

Sports massage

A comprehensive review

A. MORASKA

The science of sports massage is of interest to many populations including athletes, athletic trainers, coaches, as well as sports physiologists. While evidence to support or refute the effects of massage on sports performance is insufficient to make definitive statements, new reports and trends within data help formulate an understanding of sports massage. This article will review sports massage research on topics including lactate clearance, delayed onset of muscle soreness (DOMS), muscle fatigue, the psychological effect of massage, and injury prevention and treatment. Articles referenced in Medline, Cochrane Database, the authors library, and references from articles are included in this review. Most studies contain methodological limitations including inadequate therapist training, insufficient duration of treatment, few subjects, or over or under working of muscles that limit a practical conclusion. Muscle soreness associated with DOMS is reduced with massage, although whether force recovers more quickly is still unclear. The research literature to date is insufficient to conclude whether massage facilitates recovery from a fatiguing effort. Both tissue healing and a psychological effect of massage are areas that may prove promising with further research. Results from published literature support a positive trend for massage to benefit athletic recovery and performance; a need for further research into sports massage, especially well-designed studies utilizing therapists specifically trained to administer this type of therapy, is warranted.

KEY WORDS: Manual therapy - Physical fitness - Sports medicine - Athletes, Performance.

Athletic populations repeatedly tout the benefits of massage therapy to enhance athletic perfor-

*University of Colorado at Denver and Health Sciences Center,
Denver, CO, USA*

mance as demonstrated by the number of major athletic teams that support massage therapists on their payroll. But, perhaps surprisingly, serious investigation into the effects of massage on physiological and psychological parameters related to athletic performance has been slow and only a small body of literature on massage therapy and physical activity has been published. Conclusions from research published on sports massage are mixed with regard to the effectiveness of treatment on a specific physiological condition. Unfortunately, it is common for authors of sports massage articles to conclude that massage is not justified for facilitating athletic performance, yet the study may lack critical elements to adequately declare an effect of treatment or not. Additionally, benefits to the athletically minded may not only be observed with an effect of massage on muscle activity, but also areas that may complement performance such as a psychological effect, ability to focus on a task, or injury prevention.

A few review articles on topics associated with sports massage have been published,¹⁻⁵ most recently in 1999,² with an emphasis on delayed onset of muscle soreness (DOMS). However, a critique of the manual therapy, research methods, and results from the primary research

Address reprint requests to: A. Moraska, University of Colorado at Denver and Health Sciences Center, School of Nursing, 4200 E. Ninth Ave. C-288, Denver, CO 80262, USA. E-mail: moraska@alum.rpi.edu

literature is often deficient, which results in potentially misleading conclusions from the data. For example, the effectiveness of treatment may depend on therapist skill, yet treatment modalities (*e.g.* massage administered by a massage therapist vs physical therapist vs water massage vs electro-mechanical device) may be analyzed with equal emphasis. In a research field as new as sports massage, therapist experience and technique choice is critical to identifying whether a treatment effect exists. Other methodological flaws including insufficient duration of treatment, small subject pool, or choice of physical activity often limit the scientific power of the study and reduce the chance for a significant finding. Thus, a cohesive message critically analyzing massage technique as well as its effect on physical performance has not been synthesized from the literature. This article will begin with a review of massage techniques commonly used in research studies and then systematically review the sports massage literature that is directly or indirectly associated with athletic performance.

Description of massage techniques common to physical activity

Massage therapists who work with athletes integrate a number of massage techniques to accomplish a desired effect in the soft tissues of the subject. The techniques frequently used in research are commonly referred to as Swedish massage and include various combinations of effleurage, petrissage, tapotement, friction, and vibration massage. However, those who practice sports massage use more specialized techniques that may include compressive strokes, broad circular friction, and jostling strokes. These techniques vary in application regarding depth and speed depending on whether treatment is pre or postevent. Described below are techniques that are commonly reported in the sports massage literature, but are more generalized in their nature and may not fully represent the work of a trained sport massage therapist. Techniques that are less commonly used in sports massage include hydrotherapy, acupressure, and ice massage. These will not be discussed in this article.

