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A RELATIONSIHP BETWEEN AN ATHLETE’S LEVEL OF COMPETITION AND THEIR ABILITY TO TOLERATE PAIN

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ABSTRACT

A RELATIONSIHP BETWEEN AN ATHLETE'S LEVEL OF COMPETITION AND THEIR ABILITY TO TOLERATE PAIN

By

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Context: The ability to quantify pain is necessary for an allied health professional to evaluate the severity of an injury. **Objectives**: 1) Identify trends in pain tolerance in relation to level of athletic participation. 2) Compare Sports Inventory for Pain (SIP15) scores to subject's pressure pain testing (PPT) scores. **Design**: A 4-group comparison study (collegiate varsity, club, intramural, and recreational). **Setting**: Northern Michigan University Athletic Training Lab. **Patients or Other Participants**: Forty athletically involved individuals from NMU. **Main Outcome Measure(s):** A one-way ANOVA was used to investigate differences between athletic levels and their ability to tolerate pain through the SIP15 and PPT. A spearman correlation was used to analyze the relationships between athletic levels, PPT, pain intensity, pain affect, and SIP15 scores. **Results**: One-way ANOVA results showed no significant differences. The Spearman correlation results showed that the SIP15 subscale SOM and PPT had a significant relationship; (r= .326, p= .04). The subject's pain tolerance rating showed significant relationships with the following SIP15 subscales; COP (r= .35, p= .027), CAT (r= -.458, p= .003), and PCR (r= .465, p= .003). The SIP15 PCR subscale showed an inverse relationship with PPT pain affect rating (r= -.326, p= .043). **Conclusions**: The findings of this study support the use of the SIP15 as a tool to rate an individual's psychological ability to tolerate pain.

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(Journal of Athletic Training Format for Submission)

INTRODUCTION

In sports medicine, the accurate assessment of pain plays a critical role in the evaluation and treatment of athletes. When an athlete enters the athletic training room or healthcare clinic, they are asked to rate the pain they are experiencing on an 11-point Likert scale, 0 indicating “no pain” and 10 the “most intense that one could imagine”.[1] As objective as this measurement is, it is difficult to use due to the varying degrees of pain tolerance among individuals. Pain is an internal event that is difficult to quantify because it cannot be directly measured by the clinician.[2] The current method of pain measurement is not multidimensional; it only truly addresses one dimension of pain, the intensity. A multidimensional approach will not only assess intensity but also the affect that pain has on the athlete.[3, 4]

Galambos, Terry, Moyle, and Locke[5] concluded that psychological predictors in addition to physiological predictors could be useful to predict injury in athletes. This is where the use of the Sports Inventory for Pain (SIP15) in the athletic setting might be useful in the attempt to identify psychological predictors that could leave an athlete more prone to injury and less able to psychologically deal with an injury once it occurs.[6] The affect that the pain has on the athlete regardless of intensity could lead to psychological concerns if they are unable to cope with the pain in a healthy manner.[3] The use of a multidimensional approach as part of the pre-participation exam may provide athletic trainers better objective information regarding an individual athlete’s ability to tolerate pain, as well as an idea of how various levels of athletics (i.e. elite, varsity, club, recreational, etc.) differ in their pain tolerance.

Theories of Pain Perception

The gate control theory is the most common theory used in the field of sports medicine.[7] The most important contribution of this theory to the understanding of pain is the emphasis on the involvement of the CNS, particularly the brain as an active part of the filtering, selection, and modulating of input.[4] The neuromatrix theory of pain created by Melzack in 1993, takes the position that pain is a multidimensional experience that is produced by specific patterns of nerve impulses that are generated by a widely distributed neural network in the brain.[4, 8] It still includes the spinal cord elements of the gate control theory however, it expands upon the central control and the role internal and external factors play in the perception of pain.[4]

The neuromatrix has a characteristic output pattern that is called a neurosignature.[4, 8] This neurosignature is unique to each individual and is determined by heredity, psychosocial factors, prior pain experiences, cognitive events, emotional events, and the general stress of life.[4] Tyrer found that there are two schools of thought with regards to pain perception and the role of previous experience.[9] First, that catastrophic meaning is placed on the experience of pain because of the fear of injury or re-injury. Second, that fear of pain is due to fear of anxiety-related sensations associated with painful episodes. The idea of catastrophic feelings regarding pain has also been described by the authors of the Sports Inventory for Pain and is a key subscale when it comes to rating an individual’s ability to tolerate pain; this tool with be described in greater detail in the methods section.[6, 10, 11]

For the purpose of this study the terms pain, pain threshold, and pain tolerance will be defined. Pain is defined as an “unpleasant sensory and emotional experience associated with actual or potential tissue damage or described in terms of such damage”.[12] Pain threshold is defined as the stimulus intensity that evokes a report of minimal pain; for example, when the subject first defines the stimulus as painful.[13] Pain tolerance is defined as the maximum intensity of the painful stimulus that the athlete is able to endure during testing.[13]

Investigations into pain threshold and tolerance between different athlete groups found that pain threshold remains consistent across varying levels of athletics, but pain tolerance differs.[14] Therefore, it is most beneficial to research pain tolerance instead of pain threshold since tolerance will vary, but threshold may not vary significantly.[14]

Researching Pain in Athletics

When discussing the research of pain in athletics there are three main categories including: variance between level of contact, variance between levels of athletics, and gender differences. Significant findings indicated that contact athletes were able to withstand the highest amount of pressure causing pain, followed by non-contact athletes, and non-athletes withstanding the least amount of pressure.[10, 15]

Research has shown that higher level competitive athletes have higher levels of pain tolerance in comparison to club and non-competitive athletes.[14] This difference in pain tolerance has been speculated to be due to the amount of exposure that the athletes had to noxious stimuli through training with the greatest amount of exposure among high level competitive athletes and lowest in non-competitive athletes.[13, 14, 16, 17] This conclusion is in agreement with the neuromatrix theory indicating that exposure to noxious stimuli can change the perception of that stimulus.[4]

Similar research investigated the possible psychological reasons for the differences in pain tolerance between different athletic groups specifically. Meyers et al.[10] found that when using the SIP with college athletes, differences across rank, skill level, injury potential, and gender had significant effects on pain tolerance.[10] Post hoc tests revealed top-ranked athletes scored lower in cognitive awareness and body awareness of pain, but scored higher in avoidance when compared to lower ranked athletes. This may be a result of athletes utilizing mental techniques designed to disassociate with pain. In addition, results suggested that high injury-potential athletes are better able to cope with pain and do not experience many psychosomatic symptoms from their pain due to experience.[13, 17]

Research investigating the differences between males and females regarding pain tolerance has shown mixed results.[10, 14, 16] There were no significant differences between genders for ischemic pain threshold or for pressure pain threshold.[14, 16] Data collected by Manning & Fillingim[16] indicated that males had higher thresholds and tolerance for cold pain. However, a similar study, found no significant difference between genders concerning ischemic pain tolerance.[14] In other research males scored higher than females when it came to body awareness of pain;[10] this is interpreted as females experienced greater psychosomatic symptoms related to pain. The gender differences found might be biased or similar to research comparing contact and non-contact sports because some female sports, even if they are the same as men's, have less contact permitted during play such as hockey and lacrosse.

Applied Significance

In the field of athletic training the ability to accurately assess an athlete's pain is essential for providing the appropriate treatment according to the pain being experienced. This should result in more personalized treatment for athletes, ideally allowing for a quicker reduction in pain, increased adherence to a rehabilitation program which in turn would allow for a faster return to play or progression of rehabilitation exercises.[3, 18, 19]

The hypothesis for this project is that athletes participating in higher levels of athletics will be able to tolerate more pain as shown by their scores on the SIP 15 and the amount of pressure tolerated from a hand-held dynamometer. It is also expected that athletes who tolerate the highest amount of pressure will be the ones that exhibit a high pain tolerance through their SIP 15 scores.

