LITERATURE REVIEW

THE ROLE OF MASSAGE IN SPORTS PERFORMANCE AND REHABILITATION: CURRENT EVIDENCE AND FUTURE DIRECTION

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ABSTRACT

Background. Massage is a popular treatment choice of athletes, coaches, and sports physical therapists. Despite its purported benefits and frequent use, evidence demonstrating its efficacy is scarce.

Purpose. To identify current literature relating to sports massage and its role in effecting an athlete's psychological readiness, in enhancing sports performance, in recovery from exercise and competition, and in the treatment of sports related musculoskeletal injuries.

Methods. Electronic databases were used to identify papers relevant to this review. The following keywords were searched: massage, sports injuries, athletic injuries, physical therapy, rehabilitation, delayed onset muscle soreness, sports psychology, sports performance, sports massage, sports recovery, soft tissue mobilization, deep transverse friction massage, pre-event, and post exercise.

Results. Research studies pertaining to the following general categories were identified and reviewed: pre-event (physiological and psychological variables), sports performance, recovery, and rehabilitation.

Discussion. Despite the fact clinical research has been performed, a poor appreciation exists for the appropriate clinical use of sports massage.

Conclusion. Additional studies examining the physiological and psychological effects of sports massage are necessary in order to assist the sports physical therapist in developing and implementing clinically significant evidence based programs or treatments.

Key Words: sports massage, sports rehabilitation, sports performance, sports recovery

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INTRODUCTION

Massage has been utilized in the treatment of illness and injury for thousands of years by health care practitioners.[1] Chinese writings dating back to 2500 BC describe the use of this modality for a variety of medical purposes.[1-3] Massage has been promoted as a treatment of choice for numerous conditions such as musculoskeletal injuries, cancer, stress, relaxation, and pregnancy.[2-4]

Physical therapists who specialize in sports medicine often utilize massage techniques to aid an athlete's recovery from intense exercise or as a treatment option when performing clinical rehabilitation.[5] Sports massage has been suggested as a means to help prepare an athlete for competition, as a tool to enhance athletic performance, as a treatment approach to help the athlete recover after exercise or competition, and as a manual therapy intervention for sports-related musculoskeletal injuries.[2,3,5] While massage is frequently performed by physical therapists (and other healthcare or alternative medicine practitioners) and is popular with athletes and coaches, its actual efficacy is questionable.[5,6]

The purpose of this paper is to review and present the current literature relating to sports massage and its roles in effecting an athlete's psychological readiness, in enhancing sports performance, in recovery from exercise and competition, and in the treatment of sports-related musculoskeletal injuries. Recommendations are discussed highlighting the need for additional research in sports massage.

METHODS

Selection of Papers

The following electronic databases were used to identify papers relevant to this review: Medline (from 1950-present), CINAHL (1982-present), PsycINFO (1985-present), Cochrane Database of Systematic Reviews, and SPORTDiscus (1830-present). Table 1 presents the Medical Subject Headings (MeSHs) and textwords (tw) utilized in the search strategy for this paper. If fewer than 300 articles were identified by a search strategy, the study abstracts were reviewed from that category in order to identify potentially relevant papers. The reference list of each of the selected papers was also reviewed in order to identify additional relevant publications.

Study Selection

Inclusion Criteria

1) The report's study design must have been one of the following: randomized controlled trial, quasi-experimental, single-case design, non-randomized historical cohort comparisons, case-series, or case report.
2) The report was published in a scientific peer-reviewed journal.
3) The sports massage protocol described in the report must have included at least one or more of the following techniques: effleurage, petrissage, or deep transverse friction massage (also known as cross-friction massage).
4) The purpose of the massage intervention was to impact one or more of the following facets of athletics: pre-event (warm-up and psychological readiness), sports performance, recovery from exercise and competition, or the treatment of sports-related injuries.

Exclusion Criteria

1) Papers that were not published within a peer-reviewed scientific journal.
2) Reports that detailed the use of massage for non-sports related injuries or functions.

The rationale for these inclusion and exclusion criteria was to identify papers that investigate the use of massage in all facets of athletic care. The massage techniques included for review in this paper were based upon their prevalence within the literature and their preference among physical therapists.[7] In specific situations where there was paucity in the literature, complementary paper(s) were presented (but not included in the overall review). Massage protocols investigating efficacy for non-sports related injuries or chronic conditions were considered beyond the scope of this review.

Description of Selected Massage Techniques

Sports massage is defined as a collection of massage techniques performed on athletes or active individuals for the purpose of aiding recovery or treating pathology.[8] Three forms of massage are frequently reported in the sports medicine literature: effleurage, petrissage, and deep transverse friction massage (DTFM).[7]

Effleurage techniques are performed along the length of the muscle, typically in a distal to proximal sequence.[1-3,8] These techniques are executed throughout a massage routine, with the strokes performed slowly utilizing light or gentle pressure.[1-3,8] The petrissage techniques include kneading, wringing, and scooping strokes.[1-3,8] These

Table 1. *Search Strategy*

MeSH or tw	MeSH or tw Defined	Number of Articles Identified	Number of Articles Determined as Potentially Relevant	Number of Articles Included in Critical Appraisal
1) MeSH or tw	Massage	14032	n/a	n/a
2) MeSH or tw	Sports Injuries	4675	n/a	n/a
3) MeSH or tw	Athletic Injuries	22785	n/a	n/a
4) MeSH or tw	Physical Therapy	53602	n/a	n/a
5) MeSH or tw	Rehabilitation	169190	n/a	n/a
6) MeSH or tw	Delayed Onset Muscle Soreness	764	n/a	n/a
7) MeSH or tw	Sports Psychology	1512	n/a	n/a
8) MeSH or tw	Sports Performance	1423	n/a	n/a
9) MeSH or tw	Sports Massage	253	22	13
10) MeSH or tw	Sports Recovery	90	4	2
11) MeSH or tw	Soft Tissue Mobilization	46	6	1
12) MeSH or tw	Deep Transverse Friction Massage	6	3	2
13) MeSH or tw	Pre-event	312	n/a	n/a
14) MeSH or tw	Post Exercise	2099	n/a	n/a
1 and 2		34	2	1
1 and 3		81	4	1
4 and 9		5	0	0
5 and 9		6	0	0
6 and 9		8	4	4
7 and 9		1	1	1
8 and 9		11	4	4
9 and 10		8	4	2
9 and 11		0	0	0
9 and 13		1	0	0
9 and 14		5	2	2

MeSH: Medical Subject Heading
tw: textword
n/a: not assessed

techniques are generally performed with deeper pressure to patient tolerance.[1-3,8] Deep transverse friction massage (also known as cross-friction massage) is performed by using the fingers to apply a force moving transversely across the target tissue. [1-3,8,9]

Description of Tables

The information about to be presented is summarized in Table 3-6. Part of each of these tables includes a column called "level of evidence." The definition of these levels is defined in Table 2. The reader should refer to Table 2 when referring to the information on Tables 3-6.

