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The Effects of Massage on Mood State, Range of Motion, Sports Performance, and Perceived Performance

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THE EFFECTS OF SPORTS MASSAGE ON MOOD STATE, RANGE OF MOTION, SPORTS PERFORMANCE, AND PERCEIVED PERFORMANCE.

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by

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Introduction: Sports massage is commonly used to treat pain, soreness, and stiffness related to sports injury and training, as well as for injury prevention. Believed to increase blood flow, decrease swelling, reduce muscle tension, and increase a sense of well-being, massage is a widely used manual therapy across the world. ***Objective:*** The purpose of this study was to determine the effects of a twenty-minute sports massage on mood state, range of motion, sports performance, and perceived performance. ***Methods:*** This repeated measures study consisted of passive recovery and massage recovery trials. Baseline testing included the Profile of Mood States questionnaire, range of motion measurements of hip flexion and extension, knee flexion and extension, and ankle plantarflexion and dorsiflexion, as well as sports performance testing of vertical jump, and perceived performance rating on a scale from 1 to 10. A five minute, 100 watt, bike warm-up was completed before a 130-foot contact plyometric workout before the randomly assigned intervention. Subjects then returned at 24 and 48 hours post intervention for repeat testing of mood state, range of motion, sport performance, and perceived performance. ***Analysis:*** Descriptive statistics were calculated using Excel. All data was analyzed in SPSS using repeated measures analysis of variance with Bonferroni adjustments when necessary. ***Results:*** No significant results were found for mood state, sport performance, or range of motion ($p > .05$). Perceived performance was found to be significantly higher at the 24-hour time point in the massage group when compared to the passive recovery group ($p = .007$). ***Conclusions:*** Perceived performance after a massage intervention significantly differed from the passive recovery group. Mood state, range of motion, and sport performance provide no support for the use of sports massage, however, the psychological benefits of the perceived performance may be beneficial enough to warrant the use of the manual therapy.

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Chapter 1

Introduction

Massage, a therapeutic modality used by man since early civilization,[1] is the most natural and instinctive mean of relieving pain and discomfort.[2] The Chinese are believed to have practiced the techniques of massage as early as 3000 B.C., with the utilization of *anmo,* a technique developed over many years of experience in finding the points on the body where various movements such as rubbing, pressing, and manipulations were most effective.[2] These concepts spread to the Romans and Celsus, a practicing physician from 42-37 B.C., who recommended rubbing the muscles to strengthen, improve sluggish circulation, and to reduce edema.[1] Since the time of ancient Greece, massage and sport have co-existed.[3]

Techniques spread and were very popular for centuries; however, as the Roman Empire declined, there was also a decline in the utilization of baths and massage for health. The Renaissance (1450-1600) brought about a rebirth in healing arts, in which significant strides were made in the development of new techniques throughout this time. Massage therapy developed into a very common therapeutic modality employed in the treatment of athletic injuries and ailments, as well as in the prevention of such pathologies. Utilized in some form for hundreds of years, massage is one of the oldest and most common treatments of medical ailments. Believed to increase blood flow, decrease swelling, reduce muscle tension and neurological excitability, and increase a sense of well-being, massage has become a highly used manual therapy across the world.[4,5]

Massage was introduced in the United States in 1858 by Charles Fayette Taylor, known then as *The Swedish Movement Cure*. Sports massage became very popular after its use in the

1984 Summer Olympics, and continues to be used at every Summer and Winter Olympics.[2] Current research in the field has looked at the effects of massage on physiological aspects, such as lactate levels, blood flow, creatine kinase levels, calcium concentrations, neutrophil counts, delayed onset muscle soreness, muscle function, and muscle damage, as well as psychological responses, such as perceived exertion levels, mood states, and perceived recovery. However, current research in the field of massage is lacking consistency in results, methodology, experimental control, and standard protocols,[6,7] thus making the believed effects difficult to truly determine. A great deal of current research analyzes the signs and symptoms of delayed onset muscle soreness in an attempt to decipher the effects of massage; however, inconsistencies in methods and protocols have led to inconclusive results.

Delayed onset muscle soreness (DOMS) refers to the skeletal muscle pain that follows strenuous or novel eccentric exercise.[8,9] DOMS is thought to increase during the first 24 hours after activity, peak between 24-72 hours[8] and subside within 5 to 7 days post exercise.[4,8,9,11] Believed to be caused by physiological adaptations during exercise, symptoms of DOMS include muscle pain, swelling, and decreased muscle endurance and force production,[11] as well as stiffness, tenderness, and aching especially after palpation or movement.[8] Hart et al.[11] found that the events that occur in DOMS possibly resemble the sequence of events observed in the acute inflammatory cycle.[11] While bearable, these symptoms may hinder athletes who require maximal performance before symptoms have subsided. Various modalities have been tested to determine the best intervention to prevent pain and diminished activities of daily living that can occur with DOMS. Massage is one such modality highly considered as a possible reducer of DOMS; however, results have been unclear.

Problem Statement

The current research in massage lacks accuracy and reliability. Varied results and methods decrease the ability to determine if massage truly has an effect on performance, range of motion, and DOMS. Many claims are made about massage, but few have any empirical data to back them up, and what little data there is tends to point more to the limitations of massage than to any significant effects.[4] Psychologically, massage has been shown to have positive results on subjects and their perceived recovery. However, more research with standardized massage routines and outcome assessments are needed to determine if massage has the therapeutic, physiological, or psychological effects currently believed to be elicited by massage.

Purpose of Study

The purpose of this study was to determine the effects of effleurage, petrissage, and tapotement post-exercise sports massage on subject's performance in mood state, range of motion, sports performance, and perceived levels of performance. Subjects completed a plyometric training session inducing sufficient muscle soreness to alter performance. Subjects were randomized into one of two groups: a control group or an intervention group, in which massage was given. Performance measures were taken following the intervention and mood states were profiled.

Research Questions

Does sports massage effect range of motion in the hip, knee, and ankle after strenuous exercise?

Will sports massage alter perceived levels of performance and mood state?

Does sports massage help to increase recovery performance after strenuous exercise?

Will sports massage decrease the recovery period of delayed onset muscle soreness?

Hypotheses

H_1: Post-exercise sports massage will increase range of motion after strenuous exercise when compared to passive recovery.

H_2: Post-exercise sports massage will increase perceived levels of performance and increase levels of positive mood state.

H_3: Post-exercise sports massage will result in no differences in performance when compared to passive recovery.

H_4: Post-exercise sports massage will decrease recovery time from delayed onset muscle soreness when compared to passive recovery.

Significance of the Study

Massage therapy is commonly utilized in athletic settings to prepare athletes for activity, help flush toxins after activity, or in the prevention and treatment of athletic injuries. Currently conflicting evidence does not strongly support positive effects of massage, thus questioning the justification for its use in athletic populations. Therefore, it becomes challenging for those working with athletic populations to defend the use of massage as a treatment plan when compared to other modalities. The benefits of massage need to be determined to help practitioners weigh the positive and negative effects prior to making a decision to implement massage as a therapeutic agent.

Definition of Terms

Delayed Onset Muscle Soreness (DOMS)- the sensation of discomfort or pain in the skeletal muscles that occurs following unaccustomed muscular exertion.[9]

Effleurage- a succession of strokes applied by gliding the hand over an extended portion of the body.[2]

Massage Therapy- a mechanical manipulation of body tissues with rhythmical pressure and stroking for the purpose of promoting health and wellbeing.[5]

Petrissage- massage strokes that lift, squeeze, and press the tissues with the hands and fingers.[2]

Plyometric Exercises- a technique of exercise that involves a rapid eccentric (lengthening) stretching of a muscle, following immediately by a rapid concentric contraction of that muscle for the purpose of producing a forceful explosive movement.[12]

Profile of Mood States questionnaire (POMS)- a factor-analytically derived inventory that measures six identifiable mood or affective states.[13]

Range of Motion- the movement of a joint from one extreme of the articulation to the other.[1]

Sports Massage- the application of massage techniques that combine sound anatomical and physiological knowledge, and understanding of strength training and conditioning, and specific massage skills to enhance athletic performance.[2]

Tapotement- massage movements including tapping, slapping, hacking, cupping, and beating of the muscles and connective tissues with the hands and fingers.[2]

Delimitations

1. Eleven male and female subjects from the University of Montana took part in the study. Individuals who exercise, but did not partake in regular plyometric exercise were used for this study.
2. The intensity levels of the plyometric workout varied throughout the session. High intensity exercises were utilized to best induce delayed onset muscle soreness.
3. For testing purposes, subjects ages 18-30 were utilized. This range was selected due to the common population at the University of Montana, and to help decrease injuries in the areas of interest.

Limitations

1. Errors may have occurred with the goniometer instrumentation involved. As found by Gajdosik & Bohannon,[14] the reliability of the goniometer is found when procedures are standardized. To minimize any error, trained researchers were individually instructed on patient positioning and landmarks before completing practice measurements to increase inter rater reliability. All instruments were also properly calibrated.
2. Emotions and moods after activity vary greatly between individuals, however the Profile of Mood States questionnaire decreased variation in results, providing a standardized tool for each participant.
3. Subjects were not tested unless they had done no physical activity for 48 hours, and continued with inactivity throughout the study. This helped prevent extraneous variables from altering the results of the study.
4. Subjects were screened for frequent participation in plyometric activity to prevent any familiarization that would prevent soreness from being achieved.

5. Although subjects were not blinded to the intervention they received, a privacy screen was used to prevent control subjects from seeing the massage performed on the intervention subjects.
6. Due to the population age and activity level of the subjects, on cannot generalize the results of the study to different age demographics or populations with increased activity levels or limited activity levels.

Chapter 2

Review of Literature

A comparison of recovery techniques is a growing area of research in athletic settings; however, the most effective tools have not been well established. Comparisons between thermotherapy, cryotherapy, ultrasound, stretching, and massage on muscle recovery have been examined in a few studies, resulting in varied conclusions. Weerapong et al.[4] conducted a literature review of current research in massage, concluding that there is a relative lack of good studies or information on massage and its potential to influence muscle recovery, injury prevention and physical performance. They compiled from their research, a list of possible effects of massage with the corresponding results of the previous research. Unfortunately, no solid conclusions could be drawn from their review on any possible effects of massage.

With the utilization of sports massage, starting in the 1984 Olympics, and continuing in the public eye since, more athletes feel dependent on massage to perform at what they feel is the best of their ability. Pre-activity massages are used in conjunction with a warm-up to prepare the muscles for maximal output and to prevent injury.[4] Post-activity massages are believed to help overcome fatigue and reduce recovery time by increasing blood-flow, thus helping to remove waste products after exercise and enhance the delivery of protein and other nutrients needed for muscle repair.[4] Regardless of the timing of the massage, many elite athletes believe that massage is an important part of their success.[4]

Developed hundreds of years ago, sports massage has progressed from a restorative technique performed on Roman athletes to the intensive methods used on athletes today. In 1972, Lasse Viren credited daily deep friction massage with his ability to train hard enough to win gold

medals in the 5,000 and 10,000 meters at the Olympic games.[2,3] In the United States, sports massage was first available at the 1984 Los Angeles Olympic games and has progressed to being readily available to athletes as part of their daily training regimen.[2] The increase public eye on sports massage was instrumental in opening the door for the recognition of massage as a viable treatment for soft tissue injury, dysfunction, and pain.[2] With this came an increase in all therapeutic massage use in the United States.

Massage Techniques

Techniques in the area of massage have existed in some form since almost the beginning of civilization; however, little research explored the effects of techniques until the late 1900s to early 2000s, resulting in inadequate research to defend the employment of massage in the athletic setting. Swedish massage encompasses many of the current techniques currently utilized in the sports massage field. Consisting of five main techniques, Swedish massage can be performed in many different combinations. The five techniques that form Swedish massage are effleurage, petrissage, tapotement, friction, and vibration.[2] Effleurage consists of superficial, elongated strokes done with a standard pressure by the heel of the hand with the main goal to increase temperature and relax the tissues. Petrissage incorporates kneading and lifting of the tissues in an attempt to reach the deeper muscle tissues, whereas, tapotement includes hacking, slapping, cupping, and beating to invigorate the tissues. Friction heats deeper soft tissue structures, and it broadens the fibrous tissues of muscles, tendons, or ligaments, breaking down unwanted adhesions and restoring mobility to muscles.[2] Vibration is expected to invigorate and excite muscles to prepare for an upcoming event. It also helps return the muscle back to homeostasis after exercise; however, the effects of vibration on fatigue are unclear.[15] Sports massage is a

method of massage designed to enhance an athlete's performance, and is achieved through specialized manipulations that stimulate circulation of the blood and lymph.[2]

Sports massage protocols in research vary a great deal, thus, determining the actual true effects becomes a challenging task. Robertson et al.[6] recommend that leg massage last 10 minutes, with most massages requiring 10-30 minutes for effectiveness. However, increased times have also been found to have the greatest benefits to the physiological outcomes of massage. A thirty-minute massage, applied 2 hours after eccentric exercise of the elbow flexors and extensors reduced DOMS,[16] while a 30 minute therapeutic massage of one leg 2 hours after downhill running was effective in attenuating DOMS compared with the contra-lateral limb receiving no treatment.[17] Conversely, an eight minute massage immediately post exercise was found to have no effect on DOMS or the recovery of muscle strength.[18] With varying times causing varying effects on delayed onset muscle soreness, as well as muscle performance, a standardized post-event massage protocol has not been established.

Psychological Benefits of Massage

Although few published research studies have investigated whether massage can help counteract any negative psychological effects with respect to fatigue and perceived recovery between performances.[19] However, research to date does indicates positive effects of massage on the psychological aspects of performance levels and recovery rates. Hemmings et al.[19] found evidence that massage, while not improving physiological regeneration, was beneficial in regenerating the psychological aspects of recovery. High-intensity training or competition is associated with mental fatigue and a generalized worsening of the state of mind. Post-exercise massage can generate a sense of calm and well-being, a reduction in anxiety, and an

improvement in mood and perceived relaxation and recovery.[7] Thus, even if massage may not affect the physiological aspects of recovery, many benefits could occur from altering the psychological state of the athlete and their beliefs on how they will perform.

