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Running Head: Performance, pain, athletes, challenge and threat

Title: Motor performance during experimental pain: The influence of exposure to contact sports

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Significance

Athletes with even relatively small amounts of contact sport experience perform better during experimental pain than athletes who play non-contact sports. Experienced contact athletes had higher levels of direct coping and were more challenged and less threatened by pain than non-contact athletes.

Abstract

Background

Athletes who play contact sports are regularly exposed to pain, yet manage to perform complex tasks without significant decrement. Limited research has suggested that superior pain tolerance in contact athletes may be important in this context and this may be altered via experience of pain.

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Other psychological variables such as challenge states, pain bothersomeness and coping style may also influence skill execution during pain.

Methods

Forty experienced contact athletes (>3years experience), 40 novice contact athletes (<6months experience) and 40 non-contact athletes performed a motor task both in pain and without pain. During the pain condition, pressure pain was induced and half of each group were given challenge instructions and the other half threat based instructions. Measures of cognitive appraisal, heart rate variability, pain bothersomeness, tolerance and intensity, and coping styles were taken.

Results

Contact athletes, regardless of experience, performed better during pain compared to the non-contact athletes, this relationship was mediated by pain tolerance and physical bothersomeness. During threat condition, experience of contact sports moderated performance. Contact athletes were challenged by the pain, regardless of the instructions given, had higher direct coping and found pain less psychologically bothersome. Experienced contact athletes had higher pain tolerance and reported pain as less intense than the other groups.

Conclusions

Athletes who play contact sports may have better coping and adjustment to experimental pain, especially during threatening conditions. Performance during experimental pain is mediated by pain tolerance and physical pain bothersomeness.

Significance

Athletes with even relatively small amounts of contact sport experience perform better during experimental pain than athletes who play non-contact sports. Experienced contact athletes had higher levels of direct coping and were more challenged and less threatened by pain than non-contact athletes.

Introduction

Athletes regularly experience pain during competition and training, however the process by which they function well in pain, especially in sports where contact is integral (“contact sports”), is not fully understood. Meta-analysis has shown that athletes have a higher tolerance to pain than non-

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athletes (Tesarz, Schuster, Hartmann, Gerhardt, and Eich, 2012). In addition, there is evidence that contact athletes have a higher pain tolerance than non-contact athletes (Ryan and Kovacic, 1966). Recently, Thornton, Sheffield, and Baird (2017) found that ischaemic pain tolerance increases in adherent contact athletes over an eight-month sport season. This may be due to learning to cope with pain (Meyers, and LeUnes, 2001). Indeed, contact athletes demonstrate a high direct coping style, characterised by a willingness to endure pain and view it positively (Thornton et al., 2017). Athletes also use competitive coping strategies during pain (Manning and Fillingim, 2002; Ord and Gijsbers, 2003).

Contact athletes often perform complex tasks during inherently painful situations; however, pain inhibits performance of both complex and simple motor tasks (Brewer, Van Raalte and Linder, 1990). In the only study to examine athletes' performance during experimental pain, Walker (1971) reported that performance of a novel neuromuscular task deteriorated during pain. It is therefore unclear how contact athletes perform well whilst experiencing sports related pain. The most plausible explanation is that pain perception is altered via experience (Hall and Davies, 1991). Contact athletes typically report less pain intensity (Ryan and Kovacic, 1966), which could influence a number of variables such as cognitive appraisal and bothersomeness of pain and ultimately performance.

Performance in non-painful activities has been studied based on challenge and threat appraisals (Moore, Wilson, Vine, Coussens, and Freeman, 2013). Challenge states typically result in enhanced performance and threat, poorer performance (Turner, Jones, Sheffield, and Cross, 2012). If contact athletes have a high direct coping style, they may be challenged by pain (Jones, Meijen, McCarthy and Sheffield, 2009). Challenge and threat states can be assessed using self-report measures of cognitive appraisal (e.g. Turner et al., 2012) or physiological indexes such as heart rate variability (HRV; Laborde, Mosley, and Thayer, 2017). This research aims to explore the role of experience, challenge or threat states and coping styles during the performance of a motor task during experimental pain.

Hypotheses:

1. Decrements in performance associated with pain will be smaller in the experienced contact athletes relative to non-contact athletes and novice contact athletes
2. Challenge and threat manipulation will moderate the relationship between athlete type (i.e. contact sport experience level) and performance difference when in pain

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3. Pain tolerance, bothersomeness and direct coping will mediate the relationship between athlete type and performance difference when in pain
4. Experienced contact athletes will respond differently to pain than non-contact athletes and novice contact athletes: 4a. they will have higher pain tolerance, 4b. report pain as less intense, 4c. less bothersome; 4d. have higher direct coping and 4e. will be more challenged in pain (HRV and cognitive appraisal).