EFFICACY OF A PRE-EVENT MASSAGE

Athletes routinely prepare both physically and psychologically prior to competition. Athletes typically incorporate one or more of the following pre-competition preparation strategies: static stretching,[10,11] dynamic stretching,[12,13] warm-up drills, game simulations, and mental imagery.[14] A pre-event massage has been suggested as a strategy to decrease pre-competition anxiety and to prepare the muscles for competition.[2] Currently a paucity in the literature exists addressing the effects of a pre-event massage in order to reduce injury risk or enhance psychological readiness *(Table 3)*.

Effect on Blood Pressure

Camborn et al[15] investigated the effect of massage on a recipient's blood pressure (BP). Twenty five massage therapy students provided massage treatments to 150 current massage therapy clients.[15] The length of the massage and the techniques performed by the students were not controlled, but were instead based upon the students' perception of the clients' needs.[15] The massages ranged in time from 30 to 90 minutes. Six different massage techniques were used including Swedish, deep tissue, myofascial release, sports, trigger point, and craniosacral. The authors defined sports massage as "a more vigorous type of massage used to prepare athletes for peak performance and uses a combination of techniques including joint mobilization, stretching and/or postisometric relaxation, cross-fiber friction, and pressure point massage."[15]

Table 2. *Levels of evidence key.*

Level	Studies in Each Category
I	Large randomized trials with clear-cut results; low risk of false-positive error ( ) and false-negative ( ) error
II	Small, randomized trials with uncertain results; moderate to high risk of false-positive ( ) and/or false negative ( ) error
III	Nonrandomized, contemporaneous controls
IV	Nonrandomized, historical controls
V	Case series, uncontrolled studies, expert opinion

Adapted from Sackett DL [62]

The authors found that clients receiving Swedish massage (effleurage and petrissage) experienced the greatest reduction in blood pressure, whereas those who had received trigger point therapy and sports massage experienced an increase in blood pressure.[15] While this research provides findings that may have clinical significance, the study design challenges the overall strength of the findings. A large sample size was collected (n = 150), but 25 massage therapy students performed the non-uniform interventions to clients who were already receptive to this form of treatment. The study also lacked controls for the duration of the massage (30 to 90 minutes) and the massage techniques performed.[15]

Although this study[15] did not directly focus on an athletic population, a vigorous massage may be less desirable than a "Swedish" (or relaxation) type of massage in specific situations. Theoretically, an athlete who is experiencing pre-game anxiety or stress may increase his or her risk of sustaining an injury or of having a sub-par performance.[16] Future investigations should be performed with specific athletic populations receiving massages just prior to participating in a stressful simulation or actual competition.[15,17]

Effect on Mood and Anxiety

Leivadi et al[18] evaluated the effects of massage on mood and anxiety states in female dancers (mean age = 20.1 years, SD = 1.8 years). The dancers were randomly assigned to either a massage therapy (n = 15) group or a relaxation therapy (n = 15) group.[18] The massage therapy group received a 30-minute treatment twice a week for a five week period. The massages consisted of effleurage, petrissage, and friction techniques with a treatment emphasis on the upper torso.[18] Those assigned to the relaxation therapy group performed a series of muscle tensing and relaxation exercises while listening to a recorded tape.[18] Both groups demonstrated significant effects between the first and last treatment sessions for lowered anxiety levels and improved mood scores {as measured by the State Anxiety Inventory and the Profile of Mood States (POMS) respectively}.[18] The massage treatment group also demonstrated significantly lower cortisol levels compared to the relaxation group.

Limitations in study design threaten the strength of the findings. This investigation lacked a true control group. The subjects in the relaxation therapy group were required to independently perform the program on their own at home. To ensure that dancers fully complied with the relaxation program, each relaxation session should have been performed under the supervision an examiner.

Micklewright et al[19] investigated the effects of a pre-performance massage on mood state. Sixteen subjects (10 male and 6 female university students) participated in the study.[19] Each subject completed the POMS questionnaire to establish baseline mood state prior to receiving the treatment intervention. During the first session a subject received either 30 minutes of massage or rested 30 minutes on his or her back.[19] The subjects served as their own controls between the two sessions. After the treatment intervention subjects completed a standard Wingate anaerobic cycling test. The POMS questionnaires were also completed after the treatment intervention and after the cycling test.[19]

The investigators found that cycling performance was better after the massage compared to the control group, but this improvement was unrelated to changes in mood state.[19] The authors hypothesized that pre-performance psychological factors other than one's mood state may enhance performance.[19]

Additional studies have investigated how massage effects an athlete's perception of recovery and regeneration.[20-22] While these investigations support the beneficial psychological effects of massage; overall study design threatens the strength of the conclusions.[20-22]

EFFECTS OF MASSAGE ON SPORTS PERFORMANCE

Athletes and coaches are constantly fine tuning their training strategies in order to develop a competitive edge. The use of therapeutic modalities, such as thermal agents, electrical stimulation, and massage are often performed for this purpose. Despite the frequency that