The discovery that perceptions of recovery showed significant positive changes after massage give some scientific support for the use of massage as a recovery strategy.[19] Tiidus et al.[20] believe that massage may induce an analgesic effect on muscle sensory receptors or induce a psychological relaxation response reducing the perception of DOMS, thus allowing the athlete to believe they are feeling better then they may actually be physiologically. Because the psyche may have the ability to overcome the physiological responses sent to the brain, the psychological effects of massage may alter the amount of effort an athlete puts forth going into a follow-up bout of exercise.

However, Arroyo-Morales et al.[7] found that a lack of vigor and a tendency toward confusion after a sports massage may indicate a subjective perception of the relaxation state generally induced by massage therapy. When relaxation occurs, a person is usually able to forget about stresses and let the tense muscles go lax. Thus, this allows muscle tension to be released bringing about a better sense of well-being. Such responses to massage may not be ideal for the pre-performance treatment, but beneficial post-performance to allow for enhanced recovery.

Physiological Effects of Massage

Massage is often recommended for rapid recovery from fatigue in sports involving repeated performance.[19,21] In previous studies massage has been found to be efficient at enhancing recovery from exercise, at least in the subject's minds.[20] Currently, massage is highly employed at sporting events in which there is a short period of time between bouts of exercise,

such as boxing, swimming, and track and field. The possible mechanisms behind such frequent availability include increased blood flow, increased range of motion, increased parasympathetic activity, decreased stress hormones, decreased pain, decreased muscle tension or spasm, and decreased anxiety,[4] all of which would be considered beneficial before entering into a sporting event to best prepare the athlete for stresses soon to be placed on the body.

Blood flow has been shown to increase in select massage research, but other research has found no alterations in blood flow due to massage. Some previous research states that deep effleurage may increase muscle blood flow.[20,22] However, it was found that superficial and deep effleurage strokes on the leg immediately after, as well as 1 and 2 days post exercise, showed no significant differences between rest and massage on femoral artery mean blood velocity[20] as well as femoral artery blood flow, which was not significantly different in single massage bouts.[23] It was found that lower leg girth decreased at the level of the muscle belly in the massage group,[11] which is believed to indicate increased blood flow and decreased swelling in areas of muscle damage.

Biomarkers of physiological recovery have been analyzed to determine if massage plays a role in removal of inflammatory markers, muscle damage markers, and fatigue markers. Blood lactate is frequently evaluated as a marker of fatigue and recovery.[4] Elevated levels of lactate are present following intense exercise and previous studies have examined whether massage decreases the levels more efficiently than other recovery methods. Inconclusive results have been found regarding these methods, and conflicting results show positive and negative effects on lactate clearance with massage. Martin et al.[24] found that passive rest and massage yielded the same results in lactate clearance, while active recovery significantly decreased blood lactate concentrations. Supporting those results, Monedero et al.[25] found that an intervention of just

massage, active recovery, or passive recovery was ineffective in significant lactate removal, and active recovery with massage significantly decreased lactate levels when compared to other interventions. Another biomarker commonly examined is calcium. Eccentric exercise causes an influx in calcium ions into muscle fibers, and a subsequent disruption of calcium homeostasis.[26] The increase in blood flow, thought to be effected by massage, will cause an increase in cellular oxygentation, and thus a return of the calcium ions to the sarcoplasmic reticulum.[26] Due to inconclusive information regarding blood flow, the effects of massage on calcium levels are still unknown. Finally, creatine kinase , a marker for muscle trauma, has been evaluated for clearance with massage. Smith et al.[16] assessed the effects of massage and passive rest on the increase of creatine kinase levels after eccentric exercise. It was found that although there is still an increase in creatine kinase levels, the increase was stunted and not as exponential as active rest. This decrease in creatine kinase levels may help in the perceived decrease in delayed onset muscle soreness that occurs with a massage intervention.

Delayed Onset Muscle Soreness

DOMS is the feeling of soreness after large-force, eccentric exercise and usually peaks at 24 to 48 hours post-exercise, with resolution at 5 to 7 days. It is associated with muscle pain, swelling, and decreased muscle endurance and force production, which can be detrimental to athletic performance.[11] Therapeutic massage is often used as an intervention in an attempt to help decrease the detrimental effects DOMS may have on athletic performance in competitive athletes. While previous research has found massage to be an effective intervention, others have produced conflicting results.

The physiological mechanisms associated with DOMS sensation are unclear, but might be related to the inflammatory response and edema which may accompany muscle damage.[20] Exercise induced damage to the muscle contractile elements and post-exercise muscle degeneration, possibly mediated by reduced control over calcium homeostasis, may be prime factors in prolonged post-exercise loss of muscle force production.[20] One study indicates that massage significantly attenuates the effects of DOMS at the 48-hour time point, when tested for 96 hours post-exercise;[20] however, it was not shown to affect muscle function at any point in time.[8,20]

Effects of Plyometrics on Delayed Onset Muscle Soreness

Plyometric training is a form of physical conditioning characterized by an intense eccentric contraction of a muscle followed immediately by a rapid concentric contraction; this action produces a forceful, explosive movement.[27] Such exercises are commonly performed during athletic workouts as a way to help improve vertical jump and explosive power. When used, plyometrics can cause a great deal of soreness as the body begins to adapt to the forces placed on the muscles. It is believed that plyometrics are associated with DOMS, a normal response to unusual exertion that is part of an adaptation process that leads to greater strength as the muscle recovers and builds.[27]

During plyometric exercises the eccentric phase is a lengthening contraction of the muscle causing damage to the muscle fiber or musculotendinous junction.[27] In the long term, about 24 hours to 2-3 days post-exercise, eccentric exercise is known to be the major cause of muscle weakness, temporary loss of the range of motion, intramuscular swelling and edema, and a decline in force production.[28] The loss of strength drops by a dramatic 50% immediately after

exercise, and is slowly restored; however, there are often remaining deficits at 10 days post-exercise.[28] Full, regular range of motion has also been shown to be restricted by sarcomere damage and inability to fully shorten, for up to 10 days post eccentric exercise.[28,29] These deficits caused by eccentric exercises, and thus plyometric exercises, help to determine that delayed onset muscle soreness is a common occurrence in plyometric activities. Many athletes who partake in such workouts do not have 10 days to wait for the return of full strength, range of motion, and force in their muscles. Athletes are constantly required to continue exercise; there is a definite need for these athletes to return to full performance at an accelerated rate.

Effects of Massage on Performance

Intense exercise commonly decreases subsequent performance levels until the damage has been healed by the body. Alterations in many different biomarkers have been studied to determine exactly how intense activity alters those biomarkers and which might be attenuated by massage. Tiidus & Shoemaker,[20] stated that exercise induced damage to the muscle contractile elements and post-exercise muscle degeneration, possibly mediated by reduced control over calcium homeostasis, may be prime factors in prolonged post-exercise loss of muscle force production. A loss in force production is perceived as fatigue in many athletes. Fatigue is associated with muscle fiber changes that reflect the increased effort required to maintain a given level of mechanical performance.[7] The relaxation produced by massage therapy has proved capable of reducing local fatigue rate and muscular excitability by inducing relaxation.[7]

The research investigating massage use as a recovery intervention to improve performance, is conflicting. Tiidus et al,[20] found daily manual massage following intense eccentric exercise had no significant effect on rate of recovery of voluntary muscle force

generation up to 96 hours post-exercise.[20] In repeated bouts of high intensity exercise with massage-performed in-between, massage was found to cause a slight increase in performance levels during a Wingate test of maximal output.[6] Zelikovski et al.[30] found 45% improvements in subsequent exercise performances following a 20 minute massage recovery period when compared with a passive recovery condition. These increases found in performance levels due to massage are helpful in justifying massage as a treatment for accelerated recovery. It is still undetermined how massage effects performance in the long term when the next exercise bout is not until 24 to 48 hours after the first bout of exercise. In contrast, Jőnhagen et al.[31] found that massage does not appear to give any local effects in reducing DOMS, functional loss, and decreased muscle strength following hard eccentric exercise.

Tiidus & Shoemaker[20] found that a loss of muscle isometric contractile strength of approximately 40% lasting from several days to over one week is also a characteristic of post-eccentric muscular work, which is also known as DOMS. This loss of strength could be detrimental to subsequent performances necessary for elite athletes. However, Zainuddin et al.[32] found that massage was effective in reducing the magnitude of DOMS, as well as swelling. This resulted in a 20% to 40% decrease in the severity of soreness compared with no treatment[32] and allowed muscle strength to return. Strength is just one part of performance, in conjunction with other areas, like range of motion, which the athlete needs to compete at an elite level.

Massage is often believed to decrease soreness, and thus break-up adhesions within the muscles.[4] When DOMS sets in, the muscles involved often become shortened, with adhered tissue that limits range of motion. Massage is thought to help elongate the muscles, and improve the compliance, allowing for better range of motion to allow the body to perform better.[4] Bell[33] found that a ten-week massage regimen helped to increase low back range of motion, with results

appearing in the first week of treatment. In another study, Wiktorsson-Moller et al.,[34] found that massage on the lower extremities increased only ankle dorsiflexion range of motion, when compared to other activities like warm-up and stretching. With so few studies examining the effects of massage on goniometric range of motion, more research is needed to determine if massage is an effective strategy to increase range of motion and decrease stiffness.

Conclusion

The above review of literature shows that a base of knowledge has been developed regarding massage effects on different areas of performance and recovery. The psychological benefits of massage have been shown through the randomized control trials of Hemmings et al.[19] and Arroyo-Morales et al.[7] to be increased perceived performance and perceived relaxation and recovery. Physiologically, massage benefits show mixed results, with Best et al.[5] reporting in their review of literature six randomized control trials showing no significant benefits of massage and one randomized control trial showing positive effects on creatine kinase levels. Caferelli et al.[22] and Tiidus & Shoemaker[20] both found that massage had positive effect on blood flow in their trials, also, with the decrease in girth found by Hart et al.[11] indicated that the increased blood flow occurring is helping decrease swelling in the areas tested.

DOMS perceived intensity has been shown to decrease with the use of massage, with Best et al.[5] finding five randomized control trials with positive effects.However, conflicting research on massage benefits on performance levels after eccentric exercise argues against the use of massage to lessen the effects of DOMS. Best et al.[5] found six controlled trials with positive effects on performance and ten trials with negative effects on performance. Further review of literature found three[6,30,32] randomized control trials with positive effects on

performance, and two[20,31] with no effect on performance after massage was given. With the apparent inconclusive results, a study further exploring the effects of massage needs to be developed. The following sections will explain the subjects, instruments, methods, variables, procedures, and statistical analysis utilized in this study to assess the physiological and psychological effects of massage.

Chapter 3

Methodology

Massage is commonly performed in the athletic arena; however, there is still very little scientifically based research to fully justify the employment of such techniques on a regular basis. Each year athletes are put through strenuous plyometric workouts that cause extreme muscle soreness and decreased performance for subsequent days. It becomes imperative for some that a technique be utilized to accelerate the healing process, or at least decrease the soreness levels to prevent a detrimental decrease in performance. The main goal of this study was to determine the effects of effleurage, petrissage, tapotement, and vibration post-exercise sports massage on mood state and performance on range of motion, sports performance, and perceived levels of performance. Development and standardization of methods, instruments, and outcome procedures needs to be standardized to best examine the independent and dependent variables associated with the effects of massage after strenuous exercise.

Subjects

Twelve healthy, physically active subjects ages 18-30 (4 men and 8 women) were randomly selected from a volunteer subject pool at the University of Montana. However, one subject did not complete the second set of testing and therefore all of the data from this subject was removed from this study. Subjects were required to be physically active and familiar with plyometrics, in an attempt to prevent injury from exercise inexperience. Recruiting of subjects occurred with the use of informational flyers placed in buildings around The University of Montana campus. The flyers informed subjects what the study entailed and the outcomes

evaluated. Informed consent forms (Appendix A) were signed before subjects were allowed to participate; the consent form was approved by the University of Montana Institutional Review Board.

Once the adequate numbers of participants volunteered, subjects were randomly assigned to either group 1, in which massage was administered during the first testing session, or group 2, in which massage was administered during the second testing session. Five subjects were assigned to group 2, and six subjects were assigned to group 1, but were not informed as to which group they were assigned. Subjects were instructed to complete the "Health and Exercise History Questionnaire" (Appendix B) before moving on to data collection.

Instruments

Health and Exercise History Questionnaire

A data sheet was developed, and tested, for use during this study. The "Health and Exercise History Questionnaire" addressed questions regarding subject's health and exercise history in order to screen for any subjects that may not qualify for the study (Appendix B). The sheet contained only the subject identification number to prevent any release of personal information. Questions regarding the subject's injury and surgery histories were asked to prevent acceptance of subjects in which injury might occur with intense exercise and whose injury history could confound the results. The presence of a lower body injury in the past year disqualified them from participation in this study, injuries included hip, knee, or ankle sprains, as well as any muscular strains that would alter the results of or cause accentuated effects of the strenuous activity. Subject's allergies were requested in order to prevent the use of massage lotions or oils that may cause adverse allergic reactions to the subject. Finally, exercise history

was addressed to ensure physically active participants, with no activity in the previous 48 hours, and to obtain a baseline of the subject's plyometric experience and understanding.

Following development, the survey was evaluated by a panel of experts who work in the field of athletic training to assure validity. A panel of 10 professionals (4 certified athletic trainers, and 6 Health and Human performance graduate students) examined the survey in order to ensure its ability to assess previous history of injury, plyometric activity and screening for allergies. Six sample participants also reviewed the questionnaire to provide feedback on the instrument. The expert panel and sample participants also evaluated the questionnaire for readability and clarity, as well as length of time to complete. This evaluation established face validity, which is explained by Turocy[35] as the evaluation by both experts and sample participants to determine if the instrument measures what it is intended to measure. Being evaluated by an expert panel also established content and construct validity.[35]

Profile of Mood States-Standard Questionnaire

The Profile of Mood States-Standard questionnaire (Appendix C) was utilized to determine how subjects were feeling before beginning each session of testing, as well as at the 24 and 48-hour points during the study. Developed in 1971, the POMS Standard has proven to be an excellent measure of mood states and their fluctuations.[36] O'Conner[37] found the reliability of the POMS, in vigor and fatigue, to be reliable, with high internal consistency values, ranging from .90 to .94 for fatigue and .87 to .92 for vigor. He also found the test-retest reliability to be of acceptable consistency with theoretical expectations about the nature of mood (ranging from .07-.35). The questionnaire was analyzed according to previous validation research to ensure proper use. The questionnaire itself consisted of 64 questions, which were descriptive words in

which the subject was required to rate the level at which they felt that way according to the 1-5 Likert scale, with 1 being "not at all" and 5 being "extremely." Eight total areas were looked at including 1) friendship, 2) tension-anxiety, 3) depression-dejection, 4) anger-hostility, 5) vigor-activity, 6) fatigue-inertia, 7) confusion-bewilderment, and 8) total mood disturbance. From these 8 areas a final mood state score is calculated by adding tension-anxiety, depression-dejection, anger-hostility, fatigue-inertia, and confusion-bewilderment and subtracting the vigor-activity score from those.