Methods

Participants

One hundred and twenty male (n = 63) and female (n = 57) college and university athletes took part in the study (M age = 22.1 years, SD = 3.8 years). They were recruited via social media, notices placed around campus and word of mouth. The groups were divided as follows; experienced contact athletes (n = 40) who had been participating for over three years in contact sports such as rugby or American football (M experience = 112.24 months, SD = 61.71 months); novice contact athletes (n = 40) were athletes who took part in contact sports such as rugby or American football for less than six months, with no other prior experience of contact sports (M = 3.82 months, SD = 0.85 months); and non-contact athletes (n = 40), who were athletes taking part in team sports where contact is not permitted within the rules, with no other prior experience of contact sports for example netball and cricket (M = 87.85 months, SD = 35.80 months). All participants were pain and injury free at the time of testing. The study was approved by the University Ethics Committee and was in accordance with the Helsinki Declaration (1975). See table 1.

Materials and Measures

Motor task performance.

Participants were instructed to aim to hit ten targets with a tennis ball. Twenty numbered targets were placed on a wall in a random order and at different heights. Participants were informed 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. This was to account for decision making and to ensure there was no trade-off for time versus accuracy. All

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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.

Pain tolerance.

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. Pain tolerance was measured by pressing toward the medial side of the radius from a position of three fingers above the radial styloid process, as recommended by Park, Kim, Park, Kim, and Jang (2011). The algometer was pressed against the site in a vertical direction while increasing the force at a constant rate of $1N/cm^2s$. The pressure creates a dull pain that intensifies with time, but causes no tissue damage (Hezel, Riemann, and McNally, 2012). Pressure algometry is reported to be a reliable measure of pain tolerance in muscle, joints, tendons, and ligaments (Chesterton, Sim, Wright, and Foster, 2007). A full pilot test was conducted beforehand to ensure the experimenter was familiar with the equipment.

Demographic questionnaire.

Participants were required to provide their age, gender, 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) (Bourgeois, Meyers and LeUnes, 2009).

The SIP15 was used to measure coping styles of the participants. The SIP15 was developed from the original Sports Inventory for Pain (Meyers, Bourgeois, Stewart and LeUnes, 1992) and is a 15-item inventory that contains three subscales – Direct Coping, Somatic Awareness and Catastrophizing. 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 prepared to endure it. The Catastrophizing scale measures whether individuals ruminate on pain, feel it is unbearable or simply give up when in pain. The Somatic Awareness scale assesses whether someone is hyposensitive or hypersensitive to pain

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stimuli. The SIP15 showed a sound factor structure and is a reliable tool where brevity is required when assessing in the field (Bourgeois et al., 2009.).

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

Effort was measured following the motor task to ascertain how hard participants felt they had tried in both the pain and no pain conditions. This was measured on a 5 point Likert scale with anchors of 1 = *no effort at all* and 5 = a *great deal of effort*. 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*. 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. 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* (based on Turner et al., 2012).

HRV was measured to confirm challenge and threat states. Recently Flatt and Esco (2013) have validated a smart phone application named ithlete™ (HRV Fit Ltd. Southampton, UK). This consists of a cone which is placed over the tip of the index finger to measure HRV. Results are then sent to a smart phone application which provides a HRV measure out of 100. 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. This has more practical uses when testing in the field as it is not as time consuming as ECG. Flatt and Esco cross validated ithlete™ with ECG measures obtained in the laboratory and found a near perfect correlation between the two devices for the measurement of HRV (r = 0.99). Vagal tone has been proposed to indicate challenge and threat states, and is positively correlated with HRV (Laborde et al., 2017). Individuals with high HRV tend to feel less threatened than those with low HRV (Cocia, Uscătescu and Rusu, 2012) and high HRV can act as a buffer to threatening situations (Miskovic and Schmidt, 2010).

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Procedure

On the testing occasion, participants completed the brief demographic questionnaire. Resting HRV was then taken as a baseline measure using ithlete™. Participants then underwent a baseline 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), 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.

In the pain condition, participants were randomly allocated to a threat or a challenge condition. Accordingly, participants received either challenge or threat based instructions 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 undergoing 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, the bothersomeness, cognitive appraisal and effort questionnaires. A rest period of 60 minutes was given the participants between pain and non-pain tests. The non-pain condition followed the same procedure, but with no pain stimulus present.

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HRV was taken after instructions were provided. Following the non-pain task participants completed the effort and cognitive appraisal questionnaires. At the completion of testing all participants were thanked and debriefed.