METHODS

Participants

The method for participant recruitment was through Northern Michigan University email accounts. Varrsity coaches received the initial recruitment emails for varsity athletes; the coaches would then forward the email to their athletes. The contact person listed on the Northern Michigan University club sport webpage received the initial recruitment emails for club athletes. The emails for intramural and recreational athletes where sent out through a student announcement email sent out to all students on campus with instructions to contact the researcher if interested in participating. The participants would then email the researcher and a date and time were set up for testing.

A total number of 40 participants participated in this study (13 males and 27 females). The participants were composed of 8 varsity athletes (1 male, 7 female); 6 club athletes (1 male, 5 female), 9 intramural athletes (7 males, 4 females), and 17 recreational athletes (6 male, 11 female). The subjects came from a NCAA Division II institution; all subjects were at least 18 years old; with a mean age of 21.7 ± 4.1years old. Northern Michigan University's institutional review board approved the study, approval number HS10-338, and participants provided written informed consent (See Appendix A).

Instruments

The study used three instruments in the data collection process, which included a questionnaire to gain demographic and athletic history information (See Appendix B), the SIP 15 (See Appendix C), and pain tolerance testing (See Appendix D). The SIP 15 scores and pain tolerance scores were not revealed to the participants' during their testing session. However, upon completion of the study the participants were emailed with their scores on the SIP 15, the pain tolerance testing, as well as an explanation of his or her results.

Questionnaire. The demographic questionnaire consisted of 10 questions, which aim to gain information about the subject's athletic background. The questionnaire asked the participant to give information regarding their age, gender, and dominant leg. The questionnaire also inquired about basic athletic history information including: current level of organized athletic participation (recreational, intramurals, club, and varsity), years of organized athletic participation (0-1yr, 2-5yrs, 6-10yrs, 11-15yrs, and 16-20yrs), number of injuries sustained during athletic career that resulted in two weeks or more of missed participation, any current athletic scholarships, list of organized athletics from the past five years, and then the amount of training time in different environments (indoor, outdoor, in the cold, and in the heat). The questionnaire also asked the participant to rate their pain tolerance level on a scale of 0 to 10 in order to determine the rating of his or her own pain tolerance.

Sports Inventory for Pain 15. There are numerous tools available to measure a subject's pain tolerance in a non-pain inducing way. One technique that is often used is a questionnaire; one designed for athletics is the Sports Inventory for Pain.[11] The SIP questionnaire looks at five pain subscales including coping, cognitive, avoidance, catastrophizing, and body awareness.[11] A revised SIP scale was created for use in a more applied setting consisting of only 15 questions in place of the original 25; this new scale is called the SIP 15.[6] This type of testing utilizing questionnaires is less invasive than other pain tolerance investigative techniques and has shown to be reliable.[6] The McGill pain questionnaire can also be used to measure pain while the subject is in the middle of a painful experience.[20] However, the McGill is not specific to athletic pain and is more difficult to use appropriately in the athletic environment.[3] Therefore, the SIP 15 was chosen for its clinical applications in athletics and ease of use.

Pain Scale. The SIP15 is a useful measure of pain tolerance but is not designed for use during a painful experience. The pain scales developed by Turk & Melzack[1] are designed specifically for use during a painful experience. The first scale is that of pain intensity in which the individual rates their pain on an 11-point Likert scale from 0 representing “no pain” to 10 representing the “highest possible pain”.[1] The second scale is to measure pain affect, once again this is on an 11-point Likert scale from 0 representing “not unpleasant” to 10 representing “as unpleasant as possible”.[1] In order to better, describe the difference between pain intensity and pain affect it is suggested to explain it as if the individual is in a room where music is playing and the subject is to rate the volume of the music as intensity and how the subject feels about the music as affect.[1] This is a simple multidimensional tool to measure pain in an applied manner and can be easily administered by the clinician.

Pain Tolerance Testing. The pressure pain tolerance (PPT) testing portion of this study used a pain apparatus and procedure modified from previous research to induce pain in the subjects.[15, 21] The device used was a Baseline 100lb/45kg Push-Pull Electronic Dynamometer with a $1cm^2$ attachment to allow for pressure to be localized, and the dual handle attachment was used so pressure could easily be administered (See Fig.1). The device was set to measure pressure in kg of pressure and on the “peak” setting so that the highest pressure is kept on the screen so it can be easily recorded. After each test, the pressure was recorded and the device zeroed out prior to the next testing. A paper shield was also attached to the device in order to prevent the participant from being able to see the screen.

Testing Procedure

Testing took place in a private room with 2 investigators present. The participant was given the informed consent and instructed to read, sign, and ask any unanswered questions. The participant then filled out the questionnaire to gain demographic and athletic history information and to complete the SIP 15. Upon completion of the informed consent, questionnaire, and SIP 15 an explanation of the PPT testing was given to the participant. The participant was then instructed to sit on the examination table in a long sit position with his or her back against the wall. The participant's dominant leg was then flexed at the knee to a position that was comfortable to the subject. Any clothing covering the anterior tibia was removed and the tibial shaft was measured to find the midpoint, which was then marked with a small pen dot.

The subject was then instructed on the procedures for testing his or her pain tolerance. First the hand-held dynamometer would be placed on the midpoint of the anterior medial tibia where the shaft is the flattest in order to maintain even contact with the tibia. The pressure would be gradually increased and when it rose to a point where he or she could not tolerate the pressure applied anymore they would give the investigator a verbal cue (i.e. "okay" or "that's good" or "stop") to notify the researcher to remove the hand-held dynamometer. The pressure was increased at a rate of 1 kg/cm^2 every 3s up to a maximum of 30kg/cm^2. The same researcher applied pressure to all participants while a second researcher would place a thumb on each side of the 1cm^2 attachment to help reduce any possible slipping or movement of the hand-held dynamometer. Within 5sec of the device being removed the subject was then asked to rate his or her pain intensity on a scale of 0-10 with 0 being "no pain" and 10 being the "highest pain intensity possible".[2] The subject was then asked to rate the pain affect on a scale of 0-10 with 0 being "not unpleasant" and 10 being "as unpleasant as possible".[2] After the pressure, pain intensity, and pain affect scores were recorded, the participant was offered ice and was then complete with testing. The total testing time was about 10-15min for the subjects.

Prior to the PPT pain intensity and pain affect ratings were explained to the participants. Since most individuals are not asked about pain affect and to make sure there was no confusion all participants were told the following instructions adapted from instructions by O'Connor et al[2]. The subject was to imagine he or she was in a small room and music was playing loudly when he or she is asked to rate the intensity of the music (referring to the volume of the music) so they rate it as an 8 or 9 because the volume is so loud. The subject was then asked to rate the affect the music has on him or her so if the subject likes the music that was playing then it is only 3 or 4 because it is loud but the music itself is not unpleasant. However, if they dislike the music that was playing it is an 8 or 9 because it is not only loud but very unpleasant to them.

Statistical Analysis

A one-way ANOVA was used to look for significant differences between athletic levels with regards to the following dependent variables: pain tolerance rating, pressure pain testing scores, pain intensity ratings, pain affect ratings, and SIP 15 PCR scores. The SIP 15 PCR subscale was selected because it is a composite score and is the score used to give a rating of an individual's overall ability to tolerate pain.

A Spearman correlation was used to analyze the data collected in this study from the questionnaire, SIP 15 and pressure pain testing (PPT) procedure. It was used due to the data containing primarily interval data. The program used to analyze the data was PASW Statistics 17.0.3 (formerly SPSS) with an alpha level set apriority at .05 for all tests.

RESULTS

The mean scores and standard deviations for the four levels of athletic participation and the dependent variables of pain tolerance, pressure pain tolerance (PPT) kg/cm^2, PPT pain intensity rating, PPT pain affect rating, SIP 15 subscales of personal coping resources (PCR), coping (COP), catastrophizing (CAT), somatic awareness (SOM), and number of injuries can be found in Table 1. The one-way ANOVA results showed no significant differences between athletic levels with regards to the following dependent variables: pain tolerance rating ($F_{(3, 39)=.}$234, p=.872), pressure pain testing scores ($F_{(3,39)}$=2.046, p=.125), pain intensity ratings ($F_{(3, 39)}$=2.382, p=.086), pain affect ratings ($F_{(3, 39)}$=.429, p=.733) and SIP 15 PCR scores ($F_{(3,38)}$=1.196, p=.326). The complete results of the ANOVA can be found in Table 2. Since there were, no significant differences found post hoc analysis was not completed.