Effleurage

Effleurage (stroking) is one of the more frequently used strokes in sports massage. Strokes are delivered with the hand following the contour of the body and can vary in depth of pressure. Effleurage is administered in

the direction of lymph and venous flow. Light pressure is used at the beginning of a session to prepare the client and soft tissues for deeper massage, or at the end of treatment for flushing and relaxation purposes.^{6, 7} Depending on the depth and speed of stroke used the intent of effleurage techniques is to relax the client, warm the tissue, assist circulation and tissue drainage, stretch muscle and fascia, and soothe painful or sore areas.^{6, 8, 9}

Petrissage

Petrissage (kneading) is a technique whereby muscle tissue is lifted away from underlying structures, gently kneaded or compressed, and then released.^{6, 8} This form of massage can have a stimulating or relaxing effect on a muscle depending upon the rate and pressure of massage as well as the amount of stretch applied to the tissues. Petrissage strokes assist in the removal of metabolic waste and improve circulation around the tissue. Additionally, reported effects of petrissage are to reduce muscle soreness, tone, and local swelling; soften fascia; and loosen adhesions between tissues.⁶

Tapotement

Also known as percussion, tapotement involves repetitive light striking movement to the skin with the ulnar portion of hands or with hands in a cupped position. This technique is often performed prior to sporting events to energize muscle tissue and may stimulate the muscle spindle or Golgi tendon organ depending on location of treatment.^{6, 9}

Friction massage

Friction massage is a brisk, deep stroke that is administered either transversely to (cross-fiber) or parallel to (linear) the fiber direction of underlying tissues.^{6, 8} Circular or linear strokes are applied with the fingertips or thumb to a localized region. The use of friction massage is to initiate a small, controlled inflammatory response with the intent to break down scar tissue, separate adhered tissues, increase local circulation, or reduce trigger point activity.⁷

Vibration

Vibration (shaking) is a pre-event technique to stimulate the target muscle groups prior to competition.⁸ The procedure involves tremulous movement resulting

TABLE I.—Blood lactate recovery after massage intervention.

Authors	Participants (age)	Exercise	Recovery, groups	Study design	Massage	Therapist	Postexercise measurement points (min)	Results	Comment
Robertson <i>et al.</i> ²⁴	9 male field games players (20-22 y)	Repeated maximal efforts on bicycle ergometer	20 minutes 1. Passive rest 2. Massage	Crossover	Effleurage and kneading	Physiotherapist	0, 10, 20, 30	No difference in BL _a for passive and massage	Detailed massage protocol
Monedero <i>et al.</i> ²²	18 male cyclists (25 y)	5 K cycling time trial	15 minutes 1. Passive rest 2. Active (cycling 50% VO ₂ max) 3. Massage 4. Combined (cycling and massage)	Crossover	Massage 7.5 min/leg Combined 3.75 min/leg	Certified masseur	3, 6, 9, 12, 15	Rate of BL _a clearance for active, combined and massage > passive at 3 minute; active > than other groups at 9, 12 min	Cyclists tested on a bicycle with cycling recovery
Gupta <i>et al.</i> ²³	10 male runners (21.1 y)	Repeated efforts on bicycle ergometer @ 150% VO ₂ max	40 minutes 1. Passive rest 2. Active (30% VO ₂ max) 3. Massage (10 minutes)	Crossover	Kneading and stroking of upper and lower limbs	Physiotherapist	0, 3, 5, 10, 20, 30, 40	BL _a lower for active than other groups	Runners tested on a bicycle with cycling recovery
Dolgener <i>et al.</i> ²¹	22 male runners (25y)	Graded exercise test—treadmill	20 minutes 1. Passive rest 2. Active (40% VO ₂ max) 3. Massage	Passive (n=7) Active (n=7) Massage (n=8)	Effleurage and petrissage	Certified massage therapist	3, 5, 9, 15, 20	BL _a lower for active at 15 and 20 min	Runners tested on treadmill with cycling recovery
Bale <i>et al.</i> ²⁵	9 male runners (20.5 y)	2.5 minute treadmill run at 12-13.5 mph	17 minutes 1. Passive rest 2. Active (60% VO ₂ max) 3. Massage	Crossover	Not described	Not described	3, 20	BL _a lower for active at 20 min	Runners tested on bicycle with run recovery

BL_a: blood lactate

in a shaking of the body region massaged. The purpose of vibration is to facilitate muscle relaxation and increase circulation.^{6, 8}

