Running Head: Contact sports, motor performance, coping

Title: Exposure to contact sports results in maintained performance during experimental pain

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Highlights

- Contact sport participation is associated with adaptive pain responses
- Challenge states/adaptive coping may help to maintain performance during pain
- Pain tolerance may not be as important for maintained performance in pain

Key words: athletes, challenge, coping

Abstract

During pain, motor performance tends to decline. However, athletes who engage in contact sports are able to maintain performance despite the inherent pain that accompanies participation. This may be the result of being challenged rather than threatened by pain; adaptive coping strategies; habituation to pain; or finding pain less bothersome. This study aimed to measure performance of a novel motor task both in pain and not in pain within experienced contact athletes (n = 40), novice contact athletes (n = 40) and non-contact athletes (n = 40). Challenge and threat perceptions were manipulated during the pain condition and measures of pain tolerance, perception, coping styles and bothersomeness were taken. Results indicated that contact athletes, regardless of experience, were able to maintain their performance during painful stimulation. Non-contact athletes, conversely, performed significantly worse during pain stimulation. In addition, contact athletes tended to be more challenged and the non-contact athletes more threatened within the pain condition. Experienced contact athletes demonstrated higher levels of pain tolerance and direct coping, and reported lower levels of pain bothersomeness and intensity than the other groups. The results suggest that even relatively brief exposure to contact sports may be enough to help maintain performance in pain. Being in a challenged state appears to be an important factor during performance in pain. Moreover, pain tolerance, intensity and bothersomeness may differentiate novice and experienced athletes.

Perspective

Exposure to voluntary pain and challenge states are associated with adaptive responses to pain. Motor task performance may be maintained in individuals with more experience of sports-related pain.

Introduction

Athletes who play contact sports have a higher pain tolerance and report lower pain intensity than other athletes[31,30,33]. These reduced pain responses may result in contact athletes being able to cope better, and therefore perform better in pain than non-contact athletes[34]. Evidence suggests that performance in both complex and simple motor tasks tends to decline during painful stimulation in the general population[5] (. It is clear that some athletes are able to maintain performance despite the pain inherent in high contact sports such as rugby, however the mechanisms underpinning this ability are not yet fully understood. One explanation of the performance in pain of contact athletes is that they may perceive painful situations as challenging and may use adaptive coping approaches[23,;17]. In contrast, athletes who have less experience of pain may perceive those situations as threatening. Challenge and threat are two distinct psychophysiological responses to stressors[3,33] . Challenge is considered an adaptive approach to a motivated performance situation (e.g. a stressor such as competition), when personal resources exceed perceived situational demands, whereas threat is considered a maladaptive approach, occurring when personal resources do not meet perceived situational demands[2]. The Theory of Challenge and Threat States in Athletes (TCTSA;[17]) suggests that challenge and threat states can be manipulated via task instructions and that induced challenge states result in enhanced performance compared to induced threat states. These states can be effectively indexed using a combination of cardiovascular responses and self-report measures.

Challenge states are correlated with adaptive pain coping styles such as direct coping, which reflects an athletes' willingness to view pain as necessary and something to be overcome. Experienced contact athletes exhibit higher levels of direct coping and are more challenged by pain compared to non-contact athletes[34].

Catastrophizing, by contrast, is a maladaptive coping style, linked to threat states and poor performance during experimental pain[19]. Non-contact athletes may catastrophize more than contact athletes (cf.[33]) and we hypothesise that experienced contact athletes will be more challenged in pain, have higher direct coping and lower catastrophizing than non-contact athletes.

A final consideration is pain bothersomeness, which, when high, results in poor physical functioning[26]. Evidence suggests that it also reduces as a result of experience[10].

We tested five hypotheses:

1. Experienced contact athletes will be able to maintain performance in pain
2. Non-contact athletes will perform worse in pain compared to when not in pain

3. Experienced contact athletes will feel more challenged in pain compared to when not in pain

3.5 Experienced contact athletes' performance will not deteriorate as much as others in the threat condition

4. Experienced contact athletes will have higher direct coping and lower catastrophizing than non-contact athletes

5. Experienced contact athletes will find pain less intense, bothersome and will tolerate more pain than non-contact athletes.

