har spørsmål til prosjektet, kan du kontakte prosjektleder Per M. Aslaksen, tlf 776 49234, per.aslaksen@uit.no

1.4 Hva skjer med informasjonen om deg?

Informasjonen som registreres om deg skal kun brukes slik som beskrevet i hensikten med studien. Du har rett til innsyn i hvilke opplysninger som er registrert om deg og rett til å få korrigert eventuelle feil i de opplysningene som er registrert.

Alle opplysningene vil bli behandlet uten navn og fødselsnummer eller andre direkte gjenkjennende opplysninger.

Prosjektleder har ansvar for den daglige driften av forskningsprosjektet og at opplysninger om deg blir behandlet på en sikker måte. Informasjon om deg er anonymisert og vil forbli anonymt også etter prosjektslutt.

1.5 Forsikring

Deltakerne i denne studien er dekket av produktansvarsloven.

1.6 Økonomi

For å dekke utgifter til transport og tidsbruk vil du motta et elektronisk gavekort på Kr 200,-

1.7 Godkjenning

Prosjektet er godkjent av Regional komite for medisinsk og helsefaglig forskningsetikk, prosjekt nummer 2017/1947.

2 Samtykke til deltakelse i PROSJEKTET

2.1 Jeg er villig til å delta i prosjektet

Sted og dato

Deltakers signatur

Deltakers navn med trykte bokstaver

Hvor godt mener du at de følgende utsagnene beskriver din personlighet?

Jeg er en person som..

	Helt uenig	**Litt uenig**	**Verken enig eller uenig**	**Litt enig**	**Helt enig**
Er reservert	(1)	(2)	(3)	(4)	(5)
Stoler på andre	(1)	(2)	(3)	(4)	(5)
Tenderer til å være lat	(1)	(2)	(3)	(4)	(5)
Er avslappet, håndterer stress bra	(1)	(2)	(3)	(4)	(5)
Har få kunstneriske interesser	(1)	(2)	(3)	(4)	(5)
Er utadvendt og sosial	(1)	(2)	(3)	(4)	(5)
Bruker å påpeke feil hos andre	(1)	(2)	(3)	(4)	(5)
Fullfører det jeg har begynt på	(1)	(2)	(3)	(4)	(5)
Blir lett nervøs	(1)	(2)	(3)	(4)	(5)
Har en livlig fantasi	(1)	(2)	(3)	(4)	(5)

Fear of pain questionnaire – III

Instruksjon: Setningene under beskriver smertefulle opplevelser. Les hvert spørsmål og tenk på hvor redd du er for å oppleve SMERTEN som er forbundet med hver opplevelse. Hvis du aldri har opplevd smerte knyttet til en av situasjonene, svar slik du forventer at FRYKTEN ville vært dersom du hadde en slik opplevelse. Sett en sirkel rundt tallverdien for å rangere din FRYKT FOR SMERTE i forhold til hver opplevelse.

GRAD AV FRYKT

Ikke i det hele tatt	Litt	En god del	Veldig mye	Ekstrem	
1	2	3	4	5	1. Være med i en bilulykke.
1	2	3	4	5	2. Bite deg i tungen mens du spiser.
1	2	3	4	5	3. Brekke armen.
1	2	3	4	5	4. Skjære deg i tungen på en konvolutt.
1	2	3	4	5	5. Noe tungt treffer deg i hodet.
1	2	3	4	5	6. Brekke en fot.
1	2	3	4	5	7. Slå deg på et følsomt sted på albuen.
1	2	3	4	5	8. Ta en blodprøve med en sprøyte.
1	2	3	4	5	9. Noen slenger en tung bildør over hånden din.
1	2	3	4	5	10. Ramle ned en betongtrapp.
1	2	3	4	5	11. Få en injeksjon med en sprøyte i armen.
1	2	3	4	5	12. Brenne fingrene på en fyrstikk.
1	2	3	4	5	13. Brekke nakken.
1	2	3	4	5	14. Få en injeksjon med en sprøyte i hoften.
1	2	3	4	5	15. Få en flis i fotsålen og deretter få den fjernet med pinsett.

Fortsetter på neste side.

GRAD AV FRYKT

Ikke i det hele tatt	Litt	En god del	Veldig mye	Ekstrem	
1	2	3	4	5	16. Få et objekt som sitter fast i øyet ditt fjernet av en lege.
1	2	3	4	5	17. Få en injeksjon med en sprøyte i munnen.
1	2	3	4	5	18. Bli brent i ansiktet av en sigarettglo.
1	2	3	4	5	19. Kutte en finger på papir.
1	2	3	4	5	20. Måtte sy sting i leppa.
1	2	3	4	5	21. Få en vorte på foten fjernet av en lege med et skarpt instrument.
1	2	3	4	5	22. Kutte deg med en skarp barberhøvel når du barberer deg.
1	2	3	4	5	23. Svelge en varm drikk før den er avkjølt.
1	2	3	4	5	24. Få sterk såpe i øynene mens du dusjer eller bader.
1	2	3	4	5	25. Få en dødelig sykdom som gir deg daglig smerte.
1	2	3	4	5	26. Få trukket en tann.
1	2	3	4	5	27. Kaste opp flere ganger på grunn av matforgiftning.
1	2	3	4	5	28. Få sand eller støv blåst inn i øynene.
1	2	3	4	5	29. Bli boret i en tann.
1	2	3	4	5	30. Få muskelkrampe.

GRIT

Svaralternativer: 1 = Slett ikke typisk meg til 5 = Veldig typisk meg

1. **Jeg setter meg ofte et mål for seinere å ombestemme meg og jobbe mot et annet**

1	**2**	**3**	**4**	**5**

2. **Nye ideer og nye prosjekter kan noen ganger distrahere meg fra de jeg egentlig holdt på med**

1	**2**	**3**	**4**	**5**

3. **Jeg har vært besatt av en bestemt ide eller prosjekt i en kort periode, men har senere mistet interessen**

1	**2**	**3**	**4**	**5**

4. **Jeg har problemer med å holde fokus på prosjekter som krever mer enn noen få måneders tid å fullføre**

1	**2**	**3**	**4**	**5**

5. **Jeg gjør ferdig alt jeg begynner på**

1	**2**	**3**	**4**	**5**

6. **Tilbakegang tar ikke motet fra meg**

1	**2**	**3**	**4**	**5**

7. **Jeg er hardtarbeidende**

1	**2**	**3**	**4**	**5**

8. **Jeg er flittig**

1	**2**	**3**	**4**	**5**