Table 3. *Table Summarizing Studies Related to Pre-Event Massage*

Study (Year)	Study Design	Level of Evidence	Participants	Professional(s) Conducting the Intervention	Techniques	Treatment Time	Results and Authors' Conclusions
Cambron et al[15]	Quasi-experimental pre-test post-test design	3	150 massage therapy clients (mean age 42.5 years, range 19-79)	25 massage therapy students; 12 in their 2nd trimester and 13 in their 3rd (final) trimester	Swedish, deep tissue, myofascial release, sports, trigger point, craniosacral	One treatment session. 30 – 90 minutes per practitioner preference.	1) Nonsignificant decrease in systolic blood pressure (BP): average 1.8 (range: -24-34) mmHg and an average increase in diastolic BP of 0.1 (range: -53-18). 2) No association between BP and any of the following variables: duration, amount of pressure, and the massage therapy intern experience. 3) Swedish massage was associated with a nonsignificant decrease in systolic BP. 4) Systolic BP increased with trigger point and sports massage. When the two techniques were performed in combination both systolic and diastolic BP increases were statistically significant.
Leivadi et al[18]	Randomized controlled trial: Pre-test/Post-test group design	2	30 female adult dance majors (mean age 20.1 years, SD 1.8)	"Different trained massage therapists"	Effluerage, petrissage	Two sessions a week for 5 weeks. 30-minute sessions.	1) Significant pre-test/post-test treatment measures for anxiety levels, less depressed moods, less neck and shoulder pain, less low back pain for both groups. 2) Significant decrease in cortisol levels for the massage intervention group. 3) Those receiving massage treatment experienced a significant improvement in neck extension and shoulder abduction at the end of the study.
Micklewright et al[19]	Within subjects experimental design with counterbalanced design	3	16 university and students (10 male 6 female) mean age 22 years, SD 4.8)	One massage therapist	Effleurage, petrissage	30-minute standardized massage protocol	The massage treatment prior to Wingate Anaerobic Cycling Test significantly enhanced performance but had no effect on mood state.
Hemmings et al[20]	Within subjects experimental design with counterbalanced design	3	Eight amateur boxers (mean age 24.9 years, SD 3.8)	Sports massage therapist	Effleurage, petrissage	20-minute standardized protocol consisting of 8-minutes for the legs, 2-minutes for the back, and 10-minutes for the shoulders and arms	1) No significant difference between groups for performance. 2) Massage program significantly increased perceptions of recovery. 3) No statistical difference in blood lactate or glucose levels after either intervention. 4) Blood lactate concentration was significantly higher after the massage program.
Hemmings[21]	Within subjects experimental design with counterbalanced design	3	Nine Royal Navy boxing squad members (mean age 22 ± 3.1 years).	Sports massage therapist	Effleurage, petrissage	20-minute standardized	1) After massage, boxers' perceived recovery was significantly greater than resting and the touching control. 2) Massage did not affect saliva flow.
Hemmings[22]	Within subjects experimental design with counterbalanced design	3	Nine Royal Navy boxing squad members (mean age 22 ± 3.1 years)	Sports massage therapist	Effleurage, petrissage	20-minute standardized protocol	1) After massage intervention, significant main effects were found in the fatigue subscale and a trend towards significance in the tension subscale. 2) No main effects noted in the vigor, depression, and anger subscales.

Table 4. *Table Summarizing Studies Related to the Effects of Massage on Sports Performance*

Study (Year)	Study Design	Level of Evidence	Participants	Professional(s) Conducting the Intervention	Techniques	Treatment Time	Results and Authors' Conclusions
Leivadi et al[18]	Randomized controlled trial: pre-test/post-test group design	2	30 female adult dance majors (mean age 20.1 years, SD 1.8)	"Different trained massage therapists"	Effluerage and petrissage techniques	2 sessions a week for 5 weeks. 30-minute sessions	1) Significant pre-post treatment measures for anxiety levels, less depressed moods, less neck and shoulder pain, less low back pain for both groups. 2) Significant decrease in cortisol levels for the massage intervention group. 3) Those receiving massage treatment experienced a significant improvement in neck extension and shoulder abduction at the end of the study.
Micklewright et al[19]	Within subjects experimental design with counterbalanced design	3	16 university students (10 male and 6 female) mean age 22 years, SD 4.8)	One massage therapist	Effleurage, petrissage	30-minute standardized massage protocol	The massage treatment prior to Wingate Anaerobic Cycling Test significantly enhanced performance but had no effect on mood state.
Hemmings et al[20]	Within subjects experimental design with counterbalanced design	3	8 amateur boxers (mean age 24.9 years SD 3.8)	Sports massage therapist	Effleurage, petrissage	20-minute routine consisting of 8-minutes for the legs, 2-minutes for the back, and 10-minutes for the shoulders and arms	1) No significant difference between groups for performance. 2) Massage program significantly increased perceptions of recovery 3) No statistical difference in blood lactate or glucose levels after either intervention. 4) Blood lactate concentration was significantly higher after the massage program.
Barlow et al[23]	Within subjects experimental design with counterbalanced design	3	11 male volunteers (mean age 21 years ± 3)	Massage therapist	Effleurage, petrissage	One 15-minute massage	One massage to the hamstrings did not significantly change sit and reach performance.
Hopper et al[24]	Randomized controlled trial: pre-test/ post-test group design	2	35 competitive female field hockey players (mean age 19.8 ± 3.7, range 15 to 31). Classic group: (n=19) mean age 20.87±4.09. DSTM group: (n=16) mean age 19.13±3.15	Two physiotherapists	1. "Classic" massage (consisting of effleurage, kneading, picking up, shaking) 2. Dynamic soft tissue mobilization (DSTM) that consisted of classic massage and "dynamic" longitudinal and and cross-fibre strokes strokes	1. A standardized 8-minute classic protocol for the classic massage treatment group. 2. The DTSM group received an 8-minute treatment consisting of classic massage and longitudinal and cross-fibre strokes to tight tissue.	1) Both massage types significantly improved hamstring length following treatment. 2) There was no statistical maintenance over a 24-hr time period for either group.
Hopper et al[25]	Randomized controlled trial: pre-test/post-test group design	2	45 healthy male volunteers (mean age 23.7 years, range 18-35 years).	"Therapist"	1. "Classic" massage (consisting of effleurage, kneading, picking up, shaking) 2. Dynamic soft tissue mobilization (DSTM) that consisted of classic massage and "dynamic" longitudinal and and cross-fiber strokes	1. Control group: lying prone for 5 minutes 2. Classic protocol: 5-minutes of effleurage, kneading, picking up, and shaking 3. The DTSM group received an 8-minute treatment consisting of classic massage and longitudinal and cross-fiber strokes to tight tissue.	The DTSM protocol significantly increased hamstring flexibility as compared to either the classic massage protocol or the control group.
Brooks et al[27]	Randomized controlled trial: pre-test/post-test group design	2	52 volunteer massage-school clients, staff, faculty, and students (mean age 39 years, SD 13.63, range 18-71).	Two senior therapeutic massage students	Effleurage, friction	5 minutes	Massage intervention facilitated a significant improvement in grip strength recovery as compared to other interventions.
Mancinelli et al[28]	Randomized controlled trial: pre-test/post-test group design	2	22 NCAA Division I women basketball and volleyball players (mean age 20 ± 0.93 years).	Two massage therapists	Effleurage, petrissage, vibration	17-minute standardized protocol	1) Significant slowing in shuttle run times for the control group. 2) Significant changes in vertical jump displacement, perceived soreness, and algometer levels for the massage group.
Hilbert et al[47]	Randomized controlled trial: pre-test/post-test group design	2	18 volunteers (male and female), mean age 20.4 years ±1.0	A senior physical therapy student	Classic Swedish techniques (effleurage, percussion, petrissage)	20 minute standardized protocol	1) The massage protocol did not impact any of the following variables: range of motion, peak torque, neutrophil count, mood, or unpleasantness of soreness. 2) The massage protocol led to a significant decrease in intensity of soreness (Differential Descriptor Scale) in the massage group as compared to the control group.