The aim of this study is to examine the performance of a motor task both in pain and not in pain, amongst experienced and novice contact athletes, and non-contact athletes. Challenge and threat appraisals are manipulated to examine their role during painful stimulation.

Method

Participants

One hundred and twenty university athletes took part – the sample was characterised by a relatively even sex split (male n = 63 and female n = 57), and a mean age of 22.1 years (SD = 3.8 years). The sample size was calculated based on prospective estimates of power and effect size figures to achieve an acceptable power level of 0.8 and a large effect size of d= 0.5[7]. Participants, who were pain and injury free at the time of testing, were recruited via social media, notices placed around campus and word of mouth. They were divided into three groups according to their experience of contact sports (experienced contact athletes, novice contact athletes and non-contact athletes); experienced contact athletes (n = 40) played contact sports such as rugby or American football for more than three years, (M experience = 112.2 months, SD = 61.7 months); novice contact athletes (n = 40) took part in contact sports and had less than six months experience (M = 3.82 months, SD = 0.85 months); non-contact athletes (n = 40), played sports where contact is not allowed within the rules, for example netball and volleyball (M = 87.85 months, SD = 35.80 months). All participants provided informed consent to participate. The study was approved by the University of Derby Psychology Research Ethics Committee and was undertaken in accordance with the Helsinki Declaration (1975).

Materials and Measures

Motor task performance.

Twenty numbered targets were placed on a wall in a random order and at different heights. Participants were instructed to aim to hit ten targets with a tennis ball. The researcher informed participants of which target to aim for immediately before each attempt. The sequence for the ten targets was random (i.e. not sequential), but was the same for each participant to ensure that the task was consistent for all. Only one attempt at each target was allowed. Performance was measured based on how many targets were successfully hit and how long it took to complete ten targets, to account for decision making and to ensure there was no trade-off for time versus accuracy. All targets were placed in the same way on the wall for all participants and were occluded until the test started so participants could not memorise the positions of the targets. Participants were seated throughout each task at a distance of five metres from the targets. The purpose of the motor task was to replicate potential sporting actions (such as throwing and scanning) as well as the decision making processes that may be involved in sport (by calling out the numbers at random) to provide a degree of ecological validity. It should be noted that this test has not been validated as a measure, but the aim was to design a novel task with some element of sporting action involved.

Pain stimulus.

Pain was induced using a digital pressure algometer (Wagner Force Ten™ Digital Force Gage, FDX 50) on the non-dominant arm at the site of the extensor indicis proprius. The algometer was pressed in a vertical direction, toward the medial side of the radius from a position of three fingers above the radial styloid process, as recommended by Park et al.,[25] .Force was increased at a constant rate of 1N/cm2, creating a dull pain that intensifies with time, but causes no tissue damage[16]. Pressure algometry is reported to be a reliable measure of pain tolerance in muscle, joints, tendons, and ligaments[6]and was considered the experimental pain modality closest to contact pain to ensure some ecological validity of study findings.

Demographic questionnaire.

Participants were required to provide their age, sex, sport, number of months playing the sport and the level at which they played their sport (e.g. recreational, county, national).

Sport Inventory for Pain (SIP15)[4]

The SIP15 was used to measure coping styles of the participants. The SIP15 was developed from the original Sports Inventory for Pain[22] and is a 15-item inventory that contains three subscales – Direct

Coping, Somatic Awareness and Catastrophizing. The SIP15 is considered to be a valid and reliable measure of pain coping styles[4].It was designed to be a sports specific measure of pain coping styles and was developed by drawing on a number of established inventories such as the Coping Strategies Questionnaire[29] and the Pain and Impairment Relationship Scale[28]. The Catastrophizing scale measures whether individuals ruminate on pain, feel it is unbearable or simply capitulate when in pain. Direct Coping (through action) is a positive coping style in relation to pain and assesses the extent to which someone uses direct coping strategies to deal with pain. People who score high on this scale tend to approach pain positively and are challenged by it. The Somatic Awareness scale assesses whether someone is hyposensitive or hypersensitive to pain stimuli. All questions are answered on a 5-point Likert scale with anchors of *strongly agree* and *strongly disagree*.

Effort, bothersomeness, pain intensity Heart Rate Variability (HRV) and cognitive appraisal.