Data analysis

Data were analysed to determine how each group of athletes performed in pain and to examine the other variables measured such as direct coping, bothersomeness and challenge and threat states. A 3x2 MANOVA was conducted to examine differences between the groups of athletes using an alpha level of $p<0.05$. The independent variables were athlete type (experienced contact, novice contact, non-contact athlete) and pain condition (pain or no pain), the seven dependent variables were performance (targets hit and time to complete), physical and psychological bothersomeness, cognitive appraisal, HRV and effort. SIP subscale scores (direct coping, catastrophizing, somatic awareness) were analysed in a separate MANOVA as these were only taken once. 3x2 mixed ANOVAs were conducted to examine differences in groups for pain tolerance and pain intensity. Post-hoc Bonferroni tests were used where necessary. Mediation and moderation analysis were conducted using PROCESS for SPSS (Hayes, 2013) to test hypotheses 2 and 3. Further information regarding hypotheses and results can be found in the supplemental file.

Results

Challenge and threat and effort manipulation check.

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 (Cohen, 1988). 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; see table 1. There were no differences between athlete groups at baseline for cognitive appraisal $F_{(2,117)} = 1.17$, $p = 0.31$ or HRV $F_{(2,117)} = 1.24$, $p = 0.29$.

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Performance in pain and no pain

MANOVA was used to test hypothesis 1 regarding athlete group differences in performance in pain. There was a significant interaction between pain condition and athlete type, $F_{(14,218)} = 5.23$, V =0.50, $p < 0.0001$, r = 0.15, a small effect size. Both groups of contact athletes performed better in pain than non-contact athletes for targets hit, $F_{(2,114)} = 8.12$, $p < 0.001$, r = 0.25 and for time to complete, $F_{(2,114)} = 6.59$, p = 0.002, r = 0.23. Post-hoc Bonferroni tests indicated that experienced contact athletes hit significantly more targets in pain than non-contact athletes, $p < 0.0001$, and novice contact athletes hit significantly more targets in pain compared to the non-contact athletes, $p < 0.001$. Experienced contact athletes completed the task significantly faster than non-contact athletes, $p < 0.001$. Novice contact athletes also completed the task significantly faster than the non-contact athletes, $p < 0.01$. There was no performance difference between athlete groups in the no pain condition, $F_{(2,114)} = 1.31$, p = 0.27 (targets hit) and $F_{(2,114)} = 1.42$, p = 0.24 (time to complete). Hypothesis 1 was supported in relation to non-contact athletes only, see fig 2 and 3.

Moderation analysis was conducted using PROCESS for SPSS (Hayes, 2013) to test hypothesis 2. Athlete type (i.e. contact sport experience level; experienced contact, novice contact and non-contact athlete) was used as the predictor, performance difference between the pain and no pain condition was the outcome variable and challenge or threat manipulation were the moderators.

Performance difference was calculated for time to complete the task by subtracting the time taken to complete the task not in pain from the time to complete the task in pain. The same calculation was performed for targets hit. As such, lower (and more negative) scores indicate better/quicker performance for both measures.

For the performance measure of time to complete, threat moderated the positive relationship between athlete type and performance, b = -0.98, 95 CI [-0.36, -1.10], t = -3.77, $p < 0.001$. In addition, for the performance measure of targets hit, threat moderated the negative relationship between athlete type and performance, b = -1.0, 95 CI [-1.37, -0.62], t = -5.26, $p <0.0001$. This indicates that within the threat group, those with more experience of contact sports performed better than those with less experience.

Mediation analysis using PROCESS for SPSS was then conducted to test hypothesis 3. The predictor variable was athlete type (i.e. experienced contact, experienced novice and non-contact athlete) and the outcome was performance difference (in terms of targets hit and time to complete the task). The four mediators were placed into the model in the following order; pain tolerance, physical pain

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bothersomeness, psychological pain bothersomeness and direct coping. Bonferroni corrections were applied when examining each mediator. See fig 4.

Mediation for time to complete

Athlete type significantly predicted time to complete the task, b = 0.67, CI [0.35, 1.66] t = 3.12, $p < 0.001$. When the mediators were added to the model, there was a significant indirect effect of athlete type on time to complete the task through pain tolerance, b = 0.20, CI [0.08, 0.81], t = 1.98, p = 0.04. Physical bothersomeness was also a significant mediator, b = 0.62, CI [0.07, 1.11], t = 1.91, p = 0.05. This indicates that athlete type (i.e. contact sport experience level) influenced both pain tolerance and physical pain bothersomeness, which in turn, influenced performance. Those with higher contact sport experience had higher pain tolerance and reported lower physical pain bothersomeness and therefore performed better at the task.

Mediation for targets hit

Athlete type significantly predicted targets hit, b = -0.66, CI [-1.16, -0.09] t = -3.39, $p < 0.0001$, however none of the variables significantly mediated this relationship.