Goniometer

A standard 8-inch goniometer was utilized for range of motion testing. The goniometer was used to measure hip flexion and extension. The stationary arm was parallel to the midaxillary line, the axis was placed over the greater trochanter of the femur, and the movable arm was parallel to the longitudinal axis of the femur, pointing toward the lateral epicondyle.[38] For hip flexion the patient was in a supine position and prone for hip extension on the treatment table. Knee flexion and extension were measured with the axis of the goniometer placed over the lateral epicondyle of the femur, the stationary arm parallel to the longitudinal axis of the femur, pointing toward the greater trochanter, and the movable arm parallel to the longitudinal axis of the fibula, pointing toward the lateral malleolus.[38] The patient was supine for knee extension and flexion on the treatment table, with one to two Airex balance pads (Gymwell Co. Ltd., Tainan, Taiwan) placed under the heel during extension to allow for a full range of motion. Ankle dorsiflexion and plantarflexion were measured with the axis just inferior to the lateral malleolus, the stationary arm parallel to the longitudinal axis of the fibula, and the movable arm parallel to the sole of the heel.[38] The patient was seated with his/her knee bent at a 90 degree angle to allow

for the lower leg to hang off the end of the table for both dorsiflexion and plantarflexion measurements. To ensure reliability in measurements, range of motion was assessed at the same time each day, by a trained researcher, using the same measuring tool, the same patient position, and following a standard measurement protocol.[38] To allow for examiner error, when examining the results, an increase by 3° or 4° in range of motion indicated improvement, and anything less indicated no change.[38]

Sport Performance

A twenty-eight inch Just Jump mat (Probotics, Huntsville, AL) was used to measure the average and best of three double leg vertical jumps. The Just Jump mat measured vertical jump by measuring the amount of time in which both feet were not in contact with the mat. Power can also be calculated utilizing the Just Jump mat. Subjects were allowed to swing their arms and mimic a wall jump test by reaching up to attempt to touch the highest point possible for them. However, subjects were required to start with their dominant foot on the mat and instructed to bring their other foot in line with the dominant foot before gathering and performing a vertical jump, keeping the knees extended while in the air to prevent any error with the Just Jump mat.

Perceived Performance

At the end of each testing session subjects were asked to rank how they felt they performed on a scale of 1 to 10. For this scale 1 represented “poor” performance and 10 represented “excellent” performance. A ranking was done after the first testing session, after the 24-hour testing session, and after the 48-hour testing session.

Plyometric Exercise

Plyometric exercises consisted of bounding, jumping, skipping, and hopping exercises performed at a high intensity level, commonly utilized in athletics to increase explosive power and speed.[39] To induce soreness in subjects, a moderate to intense plyometric workout was implemented. Chu[39] determined that a moderate to intense plyometric workout should contain 100-150 foot contacts throughout the workout, thus, a 130-foot-contact workout was developed. The exercises in this study are outlined below. They consisted of 130-foot contacts and chosen due to their moderate to high intensity levels, as described by Chu.[39]

Plyometric Exercise	**Sets**	**Repetitions**
Bounding: accentuated jogging strides, covering as much distance as possible.	1	16
Double Leg Barrier Jump: bound over cones, tucking both knees to chest	3	6
Line Jumps- Side to side: Start with both feet on right side of the line, jump with both feet to the left side of the line. Every return to the right side counts as 1 repetition	2	11
Split Jumps: Starting in a lunge position with right leg in front, jump as high as possible switching legs while in the area, land in lunge position with left leg in front. Every return to right leg counts as 1 repetition	2	10
Line Jumps- Front to back: Start with both feet behind the line, jump with both feet in front of the line. Every return to behind the line counts as 1 repetition	2	11
Cone Hops with 180-degree turn: 5 cones in a line tuck jumping with 180-degree turn over each cone.	2	5
Squat Jumps for Distance: Start in the squat position, explode out of the position covering as much	2	11

ground and jumping as high as possible, land in squat position		
Total foot contacts		130

Massage

Sports massage primarily consists of effleurage and petrissage techniques with some tapotement and vibration worked in to the routine. Techniques during this study included the aforementioned techniques, with more focus placed on effleurage and petrissage. Massage on subjects was done utilizing a hypoallergenic massage lotion to help decrease friction in the area. Massages on all subjects were done by the same Licensed Massage Therapist to decrease any variation between techniques. The massage protocol was performed as follows for each subject to ensure consistency.

Minutes 0:00-5:00- Massage of the anterior left leg.

0:00-1:00- Effleurage over the anterior thigh

1:00-2:00- Effleurage over the anterior lower leg

2:00-3:00- Petrissage, tapotement, and vibration over the anterior thigh

3:00-4:00- Petrissage, tapotement, and vibration over the anterior lower leg

4:00-5:00- Effleurage/Petrissage over the entire anterior left leg

Minutes 5:00-10:00- Massage of the anterior right leg

5:00-6:00- Effleurage over the anterior thigh

6:00-7:00- Effleurage over the anterior lower leg

7:00-8:00- Petrissage, tapotement, and vibration over the anterior thigh

8:00-9:00- Petrissage, tapotement, and vibration over the anterior lower leg

9:00-10:00- Effleurage/Petrissage over the entire anterior right leg

Minutes 10:00-15:00- Massage of the posterior left leg

10:00-11:00- Effleurage over the posterior thigh

11:00-12:00- Effleurage over the posterior lower leg

12:00-13:00- Petrissage, tapotement, and vibration over the posterior thigh

13:00-14:00- Petrissage, tapotement, and vibration over the posterior lower leg

14:00-15:00- Effleurage/Petrissage over the entire posterior left leg

Minutes 15:00-20:00- Massage of the posterior right leg

15:00-16:00- Effleurage over the posterior thigh

16:00-17:00- Effleurage over the posterior lower leg

17:00-18:00- Petrissage, tapotement, and vibration over the posterior thigh

18:00-19:00- Petrissage, tapotement, and vibration over the posterior lower leg

19:00-20:00- Effleurage/Petrissage over the entire posterior right leg

Variables

Independent Variables:

1. Massage after strenuous exercise
2. Passive rest after strenuous exercise

Dependent Variable:

1. Mood state- determined from the POMS
2. Range of motion of the hip, knee, and ankle.
3. Sport Performance- determined from the vertical jump test
4. Perceived Performance

Procedures

Prior to their entering the lab, all eleven subjects were assigned a random subject ID number. Assigned ID numbers were then randomly assigned subjects into group 1 or group 2 for the remainder of the study. Subject ID numbers were computer generated and numbers then assigned to subjects depending on their sign-up date, with the first generated number given to the first subject to volunteer and so on.

During the first visit to the lab the consent form was explained in detail to the subjects before they signed and agreed to the terms. Each subject entered their age and answered the questions posed on their Health and Exercise History Questionnaire. Any subject that had participated in physical activity over the last 48 hours was asked to return after a 48-hour period of inactivity. Subjects were then weighed and height measured by the primary investigator. Subjects were then introduced to the POMS-Standard questionnaire and were asked to take a baseline questionnaire before moving on to other data collection. Next, subject's passive range of motion measurements were taken for hip flexion and extension, knee flexion and extension, and ankle plantarflexion and dorsiflexion. Each measurement was taken three times and the average of those three measurements was used for analysis. Baseline vertical jump testing was done on the Just Jump mat. An average of three jumps was taken for each subject. Finally, subjects rated on a scale from 1 to 10 how they felt they performed on the range of motion and vertical jump baseline tests. Following baseline testing, subjects utilized a stationary bicycle to warm up before heading into plyometric activity. A computer clamped stationary bicycle was used to ensure that each subject rode at 100 watts for five minutes. Subject's height and weight measurements were entered into the program before they adjusted the seat to a comfortable height and began their warm-up. Subjects were then taken through the 130-foot contact strenuous plyometric workout

(breakdown and description of exercises available in instruments section), with prior instruction on proper landing techniques to prevent injury. After the plyometric exercises subjects were directed to the treatment tables available for the study interventions. Subjects of group 2 partook in passive recovery, consisting of resting quietly on the table for 20 minutes. Subjects of group 1 received 20 minutes of massage to the lower extremities, consisting of 5 minutes on the anterior aspect of the left leg, 5 minutes on the anterior of the right leg, 5 minutes on the posterior aspect of the left leg, and 5 minutes on the posterior of the right leg. A breakdown of massage protocol is described above. Following the 20 minute intervention subjects were instructed not to partake in physical activity for the next 48 hours, and were informed of their subsequent testing times over the next 48 hours. Subjects were also given an instructional take home sheet (Appendix D) outlining restrictions for the following 48 hours, which prohibited the use of non-steroidal anti-inflammatory drugs, stretching, hot baths or hot tub use, ice or heat, and physical activity for the following 48 hours.

At 24 hours post treatment, as well as 48 hours post treatment, subjects returned to the lab for follow-up testing. A repeat of baseline procedures occured. Subjects began with the POMS questionnaire before measuring hip flexion and extension, knee flexion and extension, and ankle plantarflexion and dorsiflexion range of motion as previously described. Following range of motion, a series of three vertical jumps were done on the Just Jump mat, followed by a final rating of how they felt they performed on a scale of 1 to 10 at each of the 24 to 48 hour time points.

During the second testing session, 3 weeks after the first testing session, subjects were asked when they last performed any physical activity. Any subject who had performed physical activity in the past 48 hours was asked to return when they had not done so. Baseline

measurements were taken (following the same procedures as the first testing session) of all subject's POMS-Standard score, range of motion, vertical jump, and perceived level of performance. Following baseline testing subjects were given 5 minutes to warm-up on the provided stationary bicycle and were required to ride at the same clamped 100-watts as they performed during the first testing session. Subjects were then taken through the same 130-foot strike plyometric workout. Following the workout subjects in group 2 received 20-minutes of massage, the same protocol as described above, while subjects in group 1 participated in passive recovery on the provided treatment tables. Follow-up testing occurred at the 24 and 48 hour marks after the intervention. Follow-up protocol was the same as that which followed the first testing session.

Statistical Analysis

Excel® was used to enter all raw data and to analyze descriptive statistics to ensure normal data, exploring means and any skewness present. An SPSS®, version 17.0, program was utilized for statistical analysis. A 2 by 3 repeated measures analysis of variance with post hoc testing was done to determine differences in independent variables effects on the dependent variables at the 0-, 24-, and 48-hour time points during the two different testing sessions. The POMS-Standard was scored by the researcher and analyzed descriptively by calculating frequencies and percentages of each response.

All results are presented in Appendix E.

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The effects of sports massage on mood state, range of motion, sports performance, and perceived performance.

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Abstract

Introduction: Sports massage is commonly used to treat pain, soreness, and stiffness related to sports injury and training, as well as for injury prevention. ***Objective:*** Determine the effects of post-performance sports massage on mood state, range of motion, sports performance, and perceived performance. ***Methods:*** Repeated-measures study using passive and massage recovery trials. Baseline testing of the Profile of Mood States questionnaire, range of motion measurements of the hip, knee, and ankle, sports performance testing, and perceived performance rating. An intensive plyometric workout was performed followed by an intervention of either lower extremity massage or passive rest recovery. Follow-up testing was done at 24 and 48 hours post intervention. ***Analysis:*** Descriptive statistics were calculated using Excel. All data was analyzed in SPSS 17.0 using repeated measures ANOVA. ***Results:*** No significance between interventions was found for mood state, sport performance, or range of motion. ($p > .05$). Perceived performance was significantly higher at the 24-hour time point in the massage group when compared to the passive recovery group ($p = .007$). ***Conclusion:*** The psychological benefits of perceived performance may warrant the use of the manual therapy.

INTRODUCTION

Introduced in Ancient Greece as a part of physical fitness rituals, sports massage has developed into a highly visible modality via the 1972 Summer Olympics when Lasse Viren credited daily deep friction massage with his ability to train hard enough to win gold medals in the 5,000 and 10,000 meter races.[1] Commonly used to treat pain, soreness, and stiffness related to sports injury and training, as well as for injury prevention, sports massage has widespread use in the athletic realm. Believed to increase blood flow, decrease swelling, reduce muscle tension and neurological excitability, and increase a sense of well-being, massage has become a highly used manual therapy across the world.[2,3] Sports massage is a method of massage designed to enhance an athlete's performance, and is achieved through specialized manipulations that stimulate circulation of blood and lymph.[1] As the use of sports massage has increased in the public eye, so has the demand for a modality that is recognized as a viable treatment for soft tissue injury, dysfunction, and pain.[1] However, along with increased publicity for the use of massage comes a need for more conclusive, concrete research before a great deal of money and resources are put into this time consuming modality. Current research does not unanimously support the use of massage and is lacking consistency in results, methodology, experimental control, and standardized protocols.[4,5] Concrete results are needed to determine if sports massage elicits physiological and psychological benefits and helps decrease the detrimental effects delayed-onset muscle soreness can have on an athletes performance.

Delayed-onset muscle soreness (DOMS) refers to the skeletal muscle pain that follows strenuous or novel eccentric exercise.[6,7] DOMS is thought to increase during the first 24 hours after activity, peak between 24-72 hours,[8] and subside within 5 to 7 days post-exercise.[2,6,7,9] Hart et al.[9] believe that DOMS is caused by the physiological adaptations during exercise and results

in muscle pain, swelling, and decreased muscle endurance and force production, all of which closely resemble the sequence of events observed in the acute inflammatory cycle. This exercise induced damage to the muscle contractile elements and post-exercise muscle degeneration, possibly mediated by reduced control over calcium homeostasis, may be a prime factor in prolonged post-exercise loss of muscle force production.[10] Due to the effect that these symptoms can have on an athletes ability to perform at high levels on consecutive days, or even multiple events, it becomes necessary to determine if massage can truly hinder or at least diminish those symptoms to the point in which maximal activity is achievable.