Effort was measured on a 5 point Likert scale with anchors of 1 = *no effort at all* and 5 = a *great deal of effort* in both the pain and no pain condition. The bothersomeness question asked participants to rate how bothersome the pain was both physically (i.e. how much it interfered with physical functioning) and psychologically (i.e. how much it interfered with mental functioning) during the motor task. This was measured on a 5 point Likert scale with anchors of 1 = *not bothersome at all* and 5 = *extremely bothersome,* cf.[14]. Pain intensity was measured using a Visual Analog Scale (VAS) which consisted of a 10cm line with anchors of 0 = *no pain at all* and 10 = *worst pain imaginable*. Participants were asked to mark on the line how intense the pain was immediately after the pressure algometer was removed. Measurement was then taken in millimetres from the start of the line to the mark made by the participant. Visual Analog Scales have proved to be reliable and valid for measuring the intensity of acute pain[1]. The cognitive appraisal question asked participants to consider their feelings before the test, measured on a 9 point Likert scale with anchors of -4 = *threatened,* 0 = *neither* and +4 = *challenged* (see[36]).

HRV was measured to confirm challenge and threat states using the application ithlete™ (HRV Fit Ltd. Southampton, UK). This uses a cone placed over the tip of the index finger to measure HRV and has been successfully validated with ECG measures[12]. Ithlete™ measures the root mean square of successive R-R intervals, (RMSSD) within a 55 second time frame. This measure indicates the square root of the mean of the sum of the squares of differences between adjacent normal R-R intervals during the time frame and measures the beat-to-beat variability of heart rate. Such variation in vagal tone has been proposed to indicate challenge and threat states, and is positively correlated with HRV[18]. Individuals with high HRV tend to feel less threatened than those with low HRV[8] and high HRV is indicative of a buffer to threatening situations[24].

Procedure

Immediately prior to the test, participants completed the brief demographic questionnaire. Resting HRV was then taken as a baseline. Participants then underwent a pre-procedure pressure pain test to measure maximum tolerance in Newtons. This was used to determine 75% of their maximum pain tolerance which was then applied during experimental pain conditions, based on the recommendation of Brewer et al. (1990)[5], who defined this as "moderate pain" using a similar gross pressure device. Following baseline measurements, participants completed the motor task either without pain (as a baseline measure) or with pain. Conditions were randomised to account for order and carry over effects, see fig 1.

During the pain condition, participants were randomly allocated to a threat or a challenge condition. Accordingly, participants received either instructions designed to promote a challenge state or a threat state before they completed the motor task in pain. The instructions were derived from the wording of questions related to direct coping on the SIP15. The challenge condition instructions were: *"You will be asked to perform the task whilst you are in pain. You should be able to cope with this, many people do. You should not let the pain stand in the way of completing the task and you should be able to tough it out. You have the ability to be successful at this task and the pain should not interfere with your performance. You can therefore be confident that you will score highly. The protocol is set up in a way to allow you complete the task without any complications".*

The threat condition instructions were: *"You will be asked to perform the task whilst you are in pain. You may not be able to cope with this, many people do not. The pain may stand in the way of completing the task and you may not be able to withstand it. You may fail at this task and the pain may interfere with your performance. You therefore can't be confident that you will score highly. The protocol is set up in a way which may hinder your performance in the task."* The instructions were read out verbatim from an instruction sheet and were read by the same researcher on each occasion.

Following these instructions, HRV was taken again, then participants completed the motor task whilst experiencing pressure pain. Pressure was applied to the site, using a 1 cm rubber tip, at a constant rate, based on 75% of the maximum established at baseline. Immediately after the pressure pain was removed, participants completed the VAS to indicate the intensity of the pain. Following testing all participants completed the SIP15, bothersomeness, cognitive appraisal and effort scales. A rest period of 60 minutes was given to the participants between pain and non-pain conditions.

The non-pain condition followed the same procedure, but with no pain stimulus present and no challenge/threat instructions given. HRV was taken after instructions were provided. Following the no pain task participants completed the effort and cognitive appraisal questionnaires. At the completion of testing all participants were thanked and debriefed.