massage treatments are performed, only a few studies exist in the literature that have investigated the effect of massage on sports performance *(Table 4)*.

Massage Effects on Flexibility

A common perception held by athletes and coaches is that adequate flexibility will decrease the risk of injury and enhance performance. While these claims may be debatable (and beyond the scope of this paper), massage has been investigated as a strategy to increase range of motion.

Barlow et al[23] investigated the immediate effects of massage on hamstring flexibility in physically active young men. Eleven active men (mean age 21 $\pm$ 3 years) were randomly assigned to attend two testing sessions each separated by one week. The subjects either received a 15-minute massage (performed by a massage therapist) consisting of effleurage and petrissage strokes to the hamstring muscles bilaterally or a 15-minute supine rest. Three pre-test and post-test sit and reach measurements were performed with the best one recorded. Investigators were blinded to who had received which intervention. The subjects were also blinded when performing the sit and reach test to avoid subject bias threats to validity. The authors concluded that a single bout of hamstring massage did not have a significant effect upon sit and reach scores. Although the authors found no significant change among the small sample size, they did find that those who had low pre-test reach scores (less than 15 cm) had a higher percentage of change in reach versus those who had a 15-cm or greater reach. This led the authors to suggest a larger sampling should be performed with a "tighter" population.[23] Also, future studies should investigate the effect on flexibility when massage is applied both proximally and distally to the target tissue.

While Barlow et al[23] failed to demonstrate a statistically significant change in flexibility, Hopper et al[24] found massage made significant short term changes in hamstring flexibility. Female field hockey players from Western Australia's Premier League were recruited for the study. Thirty-nine players met the study's inclusion criteria of experiencing a stretching sensation on the posterior thigh at an angle less than 70° during a straight leg raise (SLR), having full knee extension range of motion, and having full ankle plantarflexion.[24]

Athletes were randomized into one of two treatment groups; a group receiving a "classic" massage and a group receiving dynamic soft tissue mobilization (DSTM). The classic massage consisted of effleurage, kneading (petrissage), and shaking techniques for an 8-minute treatment. The DSTM treatment consisted of classic massage strokes and a dynamic treatment approach. The dynamic technique was performed using a "long slow stroke" with a fisted hand applied both longitudinally and across the muscle fibers. This technique was applied while first passively extending the subject's knee, then while the subject actively extended their own knee, and finally while the therapist passively extended the knee while the subject performed an eccentric contraction of their hamstring muscle.[5] The DSTM program was also performed for 8-minutes.[24] The passive straight leg raise (PSLR) and passive knee extension (PKE) tests were used to measure hamstring length prior to the treatment intervention, immediately after the massage, and 24 hours later. Both techniques immediately created statistically significantly changes in hamstring lengths as measured by the PKE test. The flexibility changes though were not maintained at 24 hours in either group.[24]

In a subsequent investigation by Hopper et al,[25] they reported significant increases in hamstring flexibility after performing the DSTM program when compared to a classic massage approach or a control group. In this investigation, the subject sample was 45 healthy males (mean age = 23.7 years, SD = 4.6, range = 18 to 35 years), whereas, the previous study's population consisted of female athletes.[24] The "classic" massage protocol utilized effleurage, kneading, picking up, and shaking techniques performed for 5-minutes.[25] The DSTM program was similar to the one described in Hopper et al.[24] The DTSM group demonstrated significantly greater increases in hamstring flexibility as compared to the classic approach or the control group. While the DTSM protocol had a greater effect on immediate hamstring flexibility gains (post-test measurements conducted 90-seconds after treatment), the clinical significance of these results is difficult to extrapolate.

While it appears that some athletes may experience improvements in hamstring flexibility after one massage, these changes appear to be transient. If a short term goal is to increase an athlete's flexibility, more efficient methods may exist (especially in the absence of an adequately staffed sports medicine team).[26] Future research should investigate which athletes are ideal candidates for massage intervention, how long each massage intervention should be performed, and what duration is necessary to establish permanent flexibility changes.