The complete results of the Spearman Correlation are in Table 3. When examining the relationship of the SIP 15 subscales, the results showed the same directional relationships as stated in previous research;[6] these results are in Table 4. The only SIP 15 subscale to show a correlation with PPT was the SOM subscale; PPT tester applied (r= .326, p= .04). The subject's pain tolerance rating (listed as pain tolerance) showed significant relationships with three of the following SIP 15 subscales; COP (r= .35, p= .027), CAT (r= -.458, p= .003), and PCR (r= .465, p= .003). The SIP 15 PCR subscale showed an inverse relationship with PPT tester applied pain affect rating (r= -.326, p=.043). This was the only SIP 15 subscale that showed a correlation with either pain affect or pain intensity.

DISCUSSION

The purpose of this study was to investigate whether or not athletes participating in higher levels of athletics would be able to tolerate more pain as shown by their scores on the SIP 15 and the amount of pressure tolerated from a hand-held dynamometer. It was expected that athletes who tolerate the highest amount of pressure would be the ones that exhibited a high pain tolerance through their SIP 15 scores, particularly the SIP15 PCR subscale since that is the overall rating of an individual's ability to tolerate pain. The current study did not show a significant difference between athletic participation level and pressure pain tolerance with the current subjects. This could be due to the small number of subjects and unequal groups with regards to gender and number of subjects in each group; possibly with more subjects a significant difference could be observed.

The Spearman correlation results from the current study showed that pain affect had a moderately significant relationship with PPT, as indicated by the positive correlation of the SIP15 SOM subscale with PTT scores. This indicates the importance of asking an athlete about their pain affect in addition to their pain intensity when performing an evaluation since pain intensity did not show a significant relationship with PPT testing. As stated previously with more subjects and the possibility of a stronger relationship the SIP15 SOM subscale could be used to predict the amount of pressure an individual can tolerate. A regression was not utilized in this study even though the relationship is significant the strength of the correlation was not strong enough to produce a reliable regression.

The SIP 15 PCR subscale showed an inverse relationship with pain affect rating. The PCR subscale is the individual's overall ability to tolerate pain with the higher the score the greater the likelihood the individual will be able to tolerate higher levels of pain.[6] This was the only SIP 15 subscale that showed a correlation with either pain affect or pain intensity.

There are numerous reasons for the varying perceptions of pain among individuals, genders, and athletic groups. The role of genetics has been explored as a possible component; research into this topic has found specific genes affecting an individual's pain tolerance related to temperature, pressure, and edema.[12] Neuron conduction regarding hypersensitivity or hyposensitivity to painful stimuli has also been indicated as a genetic link.[4, 12] However, other studies have shown that through physical training, pain tolerance will increase and the rating of pain intensity will decrease.[14, 17] It has also been found that with the suggestion that a substance will increase pain tolerance, test subjects will show a significant increase in pain tolerance.[22] It is difficult to know whether some people are more genetically predisposed to their pain tolerance level, to what extent pain tolerance can be trained, and how much can be controlled psychologically.

It is also unknown how much of an increase in pain tolerance is due to changes in physiology, psychology, or a combination of both.[4, 13] What is understood is that pain sensitivity has the potential to affect professional success, physical training, and general athletic success.[12] In athletes, a decrease in pain sensitivity can promote athletic achievements; however, it may also be a cause of more serious injuries due to the inhibited recognition of painful stimuli.[12]

Understanding that we cannot change genetics, but we can teach important psychological skills that can be utilized for injury prevention, recovery, and performance enhancement, is important. Hamson-Utley et al.[23] found that athletic trainers and physical therapists that are trained in psychological interventions such as mental imagery, positive self-talk, and goal setting to increase pain tolerance, believe they improve adherence and recovery speed of rehabilitation. Johnson[24] concluded that rehabilitative work from a long-term injury should be individualized and a combination of physical and mental training programs to match the psychological profile of the athlete should be utilized.

When attempting to identify coping strategies among athletes it has been found that an injured athlete's main characteristics show more negative mood-state and they tend to seek professional help more than non-injured.[24] Many athletes have been shown to use mental training in order to prepare for competition;[25] however, this training is often not used to prepare the athlete for possible injuries and how they will overcome those injuries.[24] If these mental training techniques are used prior to injury to prepare for competition, this mental training could help them cope with their injury.[24]

A difference in coping with pain was found between genders with men more effective at coping then women.[10, 24] Individual sport athletes also appear to be more effective than team sport athletes with coping.[24] Individual sport athletes are habituated to pushing themselves and have less reliance on others whereas team athletes are accustomed to support from teammates to help them through a game and expect this same level of support during rehabilitation.[24] These team athletes will need more support from their teammates and coach in order to cope with their injury. It is important to keep them in proximity to the team and coach during the rehabilitation process and not to isolate them from their support system.

Limitations and Future Areas of Research

The limitations within this project were the number of subjects that participated, unequal number of subjects in each athletic group, and a lack of male subjects. With the significant relationships found using Spearman correlations, this could demonstrate the potential for using the SIP 15 as part of a pre-participation exam for athletic participation. We examine the athletes physically to make sure they are fit for safe participation, should we not make sure they are mentally fit for participation as well?

There are some general limitations when it comes to testing pain tolerance. The first consideration is the type of individual who will volunteer for research and be subject to a painful situation. This is where questionnaires are helpful; however, if the subject does not answer the questions honestly, the results can become misleading. Secondly, when testing an individual's tolerance for pain they might not actually reach their maximum pain tolerance because they max out on the testing device or the researcher's protocol does not allow going past a certain point for safety. Thirdly, the time of season could also play a role; with testing prior to season they might not have had much recent exposure to the painful stimuli of training, in contrast to testing during or post season where the athlete would consistently be exposed to the painful stimuli of training.[14] This time difference could possibly alter some of the results when testing pain tolerance.

Future research needs to involve the testing of the SIP15 as part of a pre-participation exam and its usefulness in the identification of athletes that are predisposed to injury due to psychological issues related to their inability to cope with pain. Better identification of athletes that might be slow to recover mentally from injury and utilization of techniques that could be used to promote mental healing are necessary.

Further investigation is needed into the different techniques that can be used to manage pain such as Zen, acupuncture, mental imagery, and improving coping skills. These different pain decreasing techniques and identification of individuals with psychological deficiencies dealing with pain could help to increase exercise and rehabilitation adherence meaning faster and improved return-to-play results.

There is also the possibility for longitudinal studies involving the SIP15 starting with testing junior high athletes and following them through their college career. Testing could be done on at least a yearly basis to determine whether those with better coping strategies and higher pain tolerance become varsity collegiate athletes or if there are substantial changes throughout their athletic career. All of these areas of further research are needed to understand pain and the role it plays in athletics.

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CHAPTER II: LITERATURE REVIEW

Introduction

In sports medicine, the accurate assessment of pain plays a critical role in the evaluation and treatment of athletes. When an athlete enters the athletic training room or healthcare clinic, he or she is asked to rate the pain they are experiencing on an 11-point Likert scale, 0 indicating "no pain" and 10 rating the pain as the "most intense that one could imagine".[1] As objective as this measurement is, it is difficult to use due to the varying degrees of pain tolerance among individuals; for instance, one athlete's rating of 5 is another athlete's rating of 2 and another's rating of 9. Pain is an internal event that is difficult to quantify because it cannot be directly measured by the clinician.[2] This current method of pain measurement is not multidimensional; it only truly addresses one dimension of pain, the intensity. A multidimensional approach will not only assess intensity but also the affect that pain has on the athlete.[3, 4]

The affect that the pain has on the athlete regardless of intensity could lead to psychological concerns if they are unable to cope with the pain in a healthy manner.[3] The use of a multidimensional approach as part of the pre-participation exam may provide athletic trainers better objective information regarding an individual athlete's ability to tolerate pain, as well as an idea of how various levels of athletics (i.e. elite, varsity, club, recreational, etc.) vary in their pain tolerance. This review of literature regarding pain in athletics and the variations that occur will be divided into five major sections (a) anatomy of pain; (b) methods of measuring pain; (c) pain in athletics; (d) the applied significance (e) and finally a discussion of the findings and areas of further research regarding this topic.