Research indicates that massage improved perceived performance and facilitated the regeneration of the psychological aspects of recovery.[11] Post exercise massage can generate a sense of calm and well-being, a reduction in anxiety, and an improvement in mood and perceived relaxation and recovery.[5] However, there is presently little published research investigating whether massage helps counteract any negative psychological effects with respect to fatigue and perceived recovery between performances.[11] This topic needs to be further investigated to determine if an athlete can psychologically overcome fatigue and still have the ability to perform at a high level. Arroyo-Morales et al.[5] found that a lack of vigor and a tendency toward confusion after a sports massage may indicate a subjective perception of a relaxation state generally induced by massage therapy. This relaxed state may allow athletes to fully relax their muscles and allow their body to better recover from the damage that has occurred from the prior athletic event.

Several studies have found massage to decrease soreness and break-up adhesions within the muscles[2], reducing the magnitude of DOMS[12], elongate muscles allowing for better range of motion[13], and regenerating the psychological aspects of recovery.[11] All of these believed benefits

are major selling points to athletes in need of increased performance or decreased recovery time. These believed benefits also sway athletes to request recovery massages after difficult workouts from their team athletic trainer or massage therapist, and it is undetermined if these benefits are really worth all the extra work and stress on the practitioner's body. Therefore, the purpose of this study was to determine the effects of effleurage, petrissage, and tapotment post-performance sports massage on mood state, range of motion, sports performance, and perceived performance. It was hypothesized that massage would increase range of motion, increase perceived levels of performance and positive mood states, decrease recovery time, and have no effect on performance when compared to passive recovery.

METHODS

Experimental Design

A randomized, repeated-measures design was used to investigate the effects of massage on mood state, range of motion, performance, and perceived performance. Participants were randomly assigned to one of two groups (massage or control) before completing the first round of data collection. Prior to testing, subjects read and signed the approved informed consent document. The University's Institutional Review Board for Use of Human Subjects approved the consent form for ethical treatment of subjects and overall safety.

Participants

Twelve healthy, physically active male and female subjects (4 male, 8 female) volunteered to participate; however, only eleven completed the study (Table 1). Participants were eligible for participation if they were between the ages of 18 to 30 and were identified as having no lower extremity injuries in the past year. Lower extremity injury criteria which

excluded participants, was defined as any self-reported injury, chronic or acute, to the hip, knee, or ankle within the 12 months prior to participating in the study. This included any strain, sprain, fracture, or surgery.

Instruments

Profile of Mood States

The Profile of Mood States-Standard (POMS) questionnaire (Multi-Health Systems Inc., North Tonawanda, NY) was utilized to determine how subjects felt prior to the start of testing. Found by O'Conner[14] to be reliable with high internal consistency, especially in the areas of fatigue and vigor (.90 to .94 for fatigue an .87 to .92 for vigor), also the POMS was found to have an acceptable consistence test-retest reliability (ranging from .07-.35) with theoretical expectations about the nature of mood. This test consisted of 65 questions, containing descriptive words pertaining to emotions and mood. Each subject rated the level in which they were feeling that emotion/mood on a 1-5 Likert scale, with 1 being " not at all" and 5 being "extremely." These 65 words related to six subscales which consisted of: tension-anxiety, depression-dejection, anger-hostility, vigor-activity, fatigue-inertia, confusion-bewilderment. Total mood disturbance is determined from a specific calculation of the subscales. Questionnaires were scored and recorded based on the specified directions that accompanied the testing materials.

Range of Motion

Bilaterally lower extremities were measured for range of motion in the areas of hip flexion, hip extension, knee flexion, knee extension, ankle dorsiflexion, and ankle plantarflexion. A standard 12-inch plastic goniometer (Medco Sports Medicine, Tonowanda, NY) was utilized for range of motion testing. Measurements were taken three times for each motion with the

average of the three being used for data analysis. Eight athletic training students took all the range of motion measurements. Each student was taken through an instruction session on proper landmarks and subjects positioning before being allowed to take measurements. To allow for examiner error, when examining the results, an increase by 3° or 4° in range of motion indicated improvement, and anything less indicated no change.[15]

Hip Flexion and Extension

Landmarks for hip flexion and extension included the stationary arm parallel to the midaxillary line, the movable arm parallel to the longitudinal axis of the femur, and the axis on the greater trochanter.[15] Subjects were supine for hip flexion and instructed to dorsiflex the ankle keeping the knee completely extended throughout the measurements. Subjects were prone for hip extension and were instructed to keep the knee completely extended and ankle plantarflexed while keeping the anterior superior iliac spine in contact with the treatment table.

Knee Flexion and Extension

Knee flexion and extension were measured using the lateral joint line for the axis, the stationary arm parallel to the longitudinal axis of the femur pointing toward the greater trochanter, and the movable arm parallel to the longitudinal axis of the fibula pointing toward the lateral malleolus.[15] For knee flexion the subjects were supine and were instructed to bring their heel as close to their buttocks as possible. For knee extension Airex balance pad(s) (Gymwell Co. Ltd., Tainan, Taiwan) were placed under the subjects' feet, allowing for full extension of the knees.

Ankle Plantarflexion and Dorsiflexion

During ankle plantarflexion and dorsiflexion testing, subjects were in a short-seated position off the end of the treatment table. The axis of the goniometer was placed just inferior to

the lateral malleolus, the stationary arm was parallel to the longitudinal axis of the fibula, and the moveable arm parallel to the sole of the heel.[15] Subjects were instructed to bring their toes toward their shin for dorsiflexion and to point their toes for plantarflexion.

Sport Performance

Sports performance was measured with vertical jump testing using a Just Jump® mat (Probotics, Huntsville, AL). Subjects wore tennis shoes while performing this testing. Subjects were instructed to start with one foot on the edge of the mat. They then brought their feet together on the mat, gathered, and performed a 2-footed, straight-leg, vertical jump to their maximum ability. Subjects were allowed to use their arms, but were required to perform the jumps the same each time. Three jumps were performed with the average of the three used for data analysis.

Perceived Performance

Subjects were asked to rank how they felt they performed on the range of motion and vertical jump test, compared to their normal. Performance was ranked on a scale from 1 to 10, with 1 being "poor" and 10 being "excellent." Perceieved performance was taken at the 0, 24 hour, and 48 hour time points, with the subject's number ranking being used for data analysis at each time point.

Procedures

Experimental Protocol

During the first visit to the lab, subjects completed a detailed Health and Exercise History Questionnaire to rule out any conditions that may have placed the subject at risk for complications during the study. The questionnaire used both open and closed ended questions to best determine each subject's history. This questionnaire also confirmed that the subjects had not

participated in any physical activity 48 hours prior to their partaking in this study, and did not perform plyometric exercises on a regular basis. Height and weight measurements were obtained and body mass index was calculated. Baseline testing of mood state, range of motion, sports performance, and perceived performance were taken before subjects continued. Subjects then began a five-minute warm-up on a Cardgirus bike (Cardgirus, Madrid, Spain) set at a computer clamped 100 watts, based on height and weight which was entered into the computer program, for 5 minutes. Following the warm-up subjects were led through an intensive plyometric exercise, outlined in-depth in Table 2. The intensity of the plyometric exercise was determined by Chu[16] to contain 100-150 foot contacts, thus a 130 foot-contact workout was developed. After completing the plyometric workout subjects either passively recovered for 20 minutes on a treatment table, or received a 20 minute massage, outlined in Table 3, depending on their random assignment prior to testing. After the recovery was complete the subjects were led through a take home instruction sheet outlining restrictions on treatment for any soreness that would be setting in over the following 48-hours. They were instructed to seek medical treatment if any abnormal pain occurred, and to report back to the lab 24 hours later for follow up testing.

Twenty-four hours post-testing subjects completed the POMS questionnaire, range of motion testing, vertical jump testing, and perceived performance ranking. Subjects were then instructed to return again 24-hours later, at the 48-hour mark. During this testing time, subjects again completed the POMS questionnaire, range of motion testing, vertical jump testing, and perceived performance ranking. After completing the 48-hour testing, subjects signed up to repeat the testing process again 3 weeks later. After the three-week wash-out period subjects returned to repeat the process, with either the passive recovery or massage. This was to ensure that all subjects received both interventions of passive recovery or sports massage.

Data Analysis

Data was entered in to Excel® (Microsoft, 2009) to calculate basic descriptive statistics and averages of the three measurements for all range of motion and sports performance testing were calculated. Perceived performance was recorded on a 1-10 scale, and the means of those numbers, were used in the data analysis. POMS questionnaires were scored as developed and the total mood disturbance used in data analysis. All data was then analyzed in SPSS 17.0 (IBM, 2009) using a 2 by 3 repeated measures analysis of variance with post hoc testing, and Bonferroni adjustments when necessary. *A priori* level was set at the $p < 0.05$ level for all data analysis.

RESULTS

Profile of Mood States

Results for the POMS questionnaire are displayed in Figure 1, with each area depicted. No significance was found for time, treatment, or time x treatment.

Range of Motion

There was no significant difference ($p > .05$) in range of motion between massage and passive recovery trials for time vs. treatment of bilateral hip flexion, bilateral hip extension, bilateral ankle plantarflexion and dorsiflexion, and bilateral knee flexion. For right knee extension there was significant difference between the zero time point and both the 24-hour ($p = .027$) and 48-hour ($p = .036$) time points, for both massage and control. However, there was no significant difference between treatments ($p > .05$). Left knee extension showed significant

difference between the zero time point and the 48-hour time point (p=0.022), but there was no significance difference when looking at the treatment interaction.

Clinical significance was determined to be a minimum of 3° increase in range of motion.[15] Results showed that massage increased right hip flexion by 3.0° compared to baseline at the 48-hour time point, left hip flexion by 5.3° at the 24-hour time point and 3.36° at the 48-hour time point compared to baseline.

Sport Performance

There was no significant difference ($p > .05$) for vertical jump height for passive recovery trials (17.633 ± 4.6, 17.79 ± 4.3, 17.75 ± 4.8 inches for 0, 24, and 48 hour time points respectively) or massage recovery trials (17.35 ± 4.8, 17.52 ± 4.4, 18.12 ± 4.6 inches for 0, 24, and 48 hour time points respectively). For the time x treatment interaction there was no significant difference ($p > .05$).

Perceived Performance

A significant time interaction was found between the 0-hour time point and the 24-hour time point for the passive recovery trial ($p = .014$). There was a significant treatment interaction between the massage and passive recovery groups at the 24-hour time point ($p = .007$), with the massage trial reporting feeling as though they performed better at that time point then the passive recovery trial. Although, subjects anecdotally reported to researchers of being unable to perform at the level of baseline performance at both the 24 and 48-hour time points, results show the massage intervention group to have an increased perceived performance compared to the passive recovery intervention.

DISCUSSION

The main goal of this study was to determine if sports massage effected subject's performance in mood state, range of motion, vertical jump, and perceived performance. The principal findings in this study were that massage caused a significant increase in rating of perceived performance 24 hours after activity and intervention, while no benefits were found with massage on mood state, range of motion, or sport performance. With these results it becomes important to examine how the results of perceived performance, mood state, range of motion and sport performance compare with previous research, and how massage techniques can alter these results.

The results of this study suggest that massage could potentially increase the psychological recovery from intense performance. As was found in a previous study by Tiidus et al,[10] massage may induce an analgesic effect on muscle sensory receptors or induce a psychological relaxation response that reduces the perception of DOMS, thus allowing the athlete to believe they are feeling better and performing better than they may actually be. This power of the psyche may justify the use of massage for recovery. Hemmings et al.[11] found that boxers ranked their performance, on a 0 to 28 scale, at a 19.0 ± 3.8 after a massage intervention compared to 12.1 ± 4.0 after a passive rest intervention. The results from Hemmings' study and the current study indicate that even without physiological benefits the psychological benefits of massage may be powerful enough to utilize massage.

In this study, although mood states were not altered by massage; they stayed very close to baseline even though the subjects were required to endure a strenuous plyometic exercise routine. As Arroyo-Morales et al.[5] reported, and was supported in this study, massage therapy does not induce positive mood state changes but possibly reduces deleterious effects induced by high-intensity exercise. Lane et al.[17], proposed that although some subjects are put into a

depressive or angry mood state after activity, these feelings could either facilitate increased performance or debilitate the performance. While subjects POMS scores may not have changed in this study, this is not necessarily a negative finding. Each individual could either choose to use the soreness and pain to motivate themselves or to sabotage their performance.

Previous research, while having similar results on the psychological aspects, also has led to similar findings regarding the effects of soreness and massage on range of motion. Joint motion can play a large role in injury prevention, or injury incidence, in the highly active athlete. Insufficient range of motion caused by poor muscle flexibility may be a possible cause of muscle strain and increased risk of injury.[18] Stretching exercises are most commonly utilized method to increase range of motion. However, pre-performance stretching to increase muscle length may be detrimental to performance, specifically a vertical jump. Behm and Kibele[19] found that all intensities of prior static stretching whether submaximal (75% of point of discomfort) or maximal (100% of point of discomfort) resulted in significant impairments in jump height. With the apparent fragile balance between optimal muscle length for performance and optimal length for range of motion, there is a thought that massage may be a better option than stretching to obtain that balance. As McKenchie et al.[20] reported, massage was able to increase range of motion of the right ankle, but there was no change in power output. As was discovered in this study, while range of motion was able to increase hip flexion in the left hip at both follow-up time points and right hip flexion at the 48-hour time point, vertical jump height was also not significantly diminished, indicating that massage may not be as detrimental as stretching, thus a more beneficial recovery modality.

The use of a full lower extremity sports massage, in this study, instead of a more focused approach to just one muscle or muscle group could have altered the effect on range of motion.

Other studies have found that even a quick 10 or 30 second musculotendinous massage, on the distal hamstrings, was able to significantly increase hip flexion range of motion.[21] Similarly, McKenchnie et al.[20] found that petrissage and tapotement significantly increased ankle dorsiflexion, when the plantarflexor group was massaged. These findings could indicate the need for massage on just muscles that are commonly injured in a specific sport instead of massage to the entire extremity. With hamstrings injuries most commonly occurring in explosive sports[22], such as sprinting or soccer, it may be beneficial to massage that area specifically to help increase range of motion and decrease the overstretching of the muscle that often occurs. With the clinically significant finding of increased hip flexion range of motion, an increased massage focus on that specific area may produce even greater increases in range of motion. This sentiment may also be carried over into other sports arenas. Massage of the rotator cuff insertions may help decrease strains which often occur in common overhead activities, such as tennis or baseball.