MANOVA and ANOVA were used to examine the fourth set of hypotheses regarding pain responses. Hypothesis 4a stated that experienced contact athletes would have higher pain tolerance than non-contact athletes and novice contact athletes. A one-way ANOVA indicated that 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. Post-hoc Bonferroni tests indicated that experienced contact athletes had a higher pain tolerance than novice contact athletes, $p < 0.0001$ and non-contact athletes, $p < 0.0001$, supporting hypothesis 4a. There were no differences between novice contact athletes and non-contact athletes, p = 0.29; see table 2.

A one-way ANOVA was conducted to test hypothesis 4b that experienced contact athletes would report pain as less intense than non-contact athletes and novice contact athletes. There was a significant effect of athlete type on pain intensity, $F_{(2,117)} = 17.65$, $p < 0.0001$, r = 0.48, a medium effect size. Post-hoc Bonferroni tests revealed that experienced contact athletes perceived the pain to be significantly less intense than non-contact athletes, $p < 0.0001$ and novice contact athletes, $p < 0.0001$, supporting hypothesis 4b. There were no differences between novice contact athletes and non-contact athletes, p = 0.36; see table 2.

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Hypothesis 4c stated that experienced contact athletes would find pain less bothersome than non-contact athletes. MANOVA revealed there was a significant difference between groups for psychological bothersomeness of pain, $F_{(2,114)} = 3.44$, $p = 0.03$, $r = 1.17$. Post-hoc Bonferroni tests revealed that experienced contact athletes found pain less psychologically bothersome than non-contact athletes, and novice contact athletes, $p < 0.0001$. Therefore, hypothesis 4c was supported for psychological bothersomeness only.

Hypothesis 4d stated that experienced contact athletes would have higher direct coping than non-contact athletes and novice contact athletes. A one-way ANOVA indicated that there was a significant effect of athlete type on direct coping, $F_{(2,117)} = 15.50$, $p < 0.0001$, $r = 0.34$, a medium effect size. Post-hoc Bonferroni tests indicated that 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, $p = 0.05$. Therefore, hypothesis 4d was supported.

Hypothesis 4e stated that experienced contact athletes would be more challenged in pain than non-contact athletes and novice contact athletes. MANOVA revealed that there were differences between the groups for cognitive appraisal, $F_{(2,114)} = 15.27$, $p < 0.0001$, $r = 0.34$, a medium effect size. Post-hoc Bonferroni tests indicated that experienced contact athletes were significantly more challenged than the non-contact athletes, $p = 0.006$, as were novice contact athletes, $p = 0.04$. There were also differences for HRV, $F_{(2,114)} = 17.0$, $p < 0.0001$, $r = 0.36$. Post-hoc Bonferroni tests revealed that experienced contact athletes had significantly higher HRV than the non-contact athletes, $p < 0.0001$, as did novice contact athletes, $p < 0.001$.

Discussion and conclusions

Contact athletes were significantly different to non-contact athletes on a number of measures during pain. First, contact athletes, regardless of experience, performed better in pain compared to non-contact athletes, the effect sizes were small to medium. . These athletes may learn how to cope with pain so that they can focus on executing skills (Brewer et al., 1990) or may simply be more motivated to perform well despite experiencing pain (e.g. Liston, Reacher, Smith and Waddington, 2006). Alternatively, this difference may reflect innate differences between contact athletes and non-athletes, i.e. individuals with better pain coping abilities may choose to participate in contact sports (cf. Thornton et al., 2017).

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Both groups of high contact athletes had higher HRV and cognitive appraisal in the pain condition compared to the non-contact athletes, regardless of the instructions provided, indicating a challenge state. Challenge states typically result in better performance than threat states (Turner et al., 2012). Contact sports participation is characterised by regular pain and discomfort (Ryan and Kovacic, 1966) yet some athletes report feeling challenged, rather than threatened by this (Liston et al., 2006), and may therefore feel challenged by experimental pain, thus impacting performance. It is also possible that the non-contact athletes were biased towards, and therefore focused on, the pain stimulus rather than the task itself (Eysenck, Derakshan, Santos and Calvo, 2007), though this was not measured.