Massage Effects on Strength

Brooks et al[27] assessed the effects of massage on power grip performance after maximal exercise in healthy adults. The authors conducted a pre-test and post-test study design with subjects randomized to one of four intervention groups. The testing protocol consisted of a pre-test grip strength measurement, the exercise protocol to fatigue the muscles of the hand, the intervention, a 5-minute rest period, and the post-test strength measurement. To fatigue the muscles of the hand and the forearm, participants isometrically squeezed a hand exerciser until performance had declined to 60% of their baseline measurement. After the exercise period, the subjects were randomized to one of the following treatment groups: a 5-minute standardized massage to the dominant hand, a 5-minute standardized massage to the non-dominant hand, 5-minutes of passive shoulder and elbow range of motion, or 5-minutes of rest.[27] The 5-minute massage protocol, consisting of effleurage and circular friction strokes, was performed by two senior therapeutic massage students.[27] The authors found the massage intervention to be significantly superior to the non-massage interventions for post exercise grip performance. It was also observed that grip performance after massage was significantly greater in the non-dominant versus the dominant arm.

The most clinically relevant outcome was that the massage intervention demonstrated better results than the natural recovery of the control group.[27] The authors surmise that applying massage (in this case for 5-minutes) shortly after fatiguing exercise is beneficial.[27]

Mancinelli et al[28] investigated the effects of massage on female collegiate athletes when performed at the beginning of the basketball and volleyball seasons. Twenty-two NCAA division I women's basketball or volleyball players were recruited (11 allocated to the treatment group and 11 serving as controls). A 17-minute massage consisting of effleurage, petrissage, and vibration techniques was performed on the day of predicted peak soreness (as predicted by the strength coach). The authors found that the massage intervention helped to significantly increase vertical jump, led to a significant increase (a slowing) of shuttle run times, and significantly decreased the athlete's perceived soreness. While the results suggest that performing a massage at an opportune time will have positive functional outcomes, the results of this study are in question due to significant design flaws. These flaws include a small sample size, the inability to control for the pre-season conditioning levels of the athletes, and the reliance upon the subjective prediction by the strength coach as to the date of expected peak muscle soreness.[28]

EFFECTS OF SPORTS MASSAGE ON RECOVERY FROM EXERCISE AND COMPETITION

Effects on Delayed Onset Muscle Soreness

Delayed onset muscle soreness (DOMS) is a common physiological response experienced by athletes after initiating or resuming an exercise routine, after increasing exercise intensity, or after performing eccentric forms of training (i.e. downhill running).[29] Delayed onset muscle soreness has been associated with minor to severe pain occurring 24 to 72 hours after the exercise bout.[29] Athletic performance may be hampered due to DOMS, loss of range of motion, and decreased muscle strength.[30,31] While these symptoms may be temporary and part of the natural process of strength and conditioning training, the ramifications for sports performance during competition may be staggering. Theoretically, it would be beneficial to prescribe modalities that could either prevent the onset or decrease the impact of DOMS.

Six theories have been proposed to explain the mechanisms of DOMS.[29] The six theories are: lactic acid, muscle spasm, connective tissue damage, muscle damage, inflammation, and enzyme efflux.[29] Researchers have specifically investigated the effects of massage upon blood lactate levels and changes in blood flow *(Table 5)*.[20,32,33]

Effect of Massage on Blood Flow

Massage has been proposed as a treatment modality to increase blood flow.[2,3,8,34] Proponents of massage argue that local circulatory changes occur as evidenced by the changes in skin temperature and superficial hyperemia.[35] Initial studies measuring Xe-133 isotope clearance and venous occlusion plethysmography indicated that massage had an effect on blood flow, whereas more recent studies using Doppler ultrasound techniques have found that massage had no effect on arterial or venous blood flow.[36-40]

Blood Lactate Clearance

The rationale behind the lactic acid theory is that lactic acid produced after exercise contributes to the pain and soreness experienced by the athlete.[29] Massaging a muscle or muscle group experiencing DOMS could, theoretically, help to facilitate the removal of lactic acid from those areas.

Table 5. *Table Summarizing Research Related to the Effects of Sports Massage on Recovery from Exercise and Competition*

Study (Year)	Study Design	Level of Evidence	Participants	Professional(s) Conducting the Intervention	Techniques	Treatment Time	Results and Authors' Conclusions
Hemmings et al[20]	Within subjects experimental design with counterbalanced design	3	Eight amateur boxers (mean age 24.9 years, SD 3.8)	Sports massage therapist	Effleurage, petrissage	20-minute standardized protocol consisting of 8-minutes for the legs, 2-minutes for the back, and 10-minutes for the shoulders and arms	1) No significant difference. between groups for performance. 2) Massage program significantly increased perceptions of recovery 3) No statistical difference in blood lactate or glucose levels after either intervention. 4) Blood lactate concentration was significantly higher after the massage program.
Robertson et al[32]	Within subjects experimental design with counterbalanced design	3	Nine male games players, mean age not presented (range 20-22 years)	Physiotherapist	Effleurage, kneading, stroking, picking up, wringing, rolling	20-minute standardized protocol	1) Massage intervention did not affect blood lactate concentration or heart rate. 2) No difference in mean or maximum power after massage. 3) Subjects scored significantly lower on the fatigue index after massage.
Dolgener et al[33]	Randomized controlled trial: pre-test/post-test design	2	22 male recreational runners; passive recovery group (n=7, mean age 24.7±5.3), bicycle recovery (n=7, mean age 26.1±6.5), massage recovery (n=8, mean age 24.2±6.77)	Massage therapist	Effleurage, petrissage	20-minute standardized routine	Massage was no better than passive or active recovery methods in reducing blood lactate concentration.
Tiidus et al[36]	Quasi-experimental pre-test/post-test	3	Nine volunteers (4 male and 5 female), mean age not reported (age range 20 to 22 years)	Massage therapist	Effleurage	10-minute	1) Massage did not significantly increase either arterial or venous blood velocity above baseline resting levels. 2) Massage failed to improve isokinetic peak torque of the quadriceps versus the contralateral control leg.
Shoemaker et al[39]	Within subjects experimental design with counter-balanced design	3	10 healthy subjects (7 male, 3 female); mean age 35.8± 3.4 years)	Massage therapist	Effleurage, petrissage, tapotement	5-minute massage per location and technique	Massage did not increase muscle blood flow (pulsed Doppler echo Doppler) regardless of type of massage or the muscle group receiving the massage.
Hinds et al[40]	Within subjects experimental design with counter-balanced design	3	13 male volunteers, mean age 21±1.4 years	Physiotherapist	Effleurage and petrissage	Two 6-minute bouts separated by a 1-minute period	1. Massage did not significantly increase femoral artery blood flow, blood lactate, blood pressure, or heart rate as compared to a control condition. 2. Skin blood flow and skin temperature were significantly increased after massage as compared to controls.
Jonhagen et al[41]	Randomized controlled trial: pre-test/post-test group design	2	16 subjects (8 men and 8 women), mean age 28 years (range 20-38)	Sport physical therapist	Effleurage, petrissage	12-minute standardized protocol	1. No statistical difference between massage and control group for level or duration of pain. 2. No statistical difference for concentrations of CGRP and NPY between massage and control groups. 3. No statistical difference for maximal strength and functional measures between groups.