Anatomy and Physiology of Pain

While there are varying definitions for pain, Rostovtseva et al.[5] defined pain as an "unpleasant sensory and emotional experience associated with actual or potential tissue damage or described in terms of such damage".[5] Pain threshold is defined as the stimulus intensity that evokes a report of minimal pain; for example, when the subject first defines the stimulus as painful.[6] Pain tolerance is defined as the maximum intensity of the painful stimulus that the athlete is able to endure during testing.[6] According to Knight and Draper,[7] pain serves three main functions: a warning for withdrawal, alert that something is wrong, and protection of the injured area of the body by eliciting muscle guarding known as a muscle spasm. In order to understand how an individual perceives pain, the important structures involved in the perception of pain must be identified.

The basic anatomy of the nervous system consists of the central nervous system (CNS) and the peripheral nervous system (PNS).[7] The CNS structures involved with pain perception are the hypothalamus, thalamus, cerebral cortex, neuron, nerve fiber, nerve, the ascending tract of the spinal cord, and the descending tract of the spinal cord.[5, 7] The structures within the PNS responsible for pain are the sensory nerves, somatic motor nerves, and the autonomic motor nerves.[7] With the anatomy structures mentioned, it is also necessary to mention the physiology of the nervous system.

The autonomic nervous system (ANS) is part of the PNS and is responsible for involuntary functions of the body.[7] The ANS is composed of the sympathetic nervous system, which is in charge of the body's fight or flight response, and the parasympathetic nervous system that is responsible for the rest and digest response.[7] The ANS is an important aspect of the PNS; however, the somatic nervous system (SNS) is the system, which contains the structures most active in the neurological recognition of a painful stimulus and the physical action taken due to this pain.

The SNS involves both somatic sensory (afferent) nerves and motor (efferent) nerves.[7] The afferent nerves enter the spinal cord through the dorsal horn while the efferent nerves exit the spinal cord through the ventral horn.[7] The synapse is the junction between two neurons where information is passed from one nerve to another; this transfer of information occurs with the release of neurotransmitters into the synaptic cleft.[7] The event that evokes activity of the nerves is called a stimulus.[7] This stimulus can occur at three different levels; 1) noxious stimulus; which causes pain, 2) threshold; which is the minimal point that a stimulus produces a response either psychological or physiological, and 3) subthreshold stimulus; which is below the threshold level evoking no response.[7]

There is a way for subthreshold stimuli to evoke a response through the process of summation. This occurs when all of the subthreshold stimuli add together allowing the threshold to be reached.[7] Summation occurs in two different ways: 1) temporal summation, which means these stimuli occur over time, and 2) spatial summation meaning the stimuli occur over a number of different axons and converge on one cell body at one time.[7] Two other important aspects of summation are facilitation (which enables a neural response) and inhibition (which suppresses a neural response).[7] The remaining aspects of the neurological physiology are positive and negative feedback. Positive feedback facilitates further activity on that neuron while negative feedback acts to inhibit further activity on that neuron.[7] Now that the basic physiology of pain has been discussed, the theories regarding how pain is perceived can be presented.

Theories of Pain Perception

There are numerous theories that attempt to explain the perception of pain including the specificity theory, pattern theory, Goldscheider's summation theory, and sensory interaction theory; however, these are not adequate in explaining the complete experience of pain.[8, 9] These theories incorporate only the physiology of pain and do not address the role the brain has in the perception of pain. In response to a need for a pain theory, that incorporates both the importance of physiology as well as psychology, Melzack and Wall[8] proposed the gate control theory of pain.

The gate control theory addresses pain at the spinal cord level with the idea of a gating mechanism located on the dorsal horn, which would only allow one sensation at a time to pass through and move up the afferent nerve to the brain.[8] This theory considers the T cell as the gate, as this is the point where both large and small diameter nerves converge. The T cell would then allow only one impulse either from the small-diameter nerve (carrying dull and aching pain sensations) or from the large-diameter nerve (carrying sharp, stinging pain sensations) to pass and continue towards the brain.[8] However, the large-diameter nerve can bypass the T cell if it has a high rate of stimulation; this could signal immediate danger to the body therefore, must be quickly addressed by the brain. In order to either facilitate or inhibit the T cell a central control is essential.[8]

The central control is the integration in the brain of information from many different sources such as vision, memory, smell, hearing, and sensory nerve fibers.[8] After compiling the information, the central control will then either inhibit or facilitate the T cell, in turn causing either an intensifying or a decreasing response to the painful stimulus.[8] The most important contribution of this theory to the understanding of pain is the emphasis on the involvement of the CNS, particularly the brain as an active part of the filtering, selection, and modulating of input.[9] One of the main flaws in this theory is that it does not adequately explain the influence of drugs on pain. Part of this flaw could be contributed to the age of this theory. Many of the drugs pathophysiology was not fully understood at the time of this theory's development.[7] Due to this deficiency, the pain theory that is now considered all-encompassing is the neuromatrix theory of pain.[7]

The neuromatrix theory of pain created by Melzack in 1993,[9] takes the position that pain is a multidimensional experience that is produced by specific patterns of nerve impulses that are generated by a widely distributed neural network in the brain.[4, 9] It still includes the spinal cord elements of the gate control theory however, it expands upon the central control and the role internal and external factors play in the perception of pain.[4] This theory came about through Melzack's research into phantom limb pain and an explanation for how an individual can experience pain in a limb that is no longer present.[9] Melzack came to four conclusions that led him to the neuromatrix theory of pain. First, since the pain experienced in phantom limbs is reported as the same as when the limb was still present he concluded that the input we normally receive from these sensory nerves can still be activated even when they are no longer present.[9] Secondly, since pain can be felt in the absence of normal sensory inputs it can be concluded that the origins of these experiences are present as neural networks in the brain.[9] Third, the body is perceived as a unity also known as "self" and is distinct from other people and the surrounding environment.[9] Finally, there is a "built-in" pain process, but this process is modified by experience.[9]

From the four conclusions Melzack made regarding phantom limb pain he developed the neuromatrix theory of pain. This theory is based on a body-self neuromatrix composed of a neural network including parallel somatosensory, limbic and thalamocortical components, affective-motivational and evaluative-cognitive dimensions.[4, 9] The neuromatrix has a characteristic output pattern that is called a neurosignature.[4, 9] This neurosignature is unique to each individual and is determined by heredity, psychosocial factors, prior pain experiences, cognitive events, emotional events, and the general stress of life.[4] With many factors contributing to the perception of pain, both physiological and psychological, it is considered to be a "biopsychological" event.[10] With each of these factors being unique to each individual, it can reasonably be assumed that pain perception is different for each individual.[7]

Regarding the role of heredity and pain perception, Rostovtseva et al.[5] investigated the genes described as controlling pain and identified up to 12 genes that have been marked as pain controlling genes. This research helps to show that there is not just one gene controlling the ability to sense pain, but rather a wide range of genes that control various aspects of pain perception.[5] Melzack suggested that experience also plays a role in pain perception and Tyrer[11] found that there are two schools of thought. First, that catastrophic meaning is placed on the experience of pain because of the fear of injury or re-injury.[11] Second, that fear of pain is due to fear of anxiety-related sensations associated with painful episodes.[11] The idea of catastrophic feelings regarding pain have also been described by the authors of the Sports Inventory for Pain (SIP) and is a key subscale when it comes to rating an individual's ability to tolerate pain; this tool will be described in greater detail in the next section.[12, 13, 14]

Pain can also be described as psychosomatic. Tyrer[11] looked at the history of describing this type of pain and some interesting points that are related to athletics include findings by Engel[15] who argued that even though pain might have an external source it most likely would become a psychological phenomenon. When it comes to the experience of chronic pain those most likely to experience it are individuals with a history of defeat, significant guilt, unsatisfied aggressive impulses, and a history of real or imagined loss.[15] These characteristics explain much of what happens in athletics and is experienced by athletes. In a clinical example, an athlete misses an important chance to score for their team to win a championship game. They would be prone to experience significant guilt over the missed opportunity, which could potentially make them more prone to the experience of chronic pain. This could be due to the amount of emotional pain the athlete is experiencing and that the tolerance for physical pain would be decreased because psychologically they are unable to separate out the emotional and physical pain. This could hypothetically trigger pain using summation with neither one trigger being significant individually, but together they trigger a pain response.