For both performance measures, when threat was high there was a significant relationship between athlete type and time difference to complete the task. This indicates that threat moderated the relationship between experience in a contact sport (i.e. athlete type) and performance. There were no effects present in the challenge condition. As such, having more experience of pain may result in better performance, especially in threatening situations. There are at least two possible explanations for this. First, experienced contact athletes simply did not feel threatened by the pain even if they received threat instructions. Results indicated that the contact athletes as a whole, felt more challenged in the pain condition regardless of instructions provided. They therefore may have felt more motivated and able to complete the task. Second, the pain stimulus may have exacerbated feelings of threat in the non-contact athletes, regardless of the instructions they were given. As such, even in the challenge condition they were threatened by the pain stimulus. The challenge condition may have elicited more varied response due to contact athletes feeling challenged anyway and non-contact athletes feeling threatened. It has been suggested that it may be easier to invoke threat responses than challenge responses (e.g. Williams, Cumming and Balanos, 2010), therefore, particularly within the non-contact group, the challenge instructions may not have been potent enough to overcome the threat of the pain stimulus. This may explain the moderation effects in the threat condition and not challenge.

Pain tolerance and physical pain bothersomeness mediated the relationship between athlete type (contact sport experience level) and time to complete the task. Experienced contact athletes performed better than non-contact athletes and this was mediated by increased pain tolerance and lower physical pain bothersomeness. Physical bothersomeness of pain and tolerance therefore may be very closely linked to one another. Riley et al. (2002) suggested that pain is experienced in a linear fashion, first as pain intensity, which is predominantly a physiological response, followed by pain tolerance, which is also physiological but also may have some psychological elements, in

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particular, there may be variations in motivation to tolerate pain for a length of time. This may be a result of pain bothersomeness, but warrants more investigation. Overall, these results indicate that performance during pain may be a result of physiological and psychological factors. That is, athletes who have experienced pain in sport may be more challenged or motivated by pain or may have a different physical response to pain than those with little pain experience.

The fourth set of hypotheses were generally supported. The experienced contact athletes had higher pain tolerance and reported pain as less intense than the other two groups with large effect sizes, suggesting that experience of contact sports has a profound influence on pain reporting (e.g. Ryan and Kovacic, 1966). Repeated exposure to heavy contact within sports may desensitize athletes from pain (Raudenbush et al., 2012). The novice contact athletes may have had insufficient experience of contact sports to have become desensitized to pain or they may not have had enough time to develop pain coping strategies. This suggests that pain exposure time may be a factor in increased pain tolerance. Furthermore, the experienced athletes may have been less willing to report pain due to sporting culture (Nixon, 1992). Contact sports athletes have reported that expressing pain may be seen as a weakness (Liston et al., 2006). As such, playing while hurt is commonplace in some sports, and athletes may be unwilling to report feeling pain, even in experimental settings (Kopka-McDowell and LaChapelle, 2005).

Experienced contact athletes found pain less psychologically bothersome than the other groups, however the effect size was small. This however, supports the performance data: athletes who performed the best in pain also found the pain less bothersome. DeRoche, Woodman, Yannick, Brewer, and Le Scanff (2011) suggested that athletes who do not allow pain to bother them can maintain performance in sports for longer than those who cannot. This perhaps creates a cyclical or reciprocal situation where more experience of pain leads to less bothersomeness and less bothersomeness leads to a willingness to experience more pain.

Experienced contact athletes also exhibited higher direct coping than the other groups. However, novice contact athletes also had higher direct coping than non-contact athletes, with medium effect sizes. Direct coping is a positive coping style where pain is viewed as part of sport and is something that can be endured (Bourgeois et al., 2009). This style is linked to mental toughness and resilience (Levy, Polman, Nicholls, and Marchant, 2009), which is characterised by a willingness to undergo stressors with confidence (Crust and Clough, 2005). It is unclear whether this is developed through habituation and experience or whether resilient individuals self-select to play contact painful sports (Raudenbush, et al., 2012). As both the experienced and novice contact athletes had higher direct

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coping than non-contact athletes, it may be that this style is developed early during contact sports or that resilient individuals are more likely to choose to play contact sports (Thornton et al., 2017).

Experience of pain within contact sports may be fundamental to performance during experimental pain, however there is little research into this area. This is surprising due to the likelihood of pain occurring in sports settings. This research has added to the scant literature and has highlighted some important areas for consideration. In particular, experience of pain appears to be an important factor which mediates performance via higher pain tolerance and lower physical pain bothersomeness. However, some psychological factors may also be important; employing a direct coping style and viewing impending pain as a challenge rather than a threat may be conducive to success during painful activities (Meyers et al., 2001). Reducing pain bothersomeness and increasing pain tolerance may be salient to performing well in pain, but more research is needed to establish how this can be achieved.

There are a number of limitations to this study; first, we employed a between-subjects design for the challenge and threat condition, so it is unclear how the challenge and threat instructions would function during the no pain condition. Further research should aim to address this. Second, experimental pain stimuli tend to lack ecological validity in relation to the contact pain experienced in sport. The chosen pain stimulus was considered closest to impact pain, but concerns over ecological validity remain and arguably it does not perfectly recreate the pain felt in contact sports. Third, it would have been very difficult to ask each individual athlete to train for the same duration and intensity, and to control for other sources of pain such as fatigue. The possibility that non-contact athletes may have experienced pain in some form, from exertion (e.g. delayed onset muscle soreness) or injury cannot be discounted.