Many amateur sports (such as track and field, boxing, and swimming) may require athletes to participate in several events or matches during a short period of time. Hemmings et al[20] studied the effects of massage on both physiologic and perceived recovery in eight amateur boxers. The investigators designed a testing protocol to examine if massage performed between bouts of simulated boxing matches would help to improve physiologic variables (blood glucose and lactate concentrations), performance, and the athlete's perception of recovery. The experimental design consisted of a 10-minute active warm up period, five 2-minute rounds of simulated boxing matches with 1-minute rest periods between each round, an intervention period (20-minute massage or no massage), a 35-minute rest period (a time period representative of the period of time between events or matches), a second 10-minute active warm up period, and a repeat of the aforementioned boxing simulation. Four of the eight boxers served as controls during the first round of testing. During the second round of testing, the boxers switched groups.[20]

During the intervention period, the athlete either received a massage or rested lying on a mat. The 20-minute massage (effleurage and petrissage) protocol consisted of 8 minutes of treatment performed on the legs, 2 minutes on the back, and 10 minutes on the shoulders and arms. Blood lactate testing was performed

Table 5. *Table Summarizing Research Related to the Effects of Sports Massage on Recovery from Exercise and Competition (cont'd)*

Lightfoot et al[42]	Randomized controlled trial	2	31 college-age subjects (12 men and 19 female)	Massage therapist	Petrissage	10-minute to the left calf	Massage intervention to the left calf demonstrated no difference for soreness levels or leg volumes as compared to the control group.
Weber et al[43]	Randomized controlled trial: pre-test/post-test design	2	40 untrained volunteer female subjects, group mean age 23.7 years, SD 4.0	Physical therapist	Effleurage, petrissage	8-minute standardized protocol	No statistical difference between massage, active recovery, microcurrent, and controls for soreness ratings and force generation.
Hart et al[44]	Within subjects experimental design with counter-balanced design	3	19 college aged volunteers (10 men, 9 women), mean age 20.6±1.2 years	Certified athletic trainer	Petrissage (kneading) and effleurage (broad stroking)	5-minute standardized "sports" massage	The sports massage protocol did not significantly reduce either leg girth or pain as compared to the control leg within 72 hours of exercise.
Monedero et al[45]	Within subjects experimental design with counterbalanced design	3	18 healthy trained male cyclists, mean age 25±0.9 years	Certified masseur	Effleurage, stroking, and taponement	Massage group: 15-minute massage Combined recovery group: 7.5 minutes of massage and 7.5 minutes of active recovery	1. Combined recovery significantly better at removing blood lactate at 12-mintues (as compared to all interventions). 2. Combined recovery was a superior approach to maintaining performance over passive recovery and active or massage interventions.
Dawson et al[46]	Quasi-experimental pre-test/post-test	3	12 runners (8 males, 4 females), mean age 35.2±8.3 years)	Massage therapists	Effleurage, petrissage	30-minute standardized protocol	The use of massage, when compared to the control leg, did not facilitate a faster return to baseline measures for strength, soreness, or leg circumference.
Hilbert et al[47]	Repeated measures pre-test/post-test RCT	2	18 volunteers (male and female), mean age 20.4±1.0 years	A senior physical therapy student	Classic Swedish techniques (effleurage, percussion, petrissage)	20 minute standardized protocol	1. The massage protocol did not impact any of the following variables: range of motion, peak torque, neutrophil count, mood, or unpleasantness of soreness. 2. The massage protocol led to a significant decrease in intensity of soreness (Differential Descriptor Scale) in the massage group as compared to the control group.
Smith et al[48]	Randomized controlled trial: pre-test/post-test design	2	14 untrained males; massage group (n=7, mean age 20.1±1.1) and control group (n=7, mean age 18.8±0.3)	Physical therapist	Effleurage (stroking), shaking, petrissage (kneading), wringing, cross-fiber massage	30-minute standardized "sports" massage performed 2 hours after exercise	A significant trend analysis for treatment by time interaction effect with 1) the massage group reporting lower levels of muscle soreness; 2) reduced CK levels in the massage group; 3) massage group demonstrating elevated neutrophil levels.

before and after each boxing simulation and after the intervention. During the rest period, each boxer completed a perceived recovery scale. The authors chose to measure performance by comparing mean peak punching force per round.[20]

The authors found that regardless of whether the athlete received a massage or had rested in a supine position, the mean punching force decreased during the second boxing simulation. As previously indicated the authors found that the massage intervention had a statistically significant effect on the boxers' perception of recovery. Massage intervention also did not affect blood lactate concentrations and, surprisingly, boxers who had received the massage intervention presented with significantly higher lactate concentrations during the second simulation.[20] This finding was unexpected, for which the authors proposed that the perceived psychological recovery might have affected the boxers' later effort and energy expenditure.[20]

Robertson et al[32] examined the effects of massage on lactate clearance, muscular power output, and fatigue after bouts of high intensity training. Nine male athletes (rugby, football, or field hockey) were recruited for the study. A testing protocol began with a standardized warm up period consisting of 5-minutes of cycling and 3-minutes of static stretching for the hamstrings, calf, and quadriceps muscles.[32] Six 30-second bouts of high intensity training were performed on a cycle ergometer (with 30 seconds of active recovery between sets). Upon completition of the high intensity repetitions, the athletes performed 5-minutes of active recovery followed by a 20-minute intervention. Subjects were randomized into one of two interventions: a 20-minute massage or 20-minutes of "passive supine rest." The massage intervention was performed each time by the same physiotherapist. The massage sequence consisted of effleurage and petrissage techniques performed in a standardized protocol sequence of 5 minutes to the back of the left leg, 5 minutes to the back of the right leg, 5 minutes to the front of the right leg, and 5 minutes to the front of the left leg. After the intervention period, the athlete performed the same 8-minute warm up (5-minutes of cycling and 3-minutes of static stretching) followed by one 30-second high intensity bout (Wingate test). Blood samples were collected prior to testing, after the first high intensity training, after 10- and 20-minutes of the intervention time period, and 3 minutes after the final high intensity test.[32]