Improved performance may be a primary goal of massage for athletes, while injury prevention may be at the top of the list for their sports medicine practitioners. This study used an intensive plyometric workout, to help determine the effects of massage, in order to better apply the effect of massage in athletics. Most studies, looking at the effects of massage, used repetitive non-weight bearing eccentric exercises. However repeated jumping and functional eccentric exercises are more common in athletics. While research does not unanimously support the ability of massage to increase performance levels, it does support the psychological benefits of massage. This study also shows that while mood state, range of motion, and sports performance were not significantly increased by post-exercise massage, perceived performance was increased 24 hours after an intense plyometric workout with massage as an intervention compared to a passive

recovery. These findings may not support the practice of massage for busy clinicians when other modalities, such as active recovery or cold whirlpool, may be more beneficial and less physically draining on the practitioner. However, an increase in the psychological benefits may warrants the use of massage to increase perceived performance and confidence within the athletic population.

Limitations

A major limitation in this study was accuracy of range of motion testing. Due to schedule conflicts and time commitments the same researcher was not able to do all of the range of motion testing and athletic training students were recruited to complete the measurements. Better results may be found in future research, if the same researcher completes all measurements to increase inter-rater reliability. Also, while subjects were required to be physically active, the type of physical activity in which they normally participate could have decreased the affects of soreness and stiffness we attempted to be obtained using the plyometric workout. A better regulation of activity would be beneficial to increase the impact of the plyometric workout and possibly cause higher levels of soreness for all subjects. The POMS questionnaire, while extremely reliable, may have decreased in significance due to the many outside factors in the stressful lives of the college aged participants. It may have been more beneficial to do the data collection during a winter break or summer break to decrease the mid-semester stresses that could alter the POMS scores. Also, the addition of a DOMS rating, or soreness ranking, would have been a beneficial addition to strengthen the study and add another component to the results.

CONCLUSION

This study was unique because, to our knowledge, it was the first to look at the possible effects of sports massage on several variables rather than focusing on one variable. In addition,

this study used plyometric exercise as an eccentric exercise instead of standard non-weight bearing repetitive eccentric contractions. This utilization of a more sports specific activity makes the study more practical in the field of sports medicine. While athletes do perform standard eccentric exercises in the weight room, more damage to the muscles and soreness seems to occur from the eccentric landing and activities during practices. Although we found only knee extension ROM to be significantly different during this study, it is difficult to speculate the reason when subjects complained of soreness and decreased motion more with hip flexion. Future research should address our limitations by using a larger sample size and the same researcher for all measurements. It would also be beneficial to look at the POMS at more frequent time points, for example before and after the plyometric workout, as well as after the intervention. Also, the use of massage at each the 0, 24, and 48 hour time points may have increased the effects of the massage on the outcomes and would be beneficial to further study.

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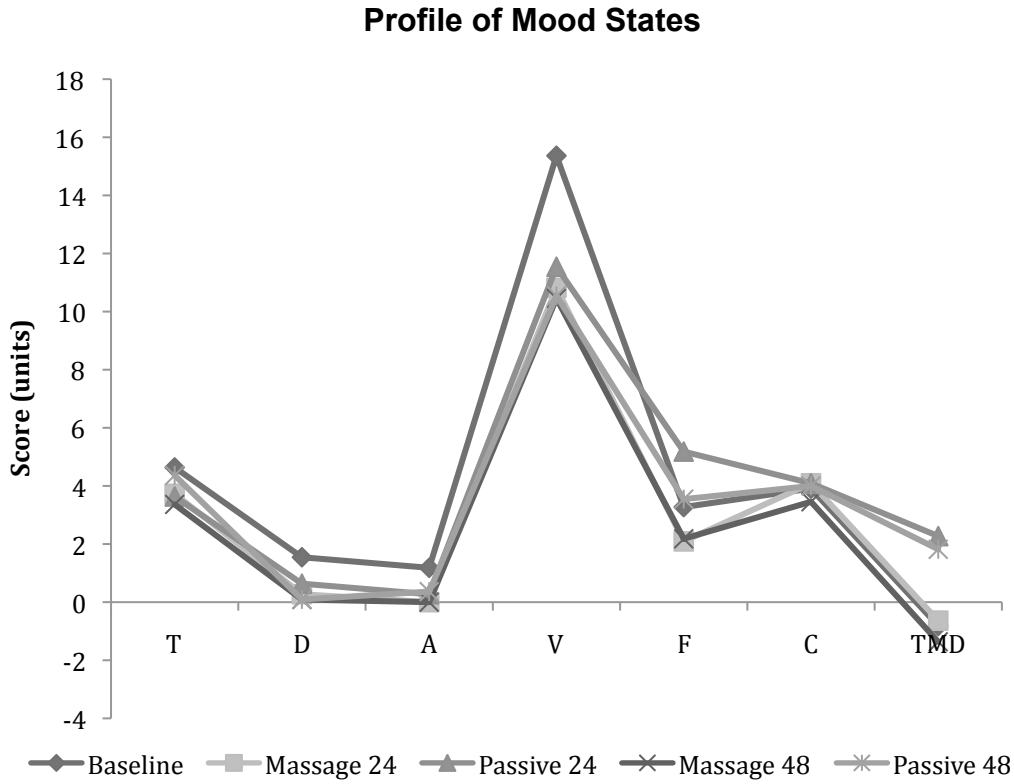

Figure 1. Changes in mood state with passive recovery and massage interventions. Profile of Mood States showing no significant differences in the Total Mood Disturbance between trials or times ($p > .05$). T= tension-anxiety. D= depression-dejection. A= anger-hostility. V= vigor-activity. F= fatigue-inertia. C= confusion-bewilderment. TMD= total mood disturbance.

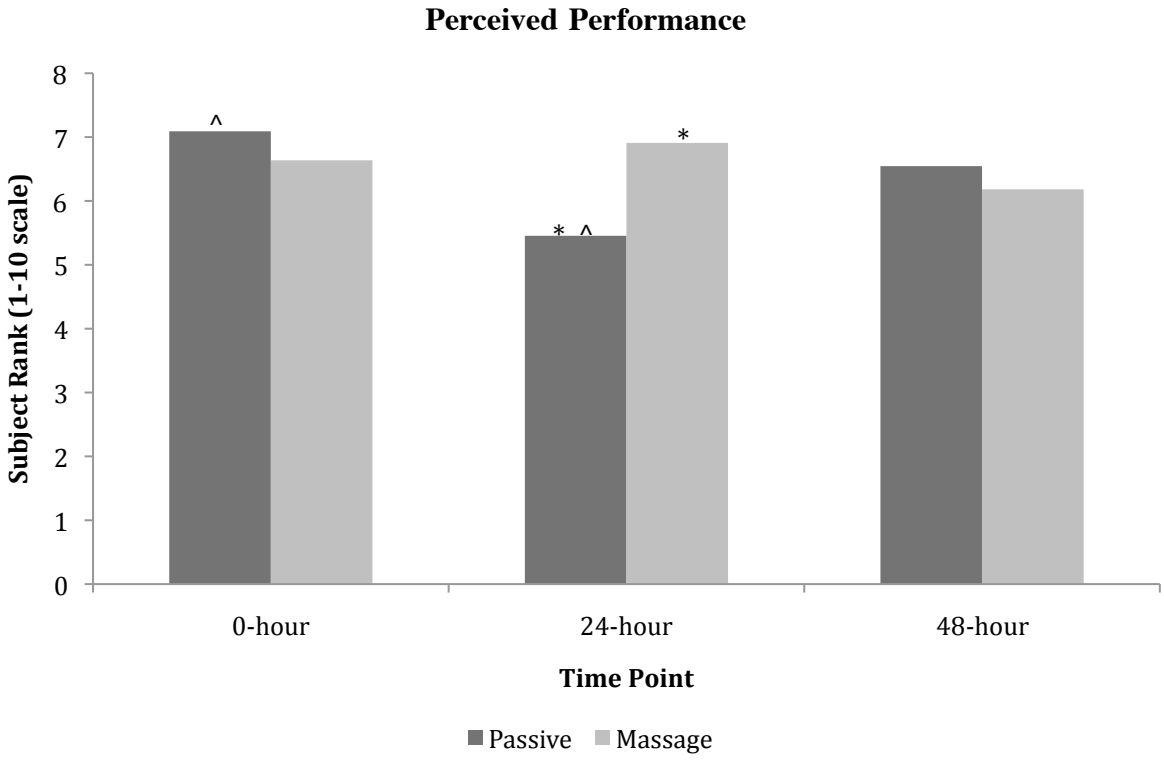

Figure 2. **Changes in perceived performance with passive recovery and massage interventions.** Subject rated perceived performance at the different time points. Showing no differences between 0-hour, 24-hour, and 48-hour time points for the control intervention. ^ Significant decrease in perceived performance in the passive recovery trial from the 0-hour time point (7.09) to the 24-hour time point (5.45) ($p = .014$). *Significantly lower perceived ranking for the passive recovery trial (5.45) compared to the massage trial (6.9).

Table 1.

Subject Demographics

Participant Information					
		Mean Age (yrs)	Mean Height (inches)	Mean Weight (lbs)	Mean Body Mass Index
Male	N = 3	24 ± 1	69.5 ± 3.9	198.67 ± 31.9	BMI 28.85 ± 3.2
Female	N = 8	23.75 ± 2.4	65.5 ± 3.4	136.13 ± 15.4	BMI 22.34 ± 2.3

Table 2.

Plyometric Exercise Protocol used to induce delayed onset muscle soreness.

Plyometric Exercise	Sets	Repetitions
Bounding: accentuated jogging strides, covering as much distance as possible.	1	16
Double Leg Barrier Jump: bound over cones, tucking both knees to chest	3	6
Line Jumps- Side to side: Start with both feet on right side of the line, jump with both feet to the left side of the line. Every return to the right side counts as 1 repetition	2	11
Split Jumps: Starting in a lunge position with right leg in front, jump as high as possible switching legs while in the area, land in lunge position with left leg in front. Every return to right leg counts as 1 repetition	2	10
Line Jumps- Front to back: Start with both feet behind the line, jump with both feet in front of the line. Every return to behind the line counts as 1 repetition	2	11
Cone Hops with 180-degree turn: 5 cones in a line tuck jumping with 180-degree turn over each cone.	2	5
Squat Jumps for Distance: Start in the squat position, explode out of the position covering as much ground and jumping as high as possible, land in squat position	2	11
Total Foot Contacts		130

Table 3.

Massage Techniques Protocol

Minute	**Massage Technique**	**Area of Lower Extremity**
0:00-1:00	Effleurage	Left Anterior Thigh
1:00-2:00	Effleurage	Left Anterior Lower Leg
2:00-3:00	Petrissage/Tapotement/Vibration	Left Anterior Thigh
3:00-4:00	Petrissage/Tapotement/Vibration	Left Anterior Lower Leg
4:00-5:00	Effleurage/Petrissage	Left Anterior Leg
5:00-10:00	Repeat above cycle on the Right Anterior Leg	
10:00-15:00	Repeat above cycle on the Left Posterior Leg	
15:00-20:00	Repeat above cycle on the Right Posterior Leg	

Appendix A.

ATHLETIC TRAINING LABORATORY

Dept. of Health and Human Performance

THE UNIVERSITY OF MONTANA

Missoula, Montana

SUBJECT INFORMATION AND CONSENT FORM

Comparing the Effects of Massage on performance, perceived performance, mood state, and range of motion.

STUDY DIRECTOR: Rebecca Guest, ATC, LAT rebecca.guest@umontana.edu

STUDY SUPERVISOR: Valerie Rich, PhD, ATC, LAT, WEMT-B, CSCS
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ADDRESS: 32 Campus Dr McGill 238 Missoula, MT 59812

This consent form may contain words that are new to you. If you read any words that are not clear to you, please ask the person who gave you this form to explain them to you.

PURPOSE OF THE RESEARCH

- You are being asked to take part in a 2 part research study looking at the effects of massage on performance, perceived performance, mood state, and range of motion. This study involves two 3 day research session, approximately 3 weeks apart, with one session using massage as the treatment intervention and the second using passive rest as the treatment intervention.

PROCEDURES

Subject Group

1. The principle investigator will ask you to fill out a health-screening questionnaire.
2. During this study you will complete the following testings 6 times. Your height and weight will be measured, as well as by completion of the Profile of Mood states questionnaire (a 65 question survey used to determine your current mood state), range of motion testing of the hip, knee, and ankle, vertical jump testing, and finally a rating of how you feel you performed in the testing on a scale of 1 to 10.
   - Flexibility assessments are performed before activity, and at 24 and 48 hour marks post treatment.

- Hip, knee and ankle motion is testing using a standard goniometer (a tool used to measure angles).
- Hip flexion will be measured with you laying on your back on a treatment table. The center of the goniometer will be placed on your hip, with one arm alongside your trunk, and other arm alongside the shaft of your thigh. The investigator will then ask you to raise your leg off the table and bring your foot to your head as far as you can without bending your knee. Three trials will be conducted on each leg, and the average recorded.
- Hip extension will be measured with you laying on your stomach on a treatment table. The center of the goniometer will be placed on your hip, and one arm alongside your trunk, and the other arm alongside the shaft of your thigh. The investigator will then ask you to raise your leg off the table without bending your knee. Three trials will be done on each leg, and the averages recorded.
- Knee flexion will be measured with you laying either on your back on a treatment table. The goniometer will be placed alongside your leg for both measurements, with the axis on the outside of your knee, one arm in line with your thigh, and the other arm in line with your lower leg. You will then be instructed to pull your heel towards your buttocks for knee flexion. Three trials will be conducted on each leg, and the averages recorded.
- Knee extension will be measured with you laying either on your back on a treatment table. The goniometer will be placed alongside your leg for both measurements, with the axis on the outside of your knee, one arm in line with your thigh, and the other arm in line with your lower leg. The researcher will place a towel under your ankle and ask you to just relax for these measurements. Three measurements will be taken on each leg, and the averages recorded.
- Ankle flexion and extension will be performed with you sitting with the lower ½ of your lower leg hanging off the table. The goniometer will be placed along the outside of your lower leg and foot. The axis will be placed just below the bone that sticks out on the side of your ankle, stationary arm alongside your lower leg, and moving arm in line with to the bottom of your foot. The investigator will instruct you to either point your toes for extension, or bring your toes towards your head for flexion. Three trials will be conducted and the average recorded.