Data Analysis

All participants were included in the final dataset. Data were analysed using ANOVA and MANOVA. ANOVA was used to examine performance differences in pain and not in pain within each athlete group and to explore differences between athlete groups in bothersomeness, pain intensity and pain tolerance. A mixed ANOVA examined the interaction between challenge and threat, athlete type and performance measures*. MANOVA was used to investigate the SIP15 subscales, using athlete group (i.e. experienced contact athlete, novice contact athlete and non-contact athlete) as the independent variable and the SIP15 subscales as dependent variables. Post-hoc Bonferroni tests were performed where necessary. When ANOVAs were conducted to examine the interaction between challenge and threat, athlete type and performance measures, we tested for interaction effects of gender and there were none.

Effort was examined in both pain and no pain conditions to check that athletes exerted themselves equally in both conditions. A 2x2x3 mixed ANOVA using the independent variables of pain/no pain condition, challenge/threat condition, and athlete type (experienced contact athlete, novice contact athlete and non-contact athlete) was conducted. The dependent variable was the amount of perceived effort expended.

Results

A manipulation check was conducted to establish whether the challenge and threat instructions were effective. Independent t-tests revealed that HRV was significantly higher in the challenge group compared to the threat group, $t_{(118)} = 3.60$, $p < 0.0001$, $r = 0.31$, a medium effect size. Cognitive appraisal was higher in the challenge condition compared to the threat condition, $t_{(118)} = 1.94$, $p = 0.05$, $r = 0.17$, a small effect size, indicating that the participants were more challenged in the challenge condition. There were no differences between athlete groups at baseline for cognitive appraisal $F_{(2,117)} = 1.17$, $p = 0.31$ or HRV $F_{(2,117)} = 1.24$, $p = 0.29$.

Table 1 displays descriptive statistics for each variable by athlete type. There was no significant main effect of effort, nor were there any interactions ($p > 0.05$), therefore perceived effort was the same regardless of condition and athlete type. In order to test hypotheses 1 and 2, a repeated measures ANOVA was performed to examine differences in performance (targets hit and time to complete the task) whilst in pain compared to when not in pain. There was a significant interaction between pain condition and athletes type, $F_{(6, 351)} = 8.96$, $p < 0.0001$. Paired t-tests were used to examine this further and results are summarised in table 2. Experienced contact athletes performed significantly faster in pain than not in pain, but there were no performance differences for targets hit. Hypothesis 1 was therefore partially supported. In addition, novice contact athletes maintained their performance whilst in pain and there were no significant differences between targets hit in each condition, or time taken to complete the task. Non-contact athletes hit significantly fewer targets in pain compared to when not in pain, and they were significantly slower in pain compared to when not in pain. Therefore, hypothesis 2 was supported.

To test hypothesis 3, paired samples t-tests were conducted within each athlete group to establish if challenge and threat states were different in pain compared to when not in pain. Experienced contact athletes felt more challenged in the pain condition compared to the no pain condition and they had higher HRV in the pain condition compared to the no pain condition. Novice contact athletes also felt significantly more challenged in the pain condition compared to the no pain condition however there were no differences in HRV for this group. The non-contact athletes felt significantly more threatened in the pain condition compared to the no pain condition and had significantly lower HRV in the pain condition compared to the no pain condition. Accordingly, hypothesis 3 was supported. A 3x2x2 ANOVA was conducted to explore interactions between athlete type, challenge or threat condition and performance. We examined both actual performance measures (i.e. how many targets were hit and time to complete) and differences in these measures between the pain and no pain conditions. There were no 3-way interactions between athlete type, challenge or threat and performance measures ($p > 0.05$). Therefore, hypothesis 3.5 was not supported.

In order to test hypothesis 4, that high contact experienced athletes would have higher direct coping than other groups, a 3x3 MANOVA was conducted. There was a significant effect of athlete type on SIP15 subscales, $F_{(6,115)} = 15.50$, $\Lambda = 0.51$, $p < 0.0001$, $r = 0.34$, a medium effect size[7]. Experienced contact athletes had higher direct coping than novice contact athletes and non-contact athletes, $p < 0.0001$. In addition, novice contact athletes had higher direct coping than non-contact athletes, $p < 0.05$. Experienced and novice contact athletes catastrophized significantly less than non-contact athletes, $p < 0.0001$. Therefore, hypothesis 4 was partially supported.