This research has indicated that experience of contact sports may have an effect on performance during pain. Contact athletes performed better in pain than non-contact athletes and they differed on pain report measures and psychological factors such as direct coping. Previous research has focused on pain reporting (tolerance and perception) between athlete groups, with most researchers agreeing that athletes report less pain than non-athletes (Tesarz et al., 2012). Pain tolerance and bothersomeness mediate the relationship between athlete type (contact sport experience level) and performance and as such, attention should now focus on the psychological mechanisms, and their role in performance during painful activities. In particular, challenge states should be examined alongside direct coping for pain. These constructs may be similar in nature and if coaches can manipulate these, athletes may perform better in contact sports. Moreover, athletes may be able to learn strategies to increase these states and reduce pain bothersomeness, which may

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be facilitative to performance. In conclusion, experience of contact sports, even for a relatively short period of time, may result in better performance during experimental pain conditions.

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Figures

Figure 1

Procedure

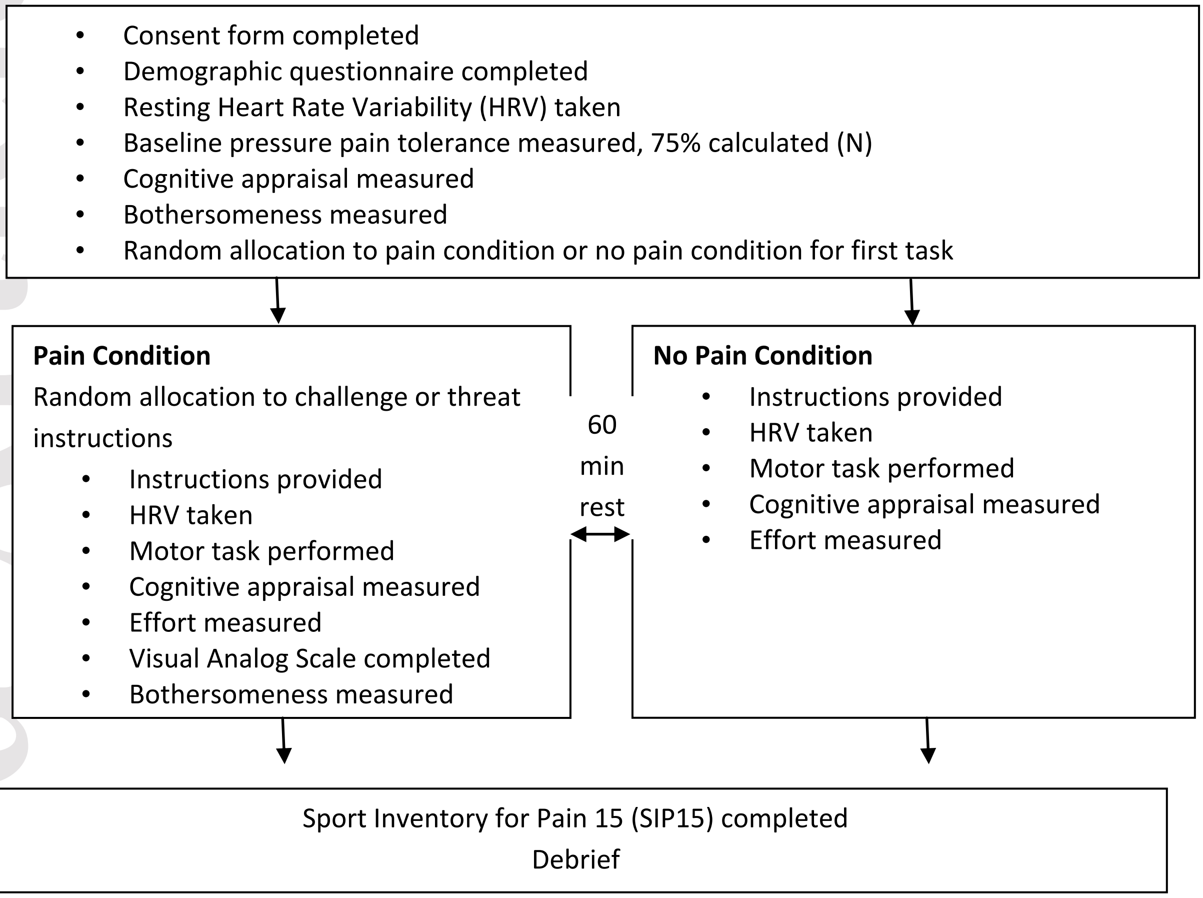

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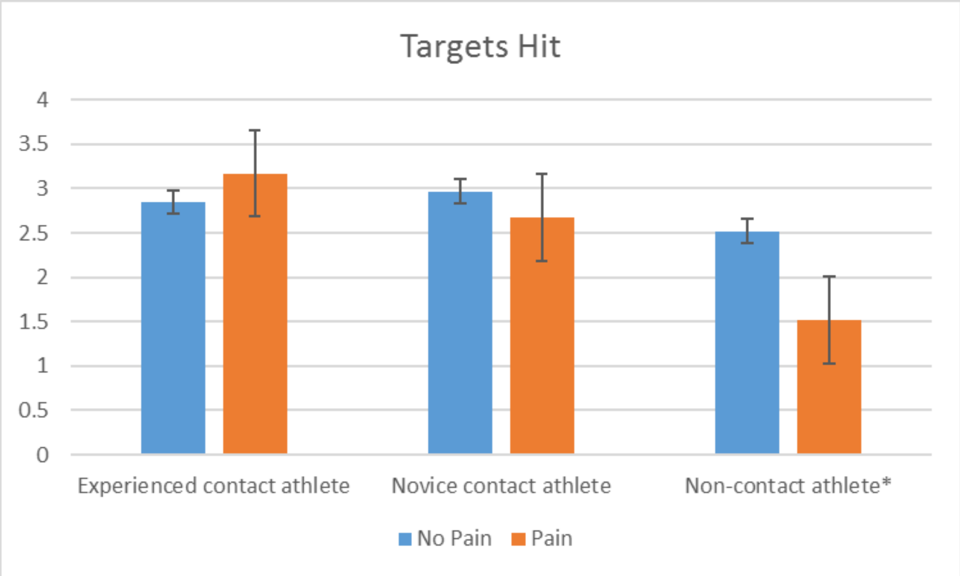
Figure 2

Performance results for targets hit by athlete according to pain condition



**Non-contact athletes performed significantly worse in pain compared to experienced and novice contact athletes. SE shown.*

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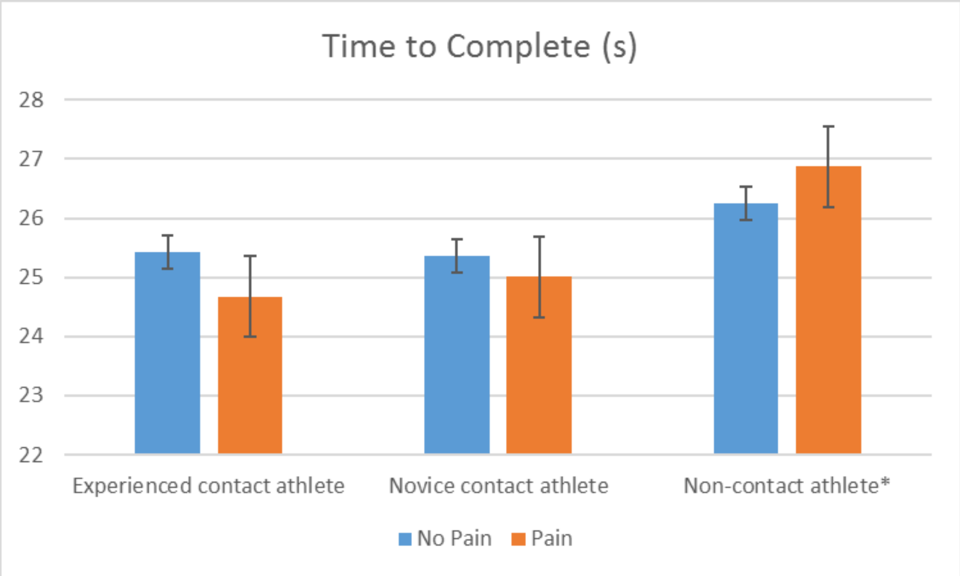
Figure 3

Performance results for time to complete by athlete according to pain condition



**Non-contact athletes performed significantly worse in pain compared to experienced and novice contact athletes. SE Shown*