Methods of Pain Measurement

There are numerous tools available to measure a subject's pain tolerance in a non-pain inducing way. One technique that is often used is a questionnaire; this type of testing is less invasive than other pain tolerance investigative techniques and has shown to be reliable.[12] The McGill pain questionnaire is a common tool that is used to measure pain while the subject is in the middle of a painful experience.[16] However, the McGill is not specific to athletic pain and is more difficult to use appropriately in the athletic environment.[3]

One tool designed for athletics is the Sports Inventory for Pain (SIP).[14] The SIP questionnaire looks at five pain subscales including coping (COP, indexes direct coping responses), cognitive (COG, measures use of cognitive strategies), avoidance (AVD, identifies individuals that will avoid pain-producing responses), catastrophizing (CAT, assess the tendency to be overwhelmed by pain), and body awareness (BOD, measure of response style).[14] These subscales are measured with questions on a 5-point Likert scale.[14] This questionnaire also includes a HURT index, which is created by subtracting the negative variables of AVD and CAT from the positive variables of COP and COG.[14] An athlete with higher positive variable scores and lower negative variable scores will be categorized as an athlete with a higher pain tolerance, while the opposite is true for an athlete with low positive variable scores and high negative variable scores.[14] The subscale of BOD was not included in the HURT index because it is a measure of response style; more specifically the extent to which an individual is either hyper or hyposensitive to physiologically produced sensory stimuli.[14] Those athletes that score high on the BOD subscale are more likely to experience psychosomatic symptoms related to their pain. This variable is described as a suppressor or moderator variable used during the research of the SIP.[14]

This scale has now been revised for use in a more applied setting; this new scale is called the SIP15.[12] The SIP15 was reduced from 25 to 15 questions to make it easier to use in an applied setting. There were adjustments made to the original subscales of the

SIP in order to make the SIP15 more efficient. The subscales of COP, CAT, and COG were still included with BOD being replaced with somatic awareness (SOM, indicates the extent to which a person is hypo or hypersensitive to stimuli) and personal coping resources (PCR, composite of COP-CAT which scores an individual's ability to deal with pain).[12] The usefulness of the SIP15 is still the same as that of the SIP however, it is considered to have a greater ease of use and scoring when compared to the SIP making it a practical choice in the field.

The SIP and SIP15 are useful measures of pain tolerance but are not for use during a painful experience. The pain scales developed by Turk & Melzack[1] are designed specifically for use during a painful experience. The first scale is that of pain intensity in which the individual rates their pain on an 11-point Likert scale from 0 representing "no pain" to 10 representing the "highest possible pain".[1] The second scale is to measure pain affect, once again this is on an 11-point Likert scale from 0 representing "not unpleasant" to 10 representing "as unpleasant as possible".[1] In order to better, describe the difference between pain intensity and pain affect it is suggested to explain it as if the individual is in a room where music is playing and the subject is to rate the volume of the music as intensity and how the subject feels about the music as affect.[1] This is a simple multidimensional tool to measure pain in an applied manner and can be easily administered by the clinician. The McGill pain questionnaire, SIP, SIP 15, pain intensity scale, and pain affect scales are useful measures to make a subjective sensation like pain, an objective measurement.

The ability to induce pain safely is essential in order to conduct research concerning pain. There are numerous techniques available for reproducing pain to determine the level an individual is able to tolerate.[13, 14, 16-23] Cold immersion is a technique frequently utilized however, when using this as an investigative tool with athletes there are potential validity and reliability issues.[16] Athletes often use cold immersion treatment post-injury or post-exercise to decrease delayed onset of muscle soreness (DOMS), mitigating the validity for pain tolerance.[16] Athletes in studies using this technique have shown a decrease in their perception of the pain caused by the cold over a relatively short period of time.[16] Since athletes are exposed frequently to cold as a stimulus, it is not the measure best suited for testing pain tolerance.[20, 24, 25] In addition, if an athlete is not experiencing pain from the cold, the temperature can only be decreased to a certain temperature before it will cause tissue damage; such as in cryosurgery where the tissue is cooled to -4 to -94°F inducing tissue damage.[7]

A common technique used to induce pain in subjects without causing harm is the use of pressure devices.[23] Pressure is a form of a mechanical stimulus that is the stimulation of a nerve due to the pressure placed upon it from swelling, muscle spasm, or an external pressure and is the most frequent type of noxious stimulus experienced in athletics.[7] With the use of a mechanical stimulus these pneumatic devices are used to reproduce pain that is not only superficial, but also pain that is similar to muscular pain and pain after surgery.[13, 18, 23] This pain shares a greater similarity to the pain experienced in athletics than the use of either hot or cold pain producing devices, which do not mimic muscular pain.[23]These pressure devices work by increasing pressure until the subject gives the command to stop the test or an established maximum pressure is reached.[13, 17, 18, 22, 23] The device can be positioned on various areas of the body including the upper arm, upper torso, rear deltoid, and upper leg.[18] One of the most common sites is the anterior portion of the tibia, which can produce great discomfort in the subject without causing any real damage to the tissue.[13, 17, 18, 22, 23] The device will give an exact measurement of the pressure which is causing pain or measureable discomfort in the athlete; however, they are safe and quick to use without causing harm.[23]

Another commonly used technique for inducing pain is creating ischemic pain. This pain is caused by decreasing the blood flow to an area which can induce a measurable amount of pain or discomfort. A sphygmomanometer[20] or a tourniquet[18, 21] can be used to occlude an artery. The brachial artery is used a majority of the time because it is easily accessible compared to other arteries like the femoral and will not cause significant damage if occluded for a short period of time like the carotid artery.[18, 20, 21] There are two methods of scoring. In one the subjects are asked to open and close the fist and the number completed is counted as their score[18, 20], another is the length of time the subjects they are able to tolerate the ischemic pain[21]. The tools to measure ischemic pain are relatively inexpensive and easily accessible making this technique a common measure for pain.

Researching Pain in Athletics

When discussing the research of pain in athletics there are three main categories including variance between level of contact, variance between levels of athletics, and gender differences. First, to be discussed are data collected investigating the relationship between level of contact in a sport and the level of pain tolerance and pain threshold.[13, 17] Ryan and Foster[17] looked at the difference between contact athletes, non-contact athletes, and non-athletes concerning pain tolerance and pain threshold. Significant findings indicated that contact athletes were able to withstand the highest amount of pressure causing pain, followed by non-contact athletes, and non-athletes withstanding the least amount of pressure.[17] Similar results were found by Meyers et al.[13] with the athletes exposed to contact sports demonstrating a higher pain tolerance than non-contact athletes do.