To test hypothesis 5 for bothersomeness, MANOVA indicated that there was a significant interaction between pain condition and athlete type, $F_{(14,218)} = 1.77$, $V = 0.21$, $p = 0.44$, $r = 0.09$, a very small effect size. There was a significant difference between groups for psychological bothersomeness of pain, $F_{(2,114)} = 3.44$, $p = 0.03$, $r = 0.17$, a small effect. Experienced contact athletes found pain less psychologically bothersome than non-contact athletes, and novice contact athletes, $p < 0.0001$. A one-way ANOVA was conducted to examine differences in pain tolerance and intensity between the three groups. The independent variable was athlete type (experienced contact athlete, novice contact athlete and non-contact athlete). There was a significant effect of athlete type on pain tolerance, $F_{(2,117)} = 41.63$, $p < 0.0001$, $r = 0.64$, a large effect size. Experienced contact athletes had a higher pain tolerance than novice contact athletes, $p < 0.0001$ and non-contact athletes, $p < 0.0001$. There were no differences between novice contact athletes and non-contact athletes, $p = 0.29$. There was also a significant effect of athlete type on pain intensity, $F_{(2,117)} = 17.65$, $p < 0.0001$, $r = 0.48$, a medium effect size. Experienced contact athletes perceived the pain to be significantly less intense than novice contact athletes, $p < 0.0001$ and non-contact athletes, $p < 0.0001$. There were no differences between novice contact athletes and non-contact athletes, $p = 0.36$.

Discussion and conclusions

The purpose of this study was to examine performance differences between contact and non-contact athlete groups when challenged or threatened. The results indicated that contact athletes, regardless of experience were able to maintain their motor performance whilst experiencing experimental pain. Indeed, the experienced contact athletes even bettered their target performance whilst in pain. Conversely, non-contact athletes performed worse in pain compared to when not in pain. Contact athletes were more challenged and coped more positively with the pain, which was associated with maintained or bettered performance.

It appears that the contact athletes typically felt challenged by the pain stimulus, whereas the non-contact athletes felt threatened, regardless of any instructions provided. This was evidenced in the HRV and cognitive appraisal data, with medium to large effect sizes. Challenge states are conducive to successful performance[36] and it has also been suggested that challenge states result in less self-regulation, leaving more attentional capacity to execute tasks[17]. Indeed, it has been suggested that more attentional resources can be used to complete a task when perceived threat is low, which results in maintained performance[9]. The contact athletes also had higher direct coping, which is associated with challenge states and a positive approach to pain[22]. Experienced contact athletes had the highest direct coping, indicating that they perceived pain as something to be overcome and embraced rather than something to be feared and avoided. This, coupled with feeling challenged as opposed to threatened, may help participants to deal better with pain and work at completing the task[15]. The non-contact athletes, conversely, were threatened by and catastrophized about the pain, which is associated with poor motor task performance[35].

The experienced contact athletes, who performed the best in pain, were more pain tolerant and reported less pain intensity than novice contact athletes and non-contact athletes. Pain tolerance has been shown to increase over time in athletes who are regularly exposed to contact related pain[33], and becoming more tolerant to pain over time may be a fundamental factor in continued engagement in sports where pain is inevitable. It may also explain how contact athletes maintain performance despite experiencing apparently high levels of pain. Experienced contact athletes also found pain less psychologically bothersome than the other groups. The effect sizes for these measures were medium to large, indicative of a meaningful difference to individuals. Finding pain less bothersome may result in better performance as it is associated with feeling challenged and using more adaptive coping styles. Equally, athletes who report less bothersomeness may adhere to sports for longer, which may result in pain desensitisation[10,27,22] or enhanced conditioned pain modulation[13] (, both of which could explain a higher level of performance in pain amongst contact athletes.

This study adopted a between subjects design for the challenge and threat conditions, and there were no 3-way interactions between athlete type, challenge/threat and performance. This suggests that, despite the manipulation check being positive, pain overrode the instructions provided. Indeed many of the experienced contact athletes were challenged in the pain condition. The within subjects results indicated, however that regardless of instructions, the contact athletes felt challenged and the non-contact athletes felt threatened in pain compared to no pain. This suggests that typical challenge and threat instructions may become redundant when a pain stimulus is present as it is typically perceived as a threat by non-contact athletes and a challenge by contact athletes[11]. Qualitative research has shown that contact athletes often view pain as an occupational hazard and as a fundamental part of sport[20]. Therefore, in the laboratory these athletes may have simply viewed pain as manageable and challenging. Equally, athletes who participate in contact sports may simply be more motivated to experience pain or may adopt adaptive coping styles.