- Vertical jump testing will be completed on a Just Jump® mat. This mat is designed to measure the amount of time in which you are in the air to calculate your vertical jump height. Your vertical jump will be measured with you standing on two feet. You will then be instructed to jump as high as you can in the same spot. Arm movement and reach are allowed during this testing as long as the test is done the same each time. Three jumps will be completed with an average recorded.

3. Before completing the exercise for this study an easy 5 minute warm-up, on a stationary bicycle, will be completed which will lead into the exercise protocol. A plyometric workout: jumping, bounding, and hopping exercises designed to have emphasis on the lowering and quick subsequent push off, instructed by the principle investigator. For this routine you will be completing a total of 130-foot contacts, which are counted every time you land on either a single leg or double leg during the workout. The exercises you will be performing consist of the following:
   - Bounding: accentuated jogging strides, covering as much distance as possible.
   - Double leg jumps over a small barrier.
   - Cone Hops with 180 degree turn- this consists of jumping up over a cone while turning 180 degrees so you will be facing the opposite direction of when you started the jump.
   - Depth Jumps: drop from a 2 foot box, land on both feet, spring up as quickly as possible.

- Front Tuck Jumps: these jumps consist of jumping up as high as you can while pulling your knees to your chest and then straightening them before landing
- Split Jumps: starting in a lunge position, jump as high as possible switching legs while in the air, landing in lunge position.
- Squat Jumps of Distance: start in squat position; explode out of position covering as much ground as possible and land in squat position.

Following the workout you will be either instructed to relax and lay on a treatment table for 20 minutes or will receive a 20-minute sports massage, using a hypoallergenic lotion, to the lower extremities. You will be involved in each group, either the massage or resting, once throughout this study.

4. Below is the breakdown of what exactly will be happening at each session and how much time you should set aside for each one.
   - Visit 1- Health screening, POMS, hip/knee/ankle range of motion measurements, vertical jumps, warm-up, jumping exercises, massage OR resting recovery. This session should take about 2.5 hours.
   - Visit 2- (24 hours after visit 1)- POMS, hip/knee/ankle range of motion measurements, vertical jumps. This session should take about 1 hour.
   - Visit 3- (24 hours after visit 2)- POMS, hip/knee/ankle range of motion measurements, vertical jumps. This session should take about 1 hour.
   - Visit 4- (3 weeks after visit 4)- Health screening, POMS, hip/knee/ankle range of motion measurements, vertical jumps, warm-up, jumping exercises, massage OR resting recovery. This session should take about 2.5 hours.
   - Visit 5- (24 hours after visit 4)- POMS, hip/knee/ankle range of motion measurements, vertical jumps. This session should take about 1 hour.
   - Visit 6- (24 hours after visit 5)- POMS, hip/knee/ankle range of motion measurements, vertical jumps. This session should take about 1 hour.
   - **Total hour commitment of approximately 9 hours.**

TIME COMMITMENT

The first and fourth testing session will last about 2.5 hours, with the second, third, fifth, and sixth sessions lasting about an hour; for a total of 9 hours participation time for each subject totaled between all sessions.

RESTRICTIONS OF ACTIVITY AND TREATMENT DURING STUDY

After participating in the first and fourth testing sessions we ask that you do not participate in any physical activity and refrain from doing any of the following that may alter the effects of the exercise and the results of the study:

- Do not ice or heat.
- Do not take any ibuprofen, Tylenol, or other medication that could help decrease soreness and help recovery.
- Do not take any hot baths, hot tub soaks, or ice baths.
- Do not do any stretching.
- Do not receive any sort of massage or other therapeutic treatment for the soreness.
- Do not exercise over the next 48 hours.

LOCATION
The study will take place in the HHP Athletic Training lab on the 2nd floor of McGill Hall, room 235.

RISK/DISCOMFORTS

1. Moderate risk, discomfort and muscle soreness will arise from the exercise required for this study. This soreness and stiffness will increase for the first 24-48 hours post activity, but will subside by 7 days at the most. You will be reminded that if you experience any excessive pain or discomfort to seek medical treatment and then contact the investigator as soon as possible for follow-up care.
2. Mild discomfort or skin irritation may occur from the sports massage. This irritation may last up to one hour. If you feel any discomfort you may ask the massager to stop the treatment.
3. During any of the treatments should symptoms, such as chest discomfort, unusual shortness of breath or other physical discomforts develop, researchers will terminate the test. If these symptoms arise, the investigators will immediately activate the emergency medical system. In addition, the investigators are both currently trained and certified in CPR.

BENEFITS OF PARTICIPATING IN THIS STUDY
There is no promise that you will receive any benefit from taking part in this study. However, this study will help determine the effectiveness and establish reliability of a massage in the clinical setting. Knowledge of your vertical jump performance measures may be obtained, as well as the perceived effects of massage on subsequent performance levels.

CONFIDENTIALITY

1. Your records will be kept private and will not be released without your consent except as required by law.
2. Only the researcher and her faculty supervisor will have access to the files.
3. Your identity will be kept confidential.
4. If the results of this study are written in a scientific journal or presented at a scientific meeting, your name will not be used.
5. All data, identified only by an anonymous ID #, will be stored in our laboratory.
6. Your signed consent form and information sheet will be stored in a locked office separate from the data.

COMPENSATION FOR INJURY
Although we believe that the risk of taking part in this study is moderate, the following liability statement is required in all University of Montana consent forms.

"In the event that you are injured as a result of this research you should individually seek appropriate medical treatment. If the injury is caused by negligence of the University or any of its employees, you may be entitled to reimbursement pursuant to the Comprehensive State Insurance Plan established by the Department of Administration under the authority of M.C.A., Title 2, Chapter 9. In the event of a claim for such injury, further information may be obtained from the University's Claim representative or University Legal Counsel,"

VOLUNTARY PARTICIPATION/WITHDRAWAL

1. Your decision to take part in this research study is entirely voluntary.
2. You have the right to request that a test be stopped at any time.

3. You may refuse to take part in or you may withdraw from the study at any time without penalty.
4. You may leave the study for any reason.

You may be asked to leave the study for any of the following reasons:

1. Failure to follow the study investigator's instructions.
2. A serious adverse reaction, which may require evaluation.
3. The study director/investigator thinks it is in the best interest of your health and welfare.
4. The study is terminated.

QUESTIONS

- You may wish to discuss this with others before you agree to take part in this study.
- If you have any questions about the research now or during the study contact Valerie Rich at 243-2703 or email valerie.rich@umontana.edu; or Becky Guest at 243-4278, or email rebecca.guest@umontana.edu
- If you have any questions regarding your rights as a research subject, you may contact the Chair of the IRB through The University of Montana Research Office at 243-6670.

Disclosure of Personal Health Information

My individual health information that may be used to conduct this research includes:

> *Age, gender, height, weight, previous heart conditions, chest pains, bone and joint problems, previous surgeries, previous dizziness or loss of consciousness, pregnancy history, asthma or exercise induced asthma, blood sugar levels, diabetes, current medications, reason for medications, allergies, history of physical activity, and current mood state.*

I authorize *Rebecca Guest* and the researcher's staff to use my individual health information for the purpose of conducting the research project entitled "*The effects of massage on performance, perceived performance, mood state, and range of motion*."

Signature: _____ Date: _____

Limits of Confidentiality

There are conditions under which confidentiality may be breached. If you indicate wanting to harm yourself or someone else, the experimenter will contact you and this informed consent may also be given to a member of the clinical faculty who may contact you. Because of this, we also require that you provide your name and phone number.

Name: _____ Phone: _____

SUBJECT'S STATEMENT OF CONSENT

I have read the above description of this research study. I have been informed of the risks and benefits involved, and all my questions have been answered to my satisfaction. Furthermore, I have been assured that a member of the research team will also answer any future questions I may have. I voluntarily agree to take part. I understand I will receive a copy of this consent form.

_____

Printed (Typed) Name of Subject

_____ _____

Subject's Signature Date

SUBJECT'S STATEMENT OF CONSENT TO BE PHOTOGRAPHED DURING DATA COLLECTION

I provide my consent to be photographed during periods of the data collection. I realize that these digital images may be used during presentation of the data at regional and national meetings to illustrate methodology of the study, and that my face will not be in the photograph(s).

_____ _____

Subject's Signature Date

Appendix B.

Health and Exercise History Data Sheet

Please complete this form as accurately and completely as possible.
Please answer all of the bold information:

Height, weight, and subject number will be entered by the investigators of this study.

Subject # _____

Gender M F Height (inches) _____

Age _____ Weight (lbs) _____

Please mark YES or No to the following:

Has your doctor ever said that you have a heart condition and recommended only medically supervised physical activity?
____yes ____no

Do you frequently have pains in your chest when you perform physical activity?
____yes ____no

Have you had chest pain when you were not doing physical activity?
____yes ____no

Have you had a stroke?
____yes ____no

Do you lose your balance due to dizziness or do you ever lose consciousness?
____yes ____no

Do you have a bone, joint or any other health problem that causes you pain or limitations that must be addressed. (i.e. diabetes, osteoporosis, high blood pressure, high cholesterol, arthritis, anorexia, bulimia, anemia, epilepsy, respiratory ailments, back problems, etc.)?
____yes ____no

Have you injured your hips, knees, or ankles in the past year? This includes muscle strains, joint strains, and any other injuries.
___yes ___no

Do you have any on-going lower extremity problems?
____yes ____no

Are you pregnant now or have given birth within the last 6 months?
____yes ____no

Do you have asthma or exercise induced asthma?

____yes ____no

Do you have low blood sugar levels (hypoglycemia)?

____yes ____no

Do you have diabetes?

____yes ____no

Have you had a recent surgery?

____yes ____no

If you have marked YES to any of the above, please elaborate below:

_____
_____
_____
_____
_____
_____
_____
_____

Do you take any medications, either prescription or non-prescription, on a regular basis?

____yes _____no

What is the medication for?

_____
_____

How does this medication affect your ability to exercise or achieve your fitness goals?

_____
_____
_____
_____
_____

Do you have any allergies? ___yes ___no

If yes, to what? _____

Last time and date participated in physical activity _____a.m. / p.m.

_____/_____/20___

How often do you regularly exercise? _____days/week

_____hours/day

Last approximate date participated in plyometric exercises: _____

Plyometric exercises are those in which the muscles of the body are loaded (i.e. landing from a jump off a box) and then immediately contracted to perform another jump or forward motion exercise.

Investigators will have the right to exclude subjects from the study if they answer yes to the following questions: doctor restrictions, chest pain with exercise, history of stroke, history of any lower extremity problems or current ongoing problems, recent pregnancy, or currently taking any medications that effect activity performance. Other answers of "yes" will be further evaluated by the investigators before exclusion.

Appendix C.

POMS™ Standard Form

BY DOUGLAS M. McNAIR, Ph.D., MAURICE LORR, Ph.D., JW P. HEUCHERT, Ph.D., & LEO F. DROPPLEMAN, Ph.D.

Client ID: _____ **Age:** _____ **Gender:** Male Female (Circle one)

Birth Date: ___/___/___ (Month / Day / Year) **Today's Date:** ___/___/___ (Month / Day / Year)

To the Administrator:

Place a checkmark ✔ in one box to specify the time period of interest.

To the Respondent:

Below is a list of words that describe feelings that people have. Please read each word carefully. Then circle the number that best describes

- ☐ how you have been feeling during the PAST WEEK, INCLUDING TODAY.
- ☐ how you feel RIGHT NOW.
- ☐ other: _____

If no box is marked, please follow the instructions for the first box.

POMS™

		Not at all	A little	Moderately	Quite a bit	Extremely
1.	Friendly	0	1	2	3	4
2.	Tense	0	1	2	3	4
3.	Angry	0	1	2	3	4
4.	Worn out	0	1	2	3	4
5.	Unhappy	0	1	2	3	4
6.	Clear-headed	0	1	2	3	4
7.	Lively	0	1	2	3	4
8.	Confused	0	1	2	3	4
9.	Sorry for things done	0	1	2	3	4
10.	Shaky	0	1	2	3	4
11.	Listless	0	1	2	3	4
12.	Peeved	0	1	2	3	4
13.	Considerate	0	1	2	3	4
14.	Sad	0	1	2	3	4
15.	Active	0	1	2	3	4
16.	On edge	0	1	2	3	4
17.	Grouchy	0	1	2	3	4
18.	Blue	0	1	2	3	4
19.	Energetic	0	1	2	3	4
20.	Panicky	0	1	2	3	4
21.	Hopeless	0	1	2	3	4
22.	Relaxed	0	1	2	3	4
23.	Unworthy	0	1	2	3	4
24.	Spiteful	0	1	2	3	4
25.	Sympathetic	0	1	2	3	4
26.	Uneasy	0	1	2	3	4
27.	Restless	0	1	2	3	4
28.	Unable to concentrate	0	1	2	3	4
29.	Fatigued	0	1	2	3	4
30.	Helpful	0	1	2	3	4

Please flip over.
Items continue on the back page...

POMS™ Standard Form

BY DOUGLAS M. McNAIR, Ph.D., MAURICE LORR, Ph.D., JW P. HEUCHERT, Ph.D., & LEO F. DROPPLEMAN, Ph.D.

POMS™

		Not at all	A little	Moderately	Quite a bit	Extremely
31.	Annoyed	0	1	2	3	4
32.	Discouraged	0	1	2	3	4
33.	Resentful	0	1	2	3	4
34.	Nervous	0	1	2	3	4
35.	Lonely	0	1	2	3	4
36.	Miserable	0	1	2	3	4
37.	Muddled	0	1	2	3	4
38.	Cheerful	0	1	2	3	4
39.	Bitter	0	1	2	3	4
40.	Exhausted	0	1	2	3	4
41.	Anxious	0	1	2	3	4
42.	Ready to fight	0	1	2	3	4
43.	Good natured	0	1	2	3	4
44.	Gloomy	0	1	2	3	4
45.	Desperate	0	1	2	3	4
46.	Sluggish	0	1	2	3	4
47.	Rebellious	0	1	2	3	4
48.	Helpless	0	1	2	3	4
49.	Weary	0	1	2	3	4
50.	Bewildered	0	1	2	3	4
51.	Alert	0	1	2	3	4
52.	Deceived	0	1	2	3	4
53.	Furious	0	1	2	3	4
54.	Efficient	0	1	2	3	4
55.	Trusting	0	1	2	3	4
56.	Full of pep	0	1	2	3	4
57.	Bad-tempered	0	1	2	3	4
58.	Worthless	0	1	2	3	4
59.	Forgetful	0	1	2	3	4
60.	Carefree	0	1	2	3	4
61.	Terrified	0	1	2	3	4
62.	Guilty	0	1	2	3	4
63.	Vigorous	0	1	2	3	4
64.	Uncertain about things	0	1	2	3	4
65.	Bushed	0	1	2	3	4

Please ensure you have answered every item.
Thank you for completing this questionnaire.