Lactate clearance after exercise

Intense physical activity leading to insufficient oxygen supply to meet energetic demands will result in partial degradation of glucose and a production of lactate that exceeds its removal. It has been suggested that accumulation of lactate is responsible for muscle fatigue and a decrease in athletic performance, although the weakest link in the onset of muscle fatigue remains elusive.^{10, 11} Active recovery interventions, such as cycling, which increase blood flow, have indeed increased clearance of blood lactate.¹² One argument for the use of massage to facilitate clearance of lactate from tissue is that massage increases movement of lymphatic fluid or blood, which can facilitate its trans-

fer to a gluconeogenic organ such as the liver. Therefore, this section will first address blood and lymph flow with massage and then review the literature on clearance of blood lactate after massage.

Several research groups have reported enhanced radioactive tracer clearance from the site of injection with massage.¹³⁻¹⁵ Tracer movement does not seem to be muscle or body region dependent, as an effect has been noted in the gastrocnemius,¹⁴ vastus lateralis,¹³ triceps surae,¹⁴ brachioradialis muscles,¹³ as well as the subcutaneous layer of the skin.¹⁵ Massage technique may be important for tracer clearance as tapotement, but not petrissage increased tracer clearance, although this contrasts with what might be predicted from these types of strokes.¹³ Distribution of tracer with massage is thought to be due to the increase in pressure resulting in movement of particles into the lymphatic system.¹⁶ With regard to blood flow after massage, the results are limited and conflicting. Two studies by the

same research group using Doppler ultrasound to monitor arterial blood flow found no change in net blood velocity in a major artery for any massage technique.^{17, 18} Although, effleurage and petrissage altered the variability of the blood velocity response; likely due to the compressive effect of massage strokes.¹⁸ More recently, findings by Hinds *et al.* also report that massage failed to change femoral artery blood flow, although skin blood flow did increase.¹⁹ Conversely, an increase in skin blood flow and blood volume to lumbar paraspinal musculature (as measured by laser blood flow meter and infrared spectroscopy) after massage has been reported.²⁰ Collectively, in the smaller draining vasculature, massage appears to effectively increase movement of chemicals, but may have a lesser effect on large blood vessels.

Whether blood lactate was elevated in runners by a 5 km maximal treadmill run,²¹ in cyclists by a graded exercise test on bicycles,²² or in runners tested on a bicycle ergometer,²³ massage failed to reduce blood lactate levels at a rate significantly greater than passive rest (Table I).²¹⁻²⁵ Collectively, these studies employed a combination of massage techniques on the legs for 10 to 20 min. The massage procedure used by Dolgener *et al.* on the runners consisted of effleurage and petrissage techniques, whereas the cyclists in the Monedero *et al.* study received 15 min of effleurage and tapotement massage.^{21, 22} Gupta *et al.* succinctly described the massage used in their study as kneading and stroking, which limits comparison of the techniques used in that study.²³ More recently, in a well-designed study with a detailed description of the massage procedure, Robertson *et al.* failed to find a main effect of massage on clearance of blood lactate in field sports athletes (rugby, football, and field hockey) who completed repeated maximal efforts on a cycle ergometer.²⁴

It is reported in one study that massage may reduce blood lactate levels in runners compared to passive rest, but only at a single time-point post activity (20 minute).²⁵ Also, problematic with that study are baseline differences and the use of a set running speed for all subjects, rather than a percent of each subjects VO_2max , which may account for the slight difference in lactate levels at that one time point.

Even with the small number of published studies it appears unlikely that massage has an additional effect on blood lactate clearance. With the quantity of lactate produced from many different muscles during maximal exercise and a normal, rapid clearance of lactate

to baseline levels during passive rest (~30 min), fluid mobilization from massage may be comparatively slow making a change difficult to detect. Manual techniques specific to tissue drainage (*e.g.* lymphatic drainage) or postevent massage including compressive and broad circular friction strokes combined with effleurage may prove more effective at lactate removal than techniques used previously.