Research conducted concerning pain variations between different athletic levels include the categories of competitive athletics, such as elite, collegiate divisions, intramurals, and recreational. Investigations into these groups have found that pain threshold remains consistent across varying levels of athletics, but pain tolerance changes.[20] This means that the point at which the painful stimulus is perceived and reported does not significantly differ between individuals; however, the amount of that painful stimulus that an individual is able to tolerate shows variance. Therefore, it is most beneficial to research pain tolerance instead of pain threshold since tolerance will vary, but threshold may not vary significantly.[20]

In a study investigating differences in pain tolerance between national competitive swimmers, club swimmers, and non-competitive swimmers there were significant differences found between groups.[20] The national competitive swimmers had significantly higher pain tolerance for ischemic pain than the other two groups and the club swimmers had significantly higher pain tolerance than the non-competitive athletes.[20] The authors speculated that this difference was due to the amount of exposure that the athletes had to noxious stimuli through training with the greatest amount of exposure among national swimmers and lowest in non-competitive swimmers.[20] Manning and Fillingim[18] found that athletes demonstrated significantly higher cold pressor pain thresholds than non-athletes. This conclusion is in agreement with the neuromatrix theory indicating that exposure to noxious stimuli can change the perception of that stimulus[4] along with other studies showing that exposure to noxious stimuli increases pain tolerance measures.[6, 19]

Similar research looked specifically at the possible psychological reasons for the differences in pain tolerance between different athletic groups. Meyers et al.[13] found that when using the SIP with college athletes, difference across rank, skill level, injury potential, and gender had significant effects on pain tolerance.[13] Post hoc tests revealed top-ranked athletes in the study scored lower on cognitive (COG) and body awareness (BOD) and higher in avoidance (AVD) than the lower ranked athletes. This could be because these athletes use mental techniques designed to mitigate pain. In addition, results showed that athletes participating in high injury-potential sports scored lower in catastrophizing (CAT) and were higher in body awareness (BOD) when compared to athletes in low injury-potential sports. They suggested that high injury-potential athletes are better able to cope with pain and do not experience many psychosomatic symptoms from their pain. They could be better able to cope with the pain due to the more experiences with pain.[6, 19] In addition, males scored higher than females when it came to BOD;[13] this is interpreted as females in their research experienced greater psychosomatic symptoms related to pain.

Further research investigating the differences between males and females regarding pain tolerance has shown mixed results.[13, 18, 20] There were no significant differences between genders for ischemic pain threshold or for pressure pain threshold.[18, 20] Data collected by Manning & Fillingim[18] indicated that males had higher thresholds and tolerance for cold pain. However, a similar study, found no significant difference between genders concerning ischemic pain tolerance.[20] The gender differences found might be biased or similar to research comparing contact and non-contact sports because some female sports, even if they are the same as men's, have less contact permitted during play such as hockey and lacrosse. In hockey, women are not allowed to check and in lacrosse, no contact is permitted unlike men's lacrosse and hockey in which checking is allowed. Thus caution must be taken when attempting to draw conclusions about gender differences because of the differences between men's and women's athletics.

Reasons for Variation

There are numerous reasons for the varying perceptions of pain among individuals, genders, and athletic groups. The role of genetics has been explored as a possible component; research into this topic has found specific genes affecting an individual's pain tolerance related to temperature, pressure, and edema.[5] Neuron conduction regarding hypersensitivity or hyposensitivity to painful stimuli has also been indicated as a genetic link.[4, 5] However, another study has shown that through physical training, pain tolerance will increase and the rating of pain will decrease.[19]

Focht et al.[19] separated subjects into two groups in which one group received 14 weeks of martial arts training while the control groups received no training; pre- and post-testing for pain tolerance testing involved using pressure pain. The martial arts group significantly increased pain tolerance with no significant changes in the control group. In addition, the martial arts group significantly decreased their rating of pain experienced with no significant changes observed in the control group. The authors drew similar conclusions as Scott and Gijsbers[20] in that exposure to the noxious stimuli present during athletic training can increase an individual's ability to tolerate pain. It is difficult to know whether some people are more genetically predisposed to their pain tolerance level, and to what extent pain tolerance can be trained. It is also unknown how much of an increase in pain tolerance is due to changes in physiology, psychology, or a combination of both.[4, 6]

In a study by Benedetti et al.,[21] the idea of changes in physiology and possible psychological influences for an increase in pain tolerance were investigated. Participants in this study were separated into four different teams and they completed a standardized pre-competition training which was performed once a week. It consisted of a test of pain tolerance involving submaximal effort tourniquet technique and told to tolerate it as long as possible.

Team A was the control group participating in normal training, given no extra solution, and no verbal cues during competition. Team B was the same as Team A however; during the competition phase, they were given a placebo one hour before training along with a verbal suggestion it was morphine. Team C was given morphine one hour before two training sessions on weeks two and three along with a verbal cue that an increase in pain tolerance was expected. On competition day, Team C was given a placebo one hour before along with the verbal suggestion it was morphine. Team D had the same training as Team C however, on competition day they were given naloxone one hour before but told it was morphine; naloxone will inhibit any endogenous opioids if present.[21]

The results showed Team C in first place, Team B second, Team A third, and Team D in fourth place.[21] This suggests that when conditioned with morphine endogenous opioids are released helping to decrease pain leading to an increase in pain tolerance. With Team B achieving second, this proposes that the suggestion of morphine and an expected increase in pain tolerance is enough for these endogenous opioids to be released. Finally, with Team A placing ahead of Team D, which received naloxone, further suggests that endogenous opioids are present during training when pain is present and that if these can be manipulated pain tolerance can be altered and possibly an increase in performance can be obtained. Since the use of morphine during training at many levels is legal, this is a possible new avenue for performance enhancement in sport.[21] This study also illustrates the significant affect the brain and athlete expectations can have on pain tolerance; if we are able to influence this through various mental training exercises we could increase an athlete's pain tolerance. Pain sensitivity has the potential to affect professional success, physical training, and general athletic success.[5] In athletes, a decrease in pain sensitivity can promote athletic achievements; however, may be a cause of more serious injuries due to the inhibited recognition of painful stimuli.[5]

Applied Significance

In the field of athletic training the ability to accurately assess an athlete's pain is essential for providing the appropriate treatment according to the pain being experienced. This will result in more personalized treatment for athletes, ideally allowing for a quicker reduction in pain and in turn, a faster return to play or progression of rehabilitation exercises. An adequate understanding of pain could help with the prediction of injury using psychological factors, athletic injury pain and rehabilitation adherence, techniques to address pain in athletes, and use of coping strategies to address pain.

Galambos et al.[26] found that measures of mood and perceived life stress were the best predictors of injury related variables. The researchers concluded that psychological predictors in addition to physiological predictors could be useful to predict injury in athletes.[26] This is where the use of the SIP15 in the athletic setting might be useful in the attempt to identify psychological predictors that could leave an athlete more prone to injury and less able to psychologically deal with an injury once it occurs.[12]

Research in the athletic environment has shown that the reduction of pain was a predisposing factor for improved adherence to rehabilitation programs along with support from others.[27] This is not only true in the competitive athletic environment but also among recreational athletes who were attending rehabilitation.[28] These individuals identified pain as a major factor for non-adherence to home rehabilitation programs as well as in clinic programs.[28] The correct identification and quantification of pain by using a multidimensional approach could lead to the recognition of possible psychological issues that could inhibit optimum recovery from an injury due to rehabilitation non-adherence.[3] Kremer et al.[3] made this recommendation for a multidimensional approach in 1983 and there is still inconsistent use of it today in the healthcare setting.[2]

Psychological skills are important during injury recovery. Hamson-Utley et al.[29] found that athletic trainers and physical therapists that are trained in psychological interventions such as mental imagery, positive self-talk, and goal setting to increase pain tolerance believe it improves adherence and recovery speed of rehabilitation. Johnson[30] concluded that rehabilitative work from a long-term injury should be individualized and a combination of physical and mental training programs to match the psychological profile of the athlete.

When attempting to identify coping strategies among athletes it has been found that injured athletes main characteristics show more negative mood-state and tend to seek professional help more than non-injured.[30] Many athletes have been shown to use mental training in order to prepare for competition[31] however; this training is often not used to prepare the athlete for possible injuries.[30] So when the athlete is injured they are not prepared to deal with the injury and tend to stop using their mental training skills. This mental training used prior to injury to prepare for competition, could help them cope with their injury.[30] A difference in coping with pain was found between genders with men more effective at coping than women and individual sport athletes more effective than team sport athletes with coping.[30] These findings are similar to Meyers et al.[13] and the finding that males scored higher on BOD than females indicating less psychosomatic symptoms of pain and better coping strategies present in males. When it comes to the differences between individual and team sports, individual sport athletes expect to have to push themselves and have less reliance on others, whereas team athletes are accustomed to support from teammates to help them through a game so it is expected during rehabilitation.[30] These team athletes are going to need more support from their teammates and coach in order to cope with their injury so it is important to keep them close to the team and coach during the rehabilitation process and not to isolate them from their support system.