Appendix D.

TAKE HOME INSTRUCTION SHEET

Thank you for participating in this study. Due to the fact that soreness is being induced, and the effects of that soreness being analyzed, it is very important that you do nothing at home that could alter the results or decrease the effects of the exercise and intervention you completed today. Over the next 48 hours you may feel muscle tightness, muscle pain, muscle stiffness, and other symptoms related to muscle soreness. Please abide by these guidelines and avoid anything that is meant to help decrease the effects of soreness.

- ∞ Do not ice or heat.
- ∞ Do not take any ibuprofen, Tylenol, or other medication that could help decrease soreness and help recovery.
- ∞ Do not take any hot baths, hot tub soaks, or ice baths.
- ∞ Do not do any stretching.
- ∞ Do not receive any sort of massage or other therapeutic treatment for the soreness.
- ∞ Do not exercise over the next 48 hours.

Please report back to the lab tomorrow (_____(date)) at _____:_____am/pm

and _____ (_____(date)) at ____:_____am/pm

If you are experiencing any excessive soreness or any complications from the activity please seek medical treatment and then contact the researchers, Becky Guest at (406) 243-4278 or rebecca.guest@umontana.edu, or Valerie Rich at (406) 243-2703. *Becky is available by email 24 hours a day.* If soreness does not subside by 4 days post-exercise please do not hesitate to contact us.

Thanks again for your cooperation and participation in this study.

Becky Guest, LAT, ATC

Valerie Rich, PhD, ATC, LAT, WEMT-B, CSCS

Appendix E.

Subject #	Age	Height(inches)	Weight (lbs)	BMI	Gender	POMS-Baseline							POMS-24 Hours					
18M	22	64	135	23.1702	F	1	0	2	20	3	2	-12	2	0	0	16	2	2
18C	22	64	135	23.1702	F	2	1	1	20	4	2	-10	7	0	0	20	4	2
93M	24	71.5	186	25.5774	M	6	0	0	8	0	3	1	4	0	0	6	0	3
93C	24	71.5	186	25.5774	M	8	0	1	11	1	4	3	4	0	1	6	4	3
53M	22	69.25	159	23.3084	F	16	14	6	9	16	8	51	10	3	0	11	3	7
53C	22	69.25	159	23.3084	F	5	0	1	9	5	5	7	6	1	0	5	6	5
47M	25	72	235	31.8682	M	2	0	0	26	0	4	-20	1	0	0	19	5	4
47C	25	72	235	31.8682	M	4	0	0	24	3	5	-12	1	1	1	20	15	1
37M	26	63.75	115	19.8927	F	2	0	0	18	3	2	-11	3	0	0	12	9	4
37C	27	63.75	115	19.8927	F	2	0	0	11	5	2	-2	4	0	0	11	7	4
26M	20	62.5	137	24.6556	F	2	0	0	14	3	2	-7	3	0	0	9	0	2
26C	20	62.5	137	24.6556	F	3	0	1	14	3	2	-5	2	0	0	10	5	3
16M	26	62.5	131	23.5758	F	2	1	0	19	0	4	-12	3	0	0	9	0	5
16C	26	62.5	131	23.5758	F	3	11	3	15	4	1	7	1	1	0	11	2	2
28M	26	63	125	22.1403	F	7	0	0	23	3	9	-4	4	0	0	21	0	6
28C	26	63	125	22.1403	F	4	0	0	27	0	2	-21	5	0	0	25	2	8
2M	23	71	129	17.9899	F	4	0	2	5	3	6	10	4	0	0	3	3	4
2C	23	71	129	17.9899	F	6	0	0	22	6	6	-4	3	0	0	10	1	4
27M	23	65	175	29.1183	M	3	0	0	4	0	4	3	3	0	0	5	0	3
27C	23	65	175	29.1183	M	3	0	0	5	0	4	2	3	0	0	4	0	3
67M	24	68	158	24.0212	F	6	1	4	13	5	6	9	4	0	0	8	1	5
67C	24	68	158	24.0212	F	11	6	5	21	5	3	9	4	4	1	5	11	10

	POMS-48 Hours							Right Hip Flexion Baseline				Right Hip Flexion 24 Hours				Right Hip Flexion 48 Hours				Left Hip Base	
-10	1	0	0	13	1	2	-9	90	91	92	91	85	97	97	93	95	97	96	96	104	104
-7	3	0	0	18	3	3	-9	87	90	93	90	82	86	88	85.3	99	97	99	98.3	96	98
1	4	0	0	7	0	3	0	77	81	79	79	68	75	72	71.7	71	74	73	72.7	66	68
6	5	0	0	4	4	4	9	70	74	77	73.7	90	85	78	84.3	81	92	84	85.7	70	78
12	5	1	0	8	4	5	7	72	70	75	72.3	86	86	90	87.3	82	87	96	88.3	72	80
13	10	0	0	4	4	6	16	87	90	92	89.7	80	89	90	86.3	87	90	92	89.7	96	95
-9	1	0	0	17	6	3	-7	72	72	74	72.7	81	83	85	83	70	68	70	69.3	66	67
-1	4	0	0	24	1	1	-18	93	90	89	90.7	79	74	80	77.7	50	60	54	54.7	89	85
4	3	0	0	11	8	4	4	48	53	59	53.3	79	84	83	82	84	82	84	83.3	48	44
4	3	0	0	8	5	2	2	62	68	63	64.3	61	58	67	62	65	72	71	69.3	62	60
-4	3	0	0	7	0	2	-2	84	91	89	88	85	83	85	84.3	75	83	82	80	86	84
0	3	0	1	7	4	3	4	85	89	90	88	70	69	71	70	80	86	83	83	87	83
-1	4	0	0	14	0	2	-8	96	97	97	96.7	92	93	94	93	90	93	97	93.3	100	95
-5	4	0	1	12	0	6	-1	110	107	103	107	84	87	89	86.7	92	93	94	93	96	94
-11	5	0	0	24	0	4	-15	100	107	103	103	98	103	103	101	96	95	98	96.3	89	96
-10	3	0	0	17	5	6	-3	94	99	97	96.7	99	101	102	101	93	94	100	95.7	96	97
8	4	0	0	8	1	5	2	66	76	83	75	74	66	71	70.3	71	76	75	74	61	72
-2	5	0	0	3	3	4	9	83	69	74	75.3	62	72	79	71	61	71	67	66.3	48	51
1	3	0	0	3	1	4	5	40	40	50	43.3	35	35	45	38.3	50	50	50	50	35	30
2	3	0	0	4	0	3	2	38	40	45	41	51	51	56	52.7	62	61	66	63	40	43
2	4	0	0	3	3	4	8	97	101	96	98	85	95	92	90.7	101	105	101	102	94	92
25	5	1	2	15	10	6	9	100	100	103	101	90	90	85	88.3	90	90	90	90	66	75

Flexion eline		Left Hip Flexion 24 Hours				Left Hip Flexion 48 Hours				Right Hip Extension Baseline				Right Hip Extension 24 Hours				Right Hip Extension 48 Hours			
101	103	101	105	104	103	107	102	99	103	17	21	20	19.3	22	23	24	23	24	25	20	23
95	96.3	100	92	92	94.7	93	92	92	92.3	25	24	23	24	20	19	17	18.7	19	26	24	23
75	69.7	62	73	68	67.7	60	65	68	64.3	29	25	25	26.3	22	30	21	24.3	13	16	16	15
80	76	80	85	81	82	75	89	75	79.7	10	16	16	14	20	25	20	21.7	18	24	24	22
90	80.7	100	95	90	95	86	86	79	83.7	18	8	8	11.3	22	21	15	19.3	27	26	24	25.7
102	97.7	88	95	91	91.3	83	85	85	84.3	39	45	40	41.3	18	17	15	16.7	19	18	22	19.7
71	68	72	70	73	71.7	62	64	66	64	25	19	21	21.7	26	24	24	24.7	20	18	22	20
92	88.7	52	71	61	61.3	76	77	79	77.3	30	26	32	29.3	33	25	25	27.7	15	15	19	16.3
54	48.7	85	86	84	85	74	72	73	73	20	20	20	20	20	19	21	20	23	18	20	20.3
64	62	65	62	61	62.7	62	66	63	63.7	29	24	22	25	20	18	19		21	20	21	20.7
82	84	88	84	82	84.7	78	80	84	80.7	14	19	15	16	16	20	19	18.3	14	15	16	15
89	86.3	61	73	77	70.3	80	78	83	80.3	25	16	22	21	14	17	18	16.3	10	16	12	12.7
100	98.3	93	96	94	94.3	93	94	94	93.7	19	19	11	16.3	15	16	18	16.3	8	16	15	13
97	95.7	82	88	84	84.7	88	92	95	91.7	19	18	15	17.3	21	19	18	19.3	23	18	22	21
98	94.3	96	101	100	99	98	97	101	98.7	9	12	15	12	21	21	23	21.7	22	23	22	22.3
100	97.7	100	100	101	100	100	99	101	100	9	17	16	14	14	16	15	15	11	12	10	11
65	66	60	65	63	62.7	60	69	64	64.3	31	35	26	30.7	20	23	25	22.7	27	31	20	26
59	52.7	50	59	61	56.7	54	58	63	58.3	21	24	19	21.3	40	28	31	33	24	25	24	24.3
30	31.7	35	30	30	31.7	55	50	50	51.7	10	10	10	10	15	15	15	15	20	20	20	20
45	42.7	36	43	51	43.3	64	50	57	57	21	14	18	17.7	16	14	11	13.7	20	17	15	17.3
85	90.3	98	93	103	98	100	94	91	95	16	20	20	18.7	26	25	26	25.7	24	25	26	25
85	75.3	80	90	95	88.3	90	95	100	95	28	30	32	30	20	20	20	20	30	30	2	20.7

Left Hip Extension Baseline				Left Hip Extension 24 Hours				Left Hip Extension 48 Hours				Right Knee Flexion Baseline				Right Knee Flexion 24 Hours				Right Knee Ho	
23	18	20	20.3	25	20	25	23.3	23	23	27	24.3	136	134	136	135	139	141	137	139	140	141
24	26	24	24.7	24	23	24	23.7	32	30	30	30.7	136	138	137	137	130	126	127	128	137	138
24	24	25	24.3	10	17	19	15.3	15	21	16	17.3	126	129	130	128	124	125	125	125	121	124
15	14	15	14.7	9	20	13	14	26	30	22	26	108	109	110	109	115	116	120	117	119	120
20	16	13	16.3	15	15	21	17	19	16	17	17.3	129	130	135	131	124	129	130	128	127	131
22	35	34	30.3	14	15	13	14	19	21	18	19.3	133	133	135	134	129	135	135	133	131	135
29	28	29	28.7	33	28	28	29.7	26	26	20	24	117	122	124	121	130	132	131	131	132	134
24	34	32	30	26	39	38	34.3	24	23	25	24	115	119	121	118	120	119	118	119	116	112
24	23	28	25	21	23	26	23.3	23	27	22	24	144	140	142	142	133	134	133	133	142	144
22	25	26	24.3	19	20	18	19	20	23	19	20.7	147	149	147	148	145	147	148	147	144	145
14	21	20	18.3	16	19	20	18.3	16	14	10	13.3	134	135	135	135	137	141	142	140	141	140
25	23	28	25.3	22	21	24	22.3	13	18	12	14.3	134	138	136	136	144	142	143	143	139	137
17	19	21	19	22	19	14	18.3	17	22	16	18.3	142	149	146	146	150	147	149	149	141	143
10	12	13	11.7	28	23	20	23.7	18	21	22	20.3	139	143	144	142	125	120	118	121	124	124
19	17	18	18	22	19	24	21.7	20	21	21	20.7	139	145	144	143	120	117	121	119	121	119
16	15	13	14.7	14	13	13	13.3	13	12	13	12.7	149	158	155	154	144	143	147	145	150	154
30	21	29	26.7	35	34	32	33.7	27	28	27	27.3	141	141	140	141	144	140	141	142	138	138
23	25	24	24	35	36	37	36	21	17	25	21	140	149	146	145	140	136	140	139	141	139
15	10	10	11.7	15	15	15	15	20	20	20	20	105	100	100	102	110	110	110	110	110	110
9	12	11	10.7	18	16	20	18	21	21	19	20.3	132	127	126	128	128	124	124	125	121	121
15	14	12	13.7	21	22	23	22	19	30	29	26	133	130	133	132	127	132	134	131	133	132
25	25	30	26.7	20	25	25	23.3	25	25	25	25	100	130	125	118	115	115	115	115	140	120