The authors found no statistical difference between the massage and passive rest interventions for blood lactate concentrations and power. A significant difference did occur between the massage intervention and the rest group for the fatigue index. The fatigue index is the percentage change in power output between the first 5-seconds and the last 5-seconds in a 30-second period. The authors suggested that additional investigations were necessary to identify the role of massage on an athlete's fatigue profile.[32]

Jonhagen et al[41] recruited 16 people (8 men and 8 women, mean age 28 years) in order to assess if sports massage can improve recovery after an eccentric exercise protocol. Subjects performed 300 maximal eccentric quadriceps contractions with each leg on a Kin-Com dynamometer (Harrison, TN).[41] A massage program was initiated 10 minutes after exercise, with one leg from each subject randomized to receive the massage treatment. The massage program consisted of 4-minutes of effleurage and 8-minutes of petrissage. The massage protocol was also performed daily each of the next two days. Testing was performed before the exercise protocol, after exercise, and on the third day. Strength testing was performed on the Kin-Com dynamometer, a vertical long jump was performed to measure functional changes, and a visual analog scale (VAS) was used to measure a subject's pain. The VAS was performed before and after exercise and before and after the massage treatment. Microdialysis was also performed in the vastus lateralis muscle to analyze levels of the neuropeptide Y (NPY) and calcitonin gene-related peptide (CGRP).[41] Both NPY and CGRP are neuropeptides involved in the vasodilatation of skin tissue and the modulation of pain.[41] The authors found that sports massage failed to influence any of the dependent variables. Resultant strength loss was significant in both treatment groups, even on the third day. Sports massage also failed to impact functional recovery. Both groups' demonstrated significantly lower long jump scores, with a normalization of scores occurring by day three. No statistical difference was observed either in pain scores between legs or for changes in CGRP and NPY levels.[41]

Additional studies evaluating the effects of massage on athletes experiencing DOMS have also failed to demonstrate positive effects.[42,43] Active recovery techniques have been shown to be consistently superior to massage for lactate clearance.[33,44,45] In addition, massage interventions have failed to effect post-exercise limb girth.[42,44,46] Subjects who received massage generally experienced no improvement in pain or soreness perception as compared with controls.[42,44,46] Hilbert et al[47] suggested massage can positively affect subjects' perceived intensity of DOMS related soreness, but not until 48 hours post exercise.

Although it is commonly thought that lactic acid accumulation after exercise leads to the pain associated with DOMS, this theory has been recently rejected.[29] Any increased lactic acid levels after exercise return to baseline in approximately one hour after exercise.[29] Lactic acid likely only contributes to acute pain versus the pain experienced 24 to 48 hours after exercise.[29]

Massage Effects on Creatine Kinase and Neutrophil Levels

Smith et al[48] designed a study to investigate the effects of massage on variables other than lactic acid. The authors theorized a massage intervention performed two hours after exercise interferes with neutrophil emigration which may reduce the intensity of pain due to inflammation. Initial results indicated that the 30-minute massage protocol applied two hours after the exercise program helped to reduce DOMS and creatine kinase levels.[48] This particular protocol appeared to demonstrate promising results, but the results are challenged by a small sample size (n = 14).[48] Although the authors called for continued studies, to date, no further clinical studies have been published on this aspect.[48]

ROLE OF SPORTS MASSAGE IN THE TREATMENT OF SPORTS INJURIES

Both classic massage techniques and deep transverse friction massage (DTFM) are performed in clinical rehabilitation settings *(Table 6)*. Despite the popularity of these forms of massage by both therapists and patients, very few studies have been conducted on this intervention, making it a challenge to draw conclusions regarding the efficacy of their use.

Paucity of Sports Massage Reports

Despite the prevalence of low back pain, a review of the literature was unable to identify any randomized controlled trials or quasi-experimental studies investigating the role of massage in the treatment of sports-related back injuries. Two "non-sports" massage papers are presented

Table 6. *Table Summarizing Research Related to the Role of Sports Massage in the Treatment of Sports Injuries*

Study (Year)	Study Design	Level of Evidence	Participants	Professional(s) Conducting the Intervention	Techniques	Treatment Time	Results and Authors' Conclusions
Preyde et al[49]	Randomized controlled trial	2	Four groups: comprehensive massage therapy (n=25, mean age 47.9±16.2); soft-tissue manipulation (n=25, mean age 46.5±18.4); remedial exercise and education (n=22, mean age 48.4± 12.9); placebo (n=26, mean age 41.9±16.6)	Two massage therapists (each > 10 years experience)	Friction, trigger points, neuromuscular therapy	30 to 35 minutes each session.	The comprehensive massage therapy group experienced significant changes in function/RDQ scores, less pain, and a decrease in PRI score.
Furlan et al[50]	Systematic Review	1	MEDLINE, Embase, Cochrane Controlled Trials Register, HealthSTAR, CINAHL, and dissertation abstracts	Not applicable	Any type of massage (using the hands or mechanical device)	Not applicable	1. Massage in combination with exercise and education may be beneficial for patients experiencing subacute or chronic nonspecific low back pain. 2. Acupuncture massage may be more effective than classic massage. Further studies are necessary to confirm this conclusion.
Pettitt et al[51]	Case report	5	19-year old female distance runner	Athletic trainer	Effleurage	5-minutes each weekday	Massage one of several treatments employed in the recovery of the subject.
Blackman et al[52]	One group-repeated measures design	3	Seven athletes (6 men and 1 woman). Mean age not provided (range 21 to 29 years)	Not provided	Longitudinal gliding, transverse gliding, digital ischemic pressure, myofascial release	15-minute standardized protocol. Each patient received 6 treatments over a 5 week period.	1. Anterior compartment pressures after the 5-week massage protocol demonstrated a nonsignificant increase. 2. Mean values for work output in dorsiflexion significantly increased after 5 weeks.

here to demonstrate the challenges in interpreting the literature.