CHAPTER III: CONCLUSIONS AND RECOMMENDATIONS

The purpose of this study was to examine whether or not athletes participating in higher levels of athletics would be able to tolerate more pain as shown as shown by their scores on the SIP 15 and the amount of pressure tolerated from a hand-held dynamometer. It was also expected that pain affect would have a significant relationship with pressure pain tolerance and SIP 15 scores. This was investigated by the use of a demographic questionnaire, SIP 15, and pressure pain tolerance testing using a hand-held dynamometer. The statistical analysis consisted of a one-way ANOVA for the independent variables of athletic level and dependent variables of pain tolerance rating, pressure pain testing scores, pain intensity ratings, pain affect ratings, and SIP 15 PCR scores. A Spearman correlation was also used to look for relationships between athletic participation, years of participation, number of injuries, athletic scholarship, pain tolerance rating, SIP 15 scores, pressure pain tolerance scores, pain affect ratings, and pain intensity ratings.

The results of this study showed no significant differences between the athletic levels in this subject pool with regards to pain tolerance rating, pressure pain testing scores, pain intensity rating, pain affect rating, and SIP 15 PCR scores. The Spearman correlation results found significant relationships between the SIP 15 subscale SOM and pressure pain tolerance. This showed that athletes that reported less somatic symptoms in response to pain were able to tolerate more pressure from the hand-held dynamometer. There was a also significant relationship between subject pain tolerance rating and the SIP 15 subscale of PCR which could mean that individuals are fairly accurate at assessing their own pain tolerance level with those self-rating a high pain tolerance level showing a high SIP 15 PCR score which is an individual's overall ability to tolerate pain. The last significant relationship found was between the SIP 15 PCR subscale and pain affect ratings. This was an inverse relationship which would be expected that if an individual earned a high PCR score they would have a low reported pain affect rating. These significant relationships support the usefulness of the SIP 15 in the assessment of an individual's pain tolerance and overall ability to psychologically address pain.

There are some general limitations when it comes to testing pain tolerance. The first, consideration is the type of individual who will volunteer for research and be subject to a painful situation. This is where questionnaires are helpful; however, if the subject does not answer the questions honestly, the results can become misleading. Secondly, when testing an individual's tolerance for pain they might not actually reach their maximum pain tolerance because they max out on the testing device or the researcher's protocol does not allow going past a certain point for safety. Thirdly, the time of season could also play a role with testing prior to season they might not have had much recent exposure to the painful stimuli of training, in contrast to testing during or post season where the athlete would consistently be exposed to the painful stimuli of training. This time difference could possibly alter some of the results when testing pain tolerance.

Future research needs to involve the testing of the SIP15 as part of a pre-participation exam. This research should examine its usefulness in the identification of athletes that are predisposed to injury due to psychological issues related to their inability to cope with pain. Better identification of athletes that might be mentally slow to recover from injury and techniques that could be used to promote mental healing is necessary.

Further investigation is needed into the different techniques that can be used to manage pain such as Zen, acupuncture, mental imagery, and improving coping skills. These different pain decreasing techniques and identification of individual with psychological issues dealing with pain could help to increase exercise and rehabilitation adherence meaning faster and improved return-to-play results.

There is also the possibility for longitudinal studies involving the SIP15 starting with testing junior high athletes throughout their college career. Testing could be done on at least a yearly basis to determine whether those with better coping strategies and higher pain tolerance become varsity collegiate athletes or if there are substantial changes throughout their athletic career. All of these areas of further research are needed to understand pain and the role it plays in athletics.

Conclusion

Research is needed to identify differences in pain between the levels of athletics and explanations for why these differences exist. The differences in pain tolerance are most likely a combination of psychological and physiological differences between individuals implicating that pain is not the same for everyone. Those in the healthcare field need to be aware of this and consider revising the current practice of only assessing one dimension of pain, being pain intensity, and take a multidimensional approach to the assessment of pain. This change in approach will be of the greatest benefit to the injured athlete. When it comes to physical training, it can allow you to know how to get the most of your athletes by addressing psychological inhibitors to pain allowing the athletes to perform at their best with the least amount of pain.

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TABLE 1

Descriptive Statistics for the Four Levels of Athletic Participation

Dependant Variable	Varsity		Club		Intramural		Recreational		Total	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Pain Tolerance	7.03	±1.86	6.92	±1.11	6.83	±1.73	6.47	±1.89	6.73	±1.71
PPT kg/cm^2	13.86	±6.59	11.54	±4.18	17.81	±8.71	11.91	±4.82	13.57	±6.41
PPT Pain Intensity Rating	6.63	±.58	6.5	±.84	5.33	±1.58	6.15	±1.03	6.11	±1.15
PPT Pain Affect Rating	3.75	±1.73	4.58	±2.11	3.39	±1.90	3.62	±2.31	3.74	±2.04
SIP 15 PCR	17.88	±3.56	16.33	±4.68	18.78	±5.09	14.63	±7.06	16.51	±5.79
SIP 15 COP	27.63	±2.88	26.33	±2.34	28.44	±3.43	25.41	±5.17	26.68	±4.15
SIP 15 CAT	9.75	±1.49	10.00	±3.29	9.67	±3.24	10.63	±2.78	10.13	±2.70
SIP 15 SOM	10.13	±2.10	10.00	±1.67	10.00	±2.06	9.00	±2.00	9.6	±1.98
Number of Injuries	2.13	±1.73	2.67	±1.21	1.89	±2.03	2.29	±4.81	2.23	±3.33

PPT = Pressure Pain Testing
PCR = Personal Coping Resources (composite of COP – CAT which scores an individual's ability to deal with pain[6]
COP = Coping (indexes direct coping responses)[6]
CAT = Catastrophizing (assess the tendency to be overwhelmed by pain)[6]
SOM = Somatic Awareness (indicates the extent to which a person is hypo or hypersensitive to stimuli)[6]

TABLE 2

One-Way ANOVA Results

		Sum of Squares	df	Mean Square	F	Sig.
Pain Tolerance	Between Groups	2.175	3	.725	.234	.872
	Within Groups	111.748	36	3.104		
	Total	113.923	39			
PPT Tester Applied kg/cm2	Between Groups	233.379	3	77.793	2.046	.125
	Within Groups	1369.060	36	38.029		
	Total	1602.440	39			
PPT Tester Applied Pain Intensity	Between Groups	8.486	3	2.829	2.382	.086
	Within Groups	42.757	36	1.188		
	Total	51.244	39			
PPT Tester Applied Pain Affect	Between Groups	5.632	3	1.877	.429	.733
	Within Groups	157.362	36	4.371		
	Total	162.994	39			
SIP15 PCR	Between Groups	118.230	3	39.410	1.196	.326
	Within Groups	1153.514	35	32.958		
	Total	1271.744	38			