Flexion 48 urs		Left Knee Flexion Baseline				Left Knee Flexion 24 Hours				Left Knee Flexion 48 Hours				Right Knee Extension Baseline				Right Knee Extension 24 Hours			
141	141	135	137	132	135	144	140	143	142	139	140	145	141	1	1	3	1.67	4	1	1	2
136	137	134	139	137	137	127	127	126	127	133	138	136	136	3	2	2	2.33	6	5	6	5.67
123	123	117	119	120	119	118	120	120	119	120	122	123	122	-4	-3	-4	-3.7	-4	-3	-3	-3.3
122	120	100	105	109	105	115	117	119	117	115	117	119	117	-2	-3	-3	-2.7	-4	-4	-5	-4.3
130	129	130	128	135	131	130	127	131	129	132	132	131	132	-11	-10	-12	-11	-10	-11	-12	-11
133	133	134	133	135	134	130	134	133	132	129	133	133	132	-13	-15	-15	-14	-12	-12	-13	-12
135	134	123	125	128	125	130	132	133	132	136	133	133	134	-6	-6	-7	-6.3	-4	-3	-4	-3.7
117	115	118	119	119	119	117	112	118	116	118	115	118	117	-4	-3	-4	-3.7	-4	-4	-5	-4.3
143	143	143	146	145	145	134	137	138	136	144	145	141	143	-8	-8	-7	-7.7	-2	-3	-1	-2
143	144	148	147	145	147	145	144	142	144	142	145	142	143	-5	-5	-6	-5.3	-4	-5	-3	-4
136	139	131	135	134	133	142	138	142	141	135	136	138	136	-1	-1	-1	-1	-1	-2	-1	-1.3
139	138	147	138	143	143	140	143	145	143	137	136	138	137	-4	-5	-6	-5	-7	-8	-6	-7
142	142	145	143	145	144	141	143	145	143	144	145	144	144	-7	-9	-10	-8.7	-8	-9	-9	-8.7
126	125	137	142	139	139	120	120	122	121	125	124	124	124	-12	-10	-13	-12	-5	-5	-5	-5
121	120	137	138	139	138	119	119	121	120	134	132	129	132	-7	-5	-4	-5.3	-4	-4	-3.5	-3.8
153	152	151	148	151	150	139	144	146	143	150	154	153	152	0	-4	-4	-2.7	0	-4	-4	-2.7
137	138	135	138	135	136	139	138	137	138	130	135	135	133	-11	-12	-12	-12	-8	-8	-10	-8.7
135	138	141	140	144	142	134	132	135	134	137	132	133	134	-2	-3	-4	-3	-2	-1	-1	-1.3
110	110	105	110	105	107	115	105	120	113	115	115	115	115	-3	-2	-2	-2.3	-2	-2	-2	-2
122	121	131	132	132	132	135	129	132	132	128	128	125	127	-9	-9	-9	-9	-4	-5	-4	-4.3
136	134	132	132	131	132	127	132	134	131	133	132	136	134	-10	-10	-10	-10	-10	-10	-10	-10
115	125	140	130	140	137	110	115	115	113	115	115	110	113	-11	-12	-11	-11	-9	-8	-8	-8.3

Right Knee Extension 48 Hours				Left Knee Extension Baseline				Left Knee Extension 24 Hours				Left Knee Extension 48 Hours				Right Ankle Dorsiflexion Baseline				Right Dorsiflexio	
3	4	2	3	2	-1	0	0.33	-1	-3	-1	-1.7	2	1	2	1.67	20	15	19	18	15	16
7	7	5	6.33	-2	-1	0	-1	0	-1	0	-0.3	5	4	3	4	18	17	16	17	20	14
-3	-4	-4	-3.7	-4	-3	-3	-3.3	-5	-3	-4	-4	-5	-4	-3	-4	4	4	6	4.67	5	6
-4	-3	-5	-4	-1	-3	-2	-2	-7	-6	-5	-6	-6	-5	-3	-4.7	4	3	5	4	7	12
-10	-11	-12	-11	-19	-15	-15	-16	-10	-12	-12	-11	-7	-9	-9	-8.3	18	18	14	16.7	10	11
-14	-14	-14	-14	-9	-9	-9	-9	-9	-10	-11	-10	-13	-13	-13	-13	12	11	13	12	5	9
-3	-4	-2	-3	-4	-4	-5	-4.3	-3	-2	-4	-3	-2	-2	-1	-1.7	-25	-19	-15	-20	-11	-12
-3	-4	-2	-3	-2	-3	-4	-3	-6	-4	-4	-4.7	-3	-3	-3	-3	-24	-14	-10	-16	-18	-14
-7	-6	-6	-6.3	-4	-5	-7	-5.3	0	-1	-3	-1.3	-6	-7	-4	-5.7	16	17	18	17	15	14
-6	-5	-4	-5	-4	-5	-6	-5	-4	-3	-4	-3.7	-3	-5	-4	-4	14	15	12	13.7	12	14
-1	-1	-2	-1.3	-1	-1	-1	-1	-1	-1	0	-0.7	-1	0	-1	-0.7	15	14	10	13	10	11
0	-2	-1	-1	-5	-3	-2	-3.3	-6	-7	-6	-6.3	-2	0	-2	-1.3	14	14	12	13.3	17	16
-8	-8	-9	-8.3	-8	-9	-10	-9	-6	-8	-9	-7.7	-8	-9	-9	-8.7	15	17	10	14	15	15
-3	-3	-3	-3	-10	-9	-9	-9.3	-4	-4	-4	-4	-4	-4	-3	-3.7	7	15	20	14	20	22
-6	-6	-6	-6	-7	-6	-6	-6.3	-3	-3	-4	-3.3	-5	-4	-4	-4.3	15	20	20	18.3	17	17
-5	-4	-5	-4.7	-6	-5	-6	-5.7	-4	-5	-4	-4.3	-5	-4	-5	-4.7	15	17	17	16.3	15	15
-5	-5	-5	-5	-12	-13	-14	-13	-5	-6	-6	-5.7	-4	-4	-4	-4	29	29	28	28.7	18	26
-1	-1	-1	-1	-3	-2	-2	-2.3	-1	-2	-2	-1.7	-2.5	-2	-2	-2.2	25	29	22	25.3	26	23
0	-1	-1	-0.7	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	20	20	20	20	10	15
0	0	0	0	-10	-10	-10	-10	-5	-5	-5	-5	1	1	1	1	20	21	16	19	20	20
-9	-9	-9	-9	-9	-9	-9	-9	-10	-10	-10	-10	-9	-9	-9	-9	20	18	19	19	22	20
-8	-8	-8	-8	-10	-10	-11	-10	-8	-8	-8	-8	-8	-8	-8	-8	15	15	15	15	20	20

Ankle n 24 Hours		Right Ankle Dorsiflexion 48 Hours				Left Ankle Dorsiflexion Baseline				Left Ankle Dorsiflexion 24 Hours				Left Ankle Dorsiflexion 48 Hours				Right Ankle Plantarflexion Baseline			
14	15	14	15	12	13.7	15	16	15	15.3	16	15	16	15.7	16	18	18	17.3	51	55	56	54
7	13.7	18	16	21	18.3	16	13	10	13	13	17	14	14.7	18	16	21	18.3	58	61	64	61
6	5.67	5	6	4	5	4	4	5	4.33	6	6	7	6.33	5	5	6	5.33	51	53	52	52
10	9.67	11	9	8	9.33	5	5	6	5.33	9	6	6	7	7	12	10	9.67	50	49	52	50.3
15	12	13	15	12	13.3	15	15	15	15	16	16	18	16.7	18	19	19	18.7	60	68	66	64.7
8	7.33	15	14	15	14.7	12	12	12	12	9	12	10	10.3	8	9	8	8.33	68	65	67	66.7
-8	-10	-10	-13	-14	-12	-20	-21	-20	-20	-8	-9	-10	-9	-14	-13	-10	-12	75	71	75	73.7
-15	-16	-18	-22	-25	-22	-15	-18	-30	-21	-16	-20	-20	-19	-22	-28	-20	-23	62	52	55	56.3
15	14.7	18	14	13	15	17	16	17	16.7	12	14	12	12.7	12	15	14	13.7	59	54	56	56.3
12	12.7	12	11	13	12	10	13	10	11	10	13	11	11.3	10	10	11	10.3	56	55	59	56.7
11	10.7	10	11	12	11	12	8	9	9.67	12	9	11	10.7	10	9	9	9.33	66	68	70	68
15	16	12	10	12	11.3	15	16	16	15.7	17	16	15	16	13	16	15	14.7	55	65	60	60
14	14.7	10	7	10	9	14	15	13	14	8	9	10	9	5	7	7	6.33	47	45	50	47.3
22	21.3	22	23	23	22.7	15	20	17	17.3	19	20	19	19.3	17	17	18	17.3	45	45	50	46.7
19	17.7	18	20	18	18.7	16	16	15	15.7	17	16	15	16	21	23	21	21.7	68	65	80	71
14	14.7	5	15	16	12	15	15	12	14	12	15	12	13	15	16	19	16.7	70	80	80	76.7
27	23.7	20	15	19	18	27	33	32	30.7	28	23	22	24.3	19	15	15	16.3	50	49	52	50.3
20	23	24	26	26	25.3	28	26	16	23.3	19	21	21	20.3	15	16	11	14	50	61	62	57.7
15	13.3	10	10	10	10	25	25	25	25	20	25	20	21.7	5	10	10	8.33	40	40	40	40
15	18.3	20	16	15	17	15	15	17	15.7	15	20	20	18.3	20	16	15	17	28	30	34	30.7
19	20.3	13	9	10	10.7	15	16	10	13.7	12	15	11	12.7	19	14	10	14.3	48	50	59	52.3
20	20	10	10	10	10	2	10	10	7.33	15	20	20	18.3	10	10	10	10	60	50	60	56.7

Right Ankle Plantarflexion 24 Hours				Right Ankle Plantarflexion 48 Hours				Left Ankle Plantarflexion Baseline				Left Ankle Plantarflexion 24 Hours				Left Ankle Plantarflexion 48 Hours				Vertical Jur Base	
50	55	57	54	54	57	56	55.7	52	57	55	54.7	55	49	50	51.3	56	55	56	55.7	17.5	16.5
59	63	55	59	56	68	60	61.3	58	61	64	61	63	65	63	63.7	54	60	58	57.3	18.8	17.5
57	55	54	55.3	50	53	54	52.3	52	53	55	53.3	52	54	59	55	53	52	55	53.3	26.5	26.7
53	50	50	51	54	53	53	53.3	52	50	52	51.3	57	51	52	53.3	52	51	51	51.3	25.2	24.7
75	70	72	72.3	70	65	68	67.7	65	73	72	70	68	60	60	62.7	66	64	65	65	12.4	16.1
64	66	65	65	65	64	66	65	69	68	70	69	64	63	63	63.3	71	69	68	69.3	16.3	17.2
56	65	60	60.3	60	58	61	59.7	63	69	70	67.3	55	60	58	57.7	49	58	60	55.7	20.4	20.1
62	64	69	65	71	66	70	69	62	52	55	56.3	65	69	70	68	63	63	65	63.7	20.7	20.5
63	65	58	62	56	59	60	58.3	53	52	58	54.3	60	58	62	60	58	61	60	59.7	13.3	16.3
63	60	63	62	59	70	65	64.7	52	58	62	57.3	60	63	58	60.3	64	62	60	62	15.4	16.4
66	63	66	65	69	68	70	69	71	68	70	69.7	65	64	67	65.3	64	68	67	66.3	14.8	11.5
60	56	60	58.7	64	62	65	63.7	53	60	58	57	55	60	63	59.3	67	65	64	65.3	10.8	17.1
50	42	55	49	50	55	53	52.7	50	50	55	51.7	50	42	55	49	50	50	56	52	14.2	13.7
35	58	40	44.3	33	30	35	32.7	45	50	52	49	41	41	45	42.3	33	39	41	37.7	12	12.8
65	65	68	66	40	38	45	41	70	71	81	74	70	68	65	67.7	55	55	56	55.3	13.4	12.7
70	75	68	71	65	75	75	71.7	75	80	80	78.3	80	82	80	80.7	70	85	75	76.7	13.7	13.2
45	47	50	47.3	47	39	43	43	50	50	47	49	48	50	52	50	49	54	51	51.3	15	14.9
36	35	46	39	60	55	50	55	59	53	65	59	46	47	54	49	42	46	49	45.7	14.7	15
15	30	30	25	40	40	40	40	30	30	30	30	25	25	15	21.7	40	40	40	40	25	25.2
40	35	35	36.7	35	38	33	35.3	30	30	38	32.7	36	40	39	38.3	36	36	35	35.7	25.6	26.5
48	44	45	45.7	46	50	54	50	59	49	50	52.7	55	54	54	54.3	53	55	50	52.7	17	15.9
60	60	60	60	60	60	65	61.7	40	50	50	46.7	30	30	35	31.7	60	65	70	65	15.9	16.1

mp Testing eline		Vertical Jump Testing 24 Hours				Vertical Jump Testing 48 Hours				PP Base line	PP 24 Hour	PP 48 Hour
17.6	17.2	17.7	17.1	18.1	17.6	18.6	18.5	19.1	18.7	6	6	7
17.6	18	19.3	18.9	19.6	19.3	18.8	17.9	17.9	18.2	6	4	6
27.1	26.8	26.5	26.7	26	26.4	25.6	26.2	26.3	26	6	5	5
26.3	25.4	25.6	25.7	26.1	25.8	27.4	27.6	26	27	5	4	5
17.9	15.5	15.8	15.5	15.9	15.7	13.5	16	15.6	15	4	6	5
16.9	16.8	14.6	14.7	15.4	14.9	15.3	15.5	15.1	15.3	6	6	7
19.9	20.1	20	20.1	19.1	19.7	19.9	20.5	20.5	20.3	10	8	8
20.2	20.5	18.2	18.6	18.1	18.3	17.6	17.7	17.3	17.5	10	6	5
16.4	15.3	15.1	15.6	15.7	15.5	14.8	15.2	15.3	15.1	6	6	3
15.4	15.7	15.3	15.3	16.2	15.6	15	15.3	14.8	15	7	6	7
13.1	13.1	14.8	13.4	16.7	15	16.5	17.1	17.3	17	7	7	6
13.8	13.9	17.4	17.9	17.3	17.5	16.3	16.8	16.5	16.5	7	3	8
14.4	14.1	14	14.7	10.1	12.9	13.4	13.6	13.1	13.4	7	6	6
13.4	12.7	13.4	13.2	13.6	13.4	14.7	14.1	15.6	14.8	7	7	8
10.8	12.3	12.6	12.8	13.5	13	13.7	13.1	12.4	13.1	5	8	6
13.8	13.6	13.8	13.8	13.6	13.7	13.1	13.6	12.6	13.1	8	5	6
14.7	14.9	15	15	15.4	15.1	16.9	16.7	16.4	16.7	7	8	7
15.5	15.1	17.2	16	16	16.4	16	15.9	15.1	15.7	8	6	7
25.7	25.3	23.4	25.3	25.6	24.8	26.8	26.7	26.9	26.8	8	8	8
26.6	26.2	25.1	25.3	25.9	25.4	26.6	26.8	27.6	27	8	7	6
16	16.3	16.9	17.1	17.1	17	17.3	16.9	17.6	17.3	7	8	7
16.3	16.1	15.3	15.8	14.9	15.3	15.9	14.6	14.8	15.1	6	6	7