Preyde[49] researched the application of massage in the treatment of patients with subacute low back pain. In this study, subjects were randomized to one of four groups: a comprehensive massage therapy group (CMT), a soft tissue mobilization only group, a remedial exercise and postural education only group, and a placebo group who received a sham ultrasound. Subjects in the CMT group experienced a statistically significant improvement in function, reported less intense pain, and experienced a decrease in the quality of pain as compared to the other three groups.[49]

Even though the author concluded that patients with subacute low back pain benefited from massage therapy, the CMT group received massage (utilizing a non-standardized treatment protocol), exercise prescription consisting of a lower extremity stretching program, were encouraged to walk, swim, do aerobics, and strengthening exercises, and received education on posture and body mechanics. While at the 1-month follow up period, a significant number of patients in the CMT group had no pain; it would be a leap to attribute all of this to the massage (only 27% of subjects in the massage only group were pain free at one month). Rather this research may demonstrate that those who receive posture/body mechanics education, perform exercises, and receive massage have better outcomes versus those who only receive one treatment modality.[49]

A recent Cochrane Collaboration Back Review has concluded that the use of massage might benefit patients with subacute and chronic nonspecific low back pain, especially when the massage is combined with patient education and exercise prescription.[50] Despite this conclusion, the panel highlights the need for additional studies to confirm the efficacy of massage for subacute and chronic LBP and to assess the effect of massage on returning-to-work.[50]

Pettitt et al[51] reported the use of massage in the management of a 19-year old female middle distance runner suffering from sport-related chronic knee pain. The patient underwent an iliotibial band release after initial failure of conservative treatment. Despite a course of post-operative therapy, the patient continued to experience symptoms. The authors implemented a treatment program consisting of joint and soft tissue (massage) mobilization, therapeutic exercise, and neuromuscular electric stimulation. The massage protocol consisted of effleurage strokes. The authors reported that the subject was able to return to running and complete an entire season of indoor track and field after receiving this 10-week course of rehabilitation. While massage was one component of the rehabilitation program, the authors acknowledge the fact that the unique role of any one treatment can not be known.[51]

Blackman et al[52] investigated the effects of massage on chronic exertional compartment syndrome (CECS). This study again highlighted the design challenges that researchers investigating massage effects have experienced. Athletes suffering from CECS complain of cramping or aching pain that develops with exercise and resolves with cessation of activity.[53,54] The authors recruited seven athletes (age range 21 to 29 years) with a confirmed diagnosis of anterior CECS.[52] Each athlete participated in a 5-week rehabilitation program. A standard massage intervention consisted of various techniques for 15-minutes each session. Massage was performed two times a week during the first two weeks and one time a week for the remaining three weeks.[52] Patients were also instructed to perform a standard stretching program for both anterior and posterior musculature twice a day. After the 5 week course of therapy, no significant changes were found in compartment pressures after exercise. The authors did find a significant change in the amount of exercise that could be performed prior to pain onset. Study limitations included the small sample size and the prescription of multiple treatments.[52]

Efficacy of Deep Transverse Friction Massage

Deep transverse friction massage (DTFM) has been suggested as a treatment option for tendon injuries such as tennis elbow.[9] Paucity in the literature exists regarding the use of DTFM in the treatment of sports-related injuries. Despite the popularity of its use,[9] a review of the available research literature fails to support the use of DTFM,[55,56] whereas, eccentric exercise has demonstrated efficacy in the conservative management of tendinopathies.[57-61]

DISCUSSION

Despite the fact that massage has been used as a treatment modality for centuries, a poor appreciation for its clinical effectiveness exists. Although several unique studies have been designed to investigate the effects of sports massage, further investigations are warranted.

Indirect evidence exists suggesting that massage may be beneficial on factors related to an individual's psychological state. While these investigations demonstrated improvements in blood pressure,[15] mood states,[18,19] and perception of recovery,[20-22] study design flaws limit the strengths of the conclusions. Future research should investigate the application of massage immediately prior to stressful sports performance situations, the effects of massage on an athlete's perception of recovery between bouts or events, and the effects of massage on an athlete's mood state throughout an entire season.

Massage has generally failed to demonstrate positive effects upon sports performance.[20,32,41] One study utilizing massage at the beginning of the season demonstrated an increase in the experimental groups' vertical jump, but the study's conclusions are threatened by several design flaws.[28] Researchers have demonstrated an association between massage and temporary changes in hamstring flexibility[23-25] and grip performance.[27] While the results from these studies do not predict future sports performance, these studies should provide guidance in the development of future investigations. Additional research should be directed at performing a massage prior to immediate athletic performance (e.g. massage to the upper extremity prior to a discus throw).

Massage has also generally failed to effect physiological parameters related to DOMS.[20,32,33,40-45] The few studies that have reported positive effects from massage on a subject's pain or soreness perception have had study design flaws and no follow-up investigations to date.[47,48] To account for the individuals who report decreased pain or a perceived improvement after a massage, future research should investigate local concentrations of chemo-inflammatory factors.

Minimal studies have been performed investigating the role of massage in sports rehabilitation.[51,52] Paucity in the literature exist related to sports massage and the management of sports-related injuries. Evidence appears to suggest that massage is efficacious for use with patients with subacute and chronic low back pain.[49,50] Clinical research and case reports are greatly needed to help guide physical therapy decision making when rehabilitating sports injuries.

CONCLUSION

Research evidence has generally failed to demonstrate massage significantly contributing to the reduction of pain associated with delayed onset muscle soreness, or significantly enhancing sports performance and recovery, or playing a significant role in the rehabilitation of sports injuries. Design flaws in research have challenged some of the positive outcomes. Additional studies examining the physiological and psychological effects of sports massage are necessary in order to enhance the sports physical therapists' ability to develop and implement clinically significant evidence based programs or treatments.

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