TABLE 3

Spearman Correlation Results

	Athletic Participation	Years of Participation	Number of Injuries	Athletic Scholarship	Pain Tolerance	SIP15 COP	SIP15 CAT	SIP15 SOM	SIP15 PCR	PPT Tester Applied kg/cm2	PPT Tester Applied Pain Intensity	PPT Tester Applied Pain Affect
Athletic Participation	1	-0.262	0.001	.74**	-0.131	-0.181	0.122	-0.23	-0.196	-0.07	-0.188	-0.078
Years of Participation	-0.262	1	-0.187	-0.138	0.26	.386*	-0.218	-0.069	.380*	-0.083	0.21	0.118
Number of Injuries	0.001	-0.187	1	-0.008	0.194	-0.063	0.135	0.029	-0.105	0.074	0.027	0.094
Athletic Scholarship	.741**	-0.138	-0.008	1	-0.054	-0.004	0.048	-0.161	-0.028	-0.057	-0.187	-0.027
Pain Tolerance	-0.131	0.26	0.194	-0.054	1	.350*	-.458**	0.279	.465**	0.298	0.019	0.025
SIP15 COP	-0.181	.386*	-0.063	-0.004	.350*	1	-.380*	0.193	.902**	0.098	-0.178	-0.245
SIP15 CAT	0.122	-0.218	0.135	0.048	-.458**	-.380*	1	-.339*	-.741**	0.059	0.13	0.291
SIP15 SOM	-0.23	-0.069	0.029	-0.161	0.279	0.193	-.339*	1	0.309	.326*	-0.183	-0.207
SIP15 PCR	-0.196	.380*	-0.105	-0.028	.465**	.902**	-.741**	0.309	1	0.041	-0.186	-.326*
PPT Tester Applied kg/cm2	-0.07	-0.083	0.074	-0.057	0.298	0.098	0.059	.326*	0.041	1	-0.15	0.051
PPT Tester Applied Pain Intensity	-0.188	0.21	0.027	-0.187	0.019	-0.178	0.13	-0.183	-0.186	-0.15	1	.500**
PPT Tester Applied Pain Affect	-0.078	0.118	0.094	-0.027	0.025	-0.245	0.291	-0.207	-.326*	0.051	.500**	1

* Indicates a p<.05 significance level
** Indicates a p<.01 significance level

TABLE 4

SIP15 Subscale Relationships

	SIP15 COP	SIP15 CAT	SIP15 SOM
SIP15 COP	1	-.380*	0.193
SIP15 CAT	-.380*	1	-.339*
SIP15 SOM	0.193	-.339*	1
SIP15 PCR	.902**	-.741**	0.309

* Indicates a p<.05 significance level
** Indicates a p<.01 significance level

FIGURE 1

Hand-Held Dynamometer

APPENDIX A

Informed Consent

The Nature of Research

The purpose of this study is to use the Sports Inventory for Pain (SIP) and a hand-held dynamometer to measure pain perception (see attached). This information will give athletic trainers a better understanding of the individual's perception of pain and proper injury treatment. The participants will be asked to fill out an informational survey, SIP 15 questionnaire, and then their pain tolerance will be tested using a hand-held dynamometer.

Risks Involved

The risks from participation in this study are minimal. The risks from participation in the hand-held dynamometer portion of the study include the following; bruising at testing site, discomfort during testing, possible discomfort for a period of time following testing, and abrasion to skin at site of testing. Any injury that occurs during testing or later due to testing will be cared for immediately by the principle investigator. If at any time during testing the subject wants to stop the test will immediately be stopped and the subject may leave.

Time Requirements

The study requires approximately twenty minutes of the participant's time.

Benefit

This information could lead to a better understanding of an individual's perception of pain, which could lead to improved methods of ascertaining pain perception information in the field of athletic training to provide the most appropriate care to individuals. The device used for pain tolerance testing could be used by future researchers in this field and in clinical settings for accurately measuring the pain tolerance of individuals. In addition, at the completion of the study the subjects will be emailed their scores on the SIP 15 along with the explanation of the score as well as their score on the pain tolerance test.

Contact Information

Principal Researcher	Research Supervisor	Dean of Graduate Studies
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I have read the above “Informed Consent Statement.” The nature, risks, demands, and benefits of the project have been explained to me. I understand that I may ask questions and that I am free to withdraw from the project at any time without incurring ill will or negative consequences. I also understand that this informed consent document will be kept separate from the data collected in this project to maintain my confidentiality. Access to this document is restricted to the principal investigator or an authorized representative. A copy of this document will be given to me.

_________________________________ _____________
Subject’s Signature Date

______________________________ _____________
Witness Signature Date

APPENDIX B

Informational Questionnaire

1. How old are you?

   ____

2. Male or female?

   M F

3. Which is your dominant leg?

   Right Left

4. What is your current highest level of organized athletic participation?

   (Listed from lowest to highest)

   Recreational Intramurals Club team Varsity

5. How long have you participated in organized athletics?

   0-1yr 2yr-5yrs 6yrs-10yrs 11yrs-15yrs 16yrs-20yrs

6. How many injuries have you had during your athletic careers that have resulted in a period of 2 weeks or more of missed participation?

   ____

7. Do you currently receive any athletic scholarships?

   Yes or No

8. Describe your participation in organized athletics in the last 5 years (organized sport with the approximate years of participation)?

   ____

   ____

   ____

9. What percentage of your time for athletics is spent in each training environment?

   ____Indoors ____Outdoors (_____In the cold _____In the heat)

10. How would you rate your ability to tolerate pain?

    1 = no pain tolerance 10=high pain tolerance

    1 2 3 4 5 6 7 8 9 10

APPENDIX C

Sports Inventory for Pain 15

Answer the following questions honestly and to the best of your ability.

1= Strongly disagree
2= Disagree
3= Neutral
4= Agree
5= Strongly agree

1. I owe it to myself and those around me to perform even when my pain is bad.
   1 2 3 4 5

2. When injured, I feel that it is never going to get better.
   1 2 3 4 5

3. When in pain, I tell myself that it doesn't hurt.
   1 2 3 4 5

4. I seldom or never have dizzy spells or headaches.
   1 2 3 4 5

5. When I am hurt, I just go on as if nothing happened.
   1 2 3 4 5

6. When hurt, I worry all the time about whether it will end.
   1 2 3 4 5

7. When injured, I tell myself to be tough and carry on.
   1 2 3 4 5

8. When injured, pain from my injuries is awful and I feel overwhelmed.
   1 2 3 4 5

9. When hurt, I tell myself I can't let the pain stand in the way of what I do.
   1 2 3 4 5

10. I hardly ever notice my heart pounding and I am seldom short of breath.
    1 2 3 4 5

11. When injured, I just ignore the pain.
    1 2 3 4 5

12. When hurt, I can't seem to keep pain out of my mind.

1 2 3 4 5

13. I do not allow pain to interfere with my performance.

1 2 3 4 5

14. I often worry about being injured.

1 2 3 4 5

15. I very seldom have spells of the blues.

1 2 3 4 5

Reference:

Bourgeois AE, Meyers MC, & LeUnes A. The Sports Inventory for Pain: Empirical and Confirmatory Factorial Validity. *Journal of Sport Behavior*. 2009;32(1):19-35.

APPENDIX D

Pain Tolerance Testing Procedure

1. Take subject to a private room.
2. Subject will be asked to lie down on an examination table and remove any clothing covering their lower leg.
3. $1cm^2$ aluminum attachment is applied to the hand-held dynamometer.
4. The hand-held dynamometer is set to peak mode.
5. A pen dot will mark the midpoint of the anterior aspect of the tibial shaft, this will be on the dominant leg of the subject.
6. The subject's knee was flexed to a point that was comfortable and that they could reach the hand-held dynamometer for the second part of testing where they have to apply the pressure themselves.
7. The hand-held dynamometer will then be positioned with the $1cm^2$ attachment over the pen dot.
8. The second researcher placed their thumbs on both sides of the attachment to help maintain contact and avoid any slipping.
9. The pressure of the hand-held dynamometer is then gradually increased.
    a. Increased at a rate of $1kg/cm^2$ every 3s up to a maximum of $30kg/cm^2$.
    b. Pressure is increased until the subject indicates verbally that he or she wants the test to stop.
    c. At this point the pressure immediately released by removing the device.
    d. The peak pressure is then obtained for the screen of the device.

10. The subject is then asked to rate the intensity of his or her pain on a scale from 0 to 10 with 0 being no intensity and 10 being the most intense they could imagine.
11. The subject is then asked to rate how the pain affects him or her on a scale of 0 to 10 with 0 being no unpleasantness and 10 being the pain was very unpleasant.
12. The subject will then be given a bag of ice if they would like to ease any discomfort they might be feeling after the test.