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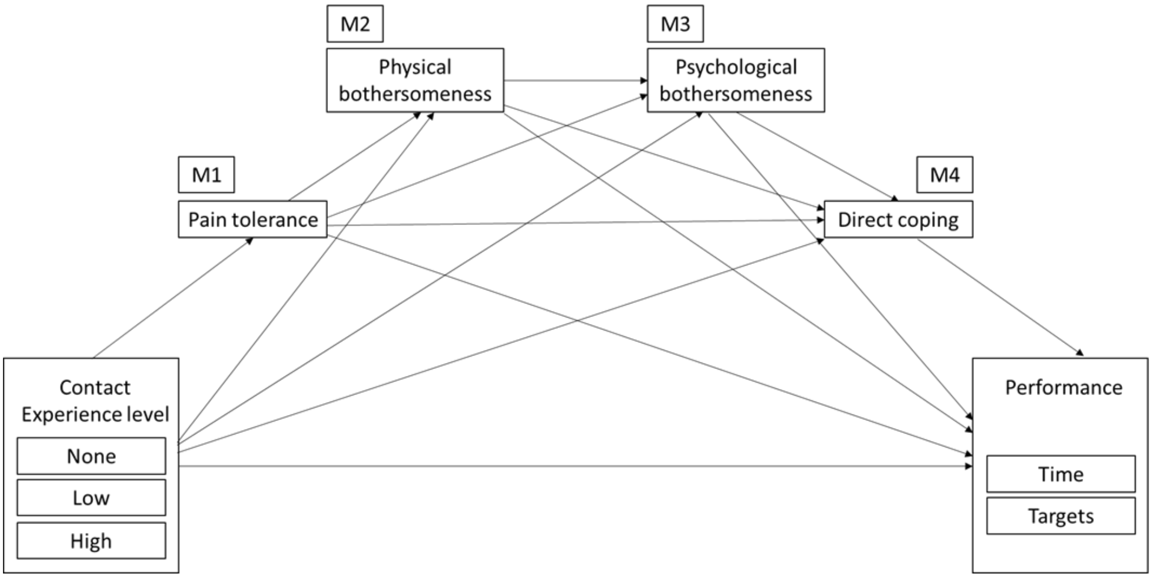
Figure 4

Mediation model using PROCESS



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Tables

Table 1

Sample Characteristics

Athlete Type	Age (M, years, SD)	Gender (N)	Level played (N)	Sports played (N)	Hours since training or competition (M, hours, SD)[d]
Experienced contact	23.5, 3.1[a]	Male: 25 Female: 15	Recreational: 22 Club: 7 County: 9 National: 2	Rugby: 29 American football: 11	35.2, 2.1
Novice contact	20.3, 2.1[b]	Male: 14[c] Female: 26	Recreational: 30 Club: 5 County: 5 National: 0	Rugby: 30 American football: 10	32.3, 3.4
Non-contact	22.4, 5.1	Male: 26 Female: 14	Recreational: 31 Club: 2 County: 7 National: 0	Cricket:12 Netball: 12 Athletics: 2 Volleyball: 14	35.1, 2.4
Total	22.1, 3.4	Male: 65 Female: 55	Recreational: 83 Club: 14 County: 21 National: 2	Rugby: 59 American football: 21 Cricket:12 Netball: 12 Athletics: 2 Volleyball: 14	34.2, 2.6

[a] experienced contact athletes were significantly older than novice contact athletes ($p < 0.0001$)[b] novice contact athletes were significantly younger than non-contact athletes

[c] there were significantly more males in the non-contact group, compared to the novice contact group

[d] measured at the point at which testing took place

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Table 2

Descriptive Statistics: Heart Rate Variability (HRV) *and Cognitive Appraisal according to challenge and threat state and athlete type*

		Heart Rate Variability		Cognitive Appraisal	
Type of Athlete	No Pain Condition	Mean	Standard Deviation	Mean	Standard Deviation
Experienced Contact	Challenge	81.00	6.23	1.65	1.03
	Threat	79.90	8.83	1.35	1.08
Novice contact	Challenge	79.05	5.21	1.40	0.94
	Threat	76.60	5.29	1.70	0.97
Non-contact	Challenge	74.00	6.39	1.85	1.03
	Threat	76.80	10.55	1.80	1.05
Type of Athlete	Pain Condition	Mean	Standard Deviation	Mean	Standard Deviation
Experienced contact	Challenge	84.90	6.47	2.00	0.64
	Threat	79.95	9.41	1.90	1.78
Novice contact	Challenge	82.95	5.34	1.90	0.85
	Threat	76.00	5.82	1.80	1.00
Non-contact	Challenge	75.50	6.30	1.70	0.92
	Threat	72.05	11.06	0.90	1.07

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Table 3

Descriptive Statistics: Pressure Pain Tolerance in Newtons (N/cm^2) and Pain Intensity Reports (100mm Visual Analog Scale) according to athlete type

	Pain Tolerance		Pain Intensity	
Type of Athlete	Mean (N/cm^2)	Standard Deviation (N)	Mean (mm)	Standard Deviation (mm)
Experienced contact	169.33	26.37	24.22	12.39
Novice contact	124.93	20.20	41.35	19.83
Non-contact	115.06	36.11	47.62	21.21

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