DOMS

A decrease in the ability to generate force and heightened sensitivity to pain are characteristics of DOMS. Soreness associated with DOMS is first sensed 12-24 hours after an unaccustomed exercise bout containing eccentric muscle contraction. Soreness peaks at about 48 hours, but complete resolution of symptoms may take a week to 10 days.^{26, 27} Peak force deficits occur 24-48 hours postactivity. A reduction in eccentric, concentric, and isometric force is present in people suffering from DOMS; eccentric force generation may take 8-10 days to fully recover whereas recovery of concentric and isometric force is more rapid (4 days).²⁸ Histological examination of muscle cells after eccentric contractions indicates structural damage to the cells and discharge of cellular components, which leads to edema and a localized inflammatory response.²⁹⁻³¹ While the cause of pain sensation is as yet unclear, the presence of noxious chemicals from structural damage (muscle and connective tissue), enzyme efflux, lactic acid accumulation, and pressure or chemicals (*e.g.* histamine, prostaglandins) produced by the inflammatory response and stimulating nerve endings have been proposed.^{28, 29} Connective tissue damage, indicated by elevated urinary and hydroxyproline and hydroxylysine, has also been reported after eccentric activity and may contribute to pain or functional decrements. An influence on tissue fluid movement by massage may reduce the concentration of noxious chemicals that sensitize nerve endings and reduce soreness sensation. Alternatively, the delivery of nutrients to damaged tissues may be accelerated with massage, which could hasten the repair process and strength recovery.

Only 5 full-length research articles investigating massage and DOMS have been published (Table II).^{17, 32-37} To varying degrees, all five of the articles are supportive of massage as a means to reduce muscle soreness associated with eccentric activity. The degree

TABLE II.—*Recovery of soreness and strength in DOMS subjects treated with massage therapy.*

Authors	Muscle group	Induction of DOMS	Participants (age)	Therapist	Massage	Time of massage after exercise	Measurement time points postexercise (h)	Results: force or torque	Results: soreness	Study limitations
Hilbert <i>et al.</i> ³³	Hamstring	6 sets of 8 MVC + 5 MVC	18 male and female (9 control, 9 massage) (20.4 y)	Physical therapy student	20 min effleurage, petrissage and tapotement	2 h	2, 6, 24, 48	No effect of massage on eccentric torque	Soreness lower at 48 h with massage	Student massage. Baseline strength differences. Force not recovering by end of study
Farr <i>et al.</i> ³⁵	Legs	Downhill Walking (+10% bodymass): 40 min	8 males (22.3 y)	Masseur	30 min effleurage and petrissage	2 h	1, 24, 72, 120	Massage may improve isometric, but not isotonic strength	Soreness lower for massaged leg at 24 h	Opposite leg served as control
Tiidus <i>et al.</i> ¹⁷	Quadriceps	7 sets of 20 MVC	4 male and 5 female (20-22 y)	Registered massage therapist	10 min effleurage each day of measurement	1 h	24, 48, 96	Trend for increased force with massage at 60°/s. No effect at 0° or 180°/s	Soreness lower at 48 h, trend between 48-96 h for massaged leg	Opposite leg served as control
Rodenburg <i>et al.</i> ³⁴	Elbow flexors	120 maximal extensions	50 (27 control, 23 massage) (23.3 y)	Physio therapist	15 min effleurage, tapotement, and petrissage	15 min	1, 24, 48, 72, 96	Main effect of increased isotonic force with massage	Soreness lower at all time points with massage	Massage as part of treatment including a warm-up and stretching
Smith <i>et al.</i> ³²	Elbow flexors and extensors	4-5 sets of 35 at 75% MVC	14 male (7 control, 7 treatment)	Physical therapist	30 min effleurage and petrissage	2 h	8, 24, 48, 72, 96, 120	NA	Soreness lower from 24-96 h for massage	Physical therapist administered massage
Abstracts Hasson <i>et al.</i> ³⁶	Quadriceps	NA	16 (6 massage, 5 touch control, 5 control) (24-35 y)	N/A	30 strokes at 40 Newtons	24 h after exercise	24, 48	Massage no benefit	Massage no benefit	Only one measurement point
Wenos <i>et al.</i> ³⁷	Quadriceps	NA	9 (24-35 y)	Licensed massage therapist	NA	0 h	0, 24, 48, 72	Massage no benefit	Massage no benefit	Opposite leg served as control

MVC: maximal voluntary contraction

of support for massage on soreness recovery may have to do with the number of massages given (