The experienced contact athletes and novice contact athletes differed on a number of measures which warrant discussion. The novice contact athletes reported higher psychological bothersomeness, higher pain intensity and were significantly less pain tolerant than the experienced group. Despite this, the novice contact athletes were able to maintain performance whist in pain. This may be a result of them feeling challenged during the pain condition, regardless of instructions provided. Novice contact athletes also reported lower direct coping than the experienced group, but had higher scores for this measure compared to the non-contact athletes. This suggests that adaptive coping styles may be learned early in contact sports by some individuals, thereby maintaining participation and with it, further exposure. It has been suggested that other changes such as those to pain bothersomeness, pain tolerance and pain intensity may take longer to develop in contact athletes[33]. The novice contact athletes did not differ from non-contact athletes on these measures, supporting such a suggestion. However, these variables may therefore not be as salient for maintained performance under experimental pain conditions. This, nevertheless warrants further investigation.

Limitations

The experimental nature of this study means that the pain stimulus used may not accurately reflect the true nature of pain experienced in sports via collisions and tackles. There are other alternatives such as thermal or ischemic pain, but pressure pain was chosen as it reflects, to some degree, the pain that might be felt within contact sports. Athletes also were aware that the stimulus was safe and finite, which is not necessarily the case in real life sporting situations. In addition, the motor task was designed to be novel for the athletes, but does not reflect the dynamic nature of sports participation. Due to the pain stimulus it was difficult to design a motor task that allowed athletes to move freely as they would in their sport, however the task did involve decision making, gross limb movement and co-ordination, all salient factors in sports performance. Further, using a contact – non-contact athlete dichotomy presents problems in terms of pain experienced in sport. That is, it is entirely probable that the non-contact athletes had experienced some form of pain, at some point, in their athletic careers. For example they may have experienced pain from other sources, such as injury or exertion. The experienced contact athletes reported significantly more injuries than the on-contact athletes, and the study does highlight that contact sports participants may respond differently to pain than other athletes. Put here – ch and threat only in pain – therefore statistical power was lessened -

Summary and Future Directions

This study demonstrated that exposure to contact sports is associated with challenge states and maintained performance during experimental pain. Athletes who engage in contact sports, even for a short period of time, may be more adapted to, and function better in pain. Pain indicators such as tolerance, perception and bothersomeness may be important to differentiate those with more experience of contact sports from those with less. Experienced contact athletes had higher pain tolerance, direct coping and reported lower pain intensity and bothersomeness compared to novices but both groups maintained performance in the experimental task; this may be due to the novice athletes also feeling challenged when in pain. Over time, increased pain tolerance, improved coping and reductions in pain intensity may develop in contact athletes and these factors may be helpful in maintaining adherence to contact sports. However, it does not appear that these need to be fully present to maintain performance in pain within contact athletes. Novice contact athletes had higher direct coping and were more challenged than non-contact athletes and therefore these may be the most important factors during task performance when in pain. Indeed, adaptive approaches such as these may explain why some athletes choose to engage in painful sports, and those who are more comfortable with pain may choose to play contact sports.

Further research should seek to examine the mechanisms through which challenge states and direct coping are developed and explore the temporal nature of coping and pain reporting within contact sports. Future studies could also aim to explore how coaches can develop adaptive pain coping strategies in athletes to facilitate effective performance despite the experience of pain. Understanding how contact athletes function in pain could be useful for other populations such as those suffering from post-surgical or injury-related pain. Strategies could be developed to help those suffering from clinical pain to be able to maintain performance on day to day tasks and feel more able to cope. This might expedite recovery processes and improve clinical outcomes.

This study is the first to examine pain responses and performance alongside challenge and threat states. Results suggest that voluntary exposure to contact sports may result in more adaptive responses to pain and that being challenged is important for maintained performance in pain.

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Legends

Figure 1: Procedure

Table 1: Descriptive statistics

Table 2: T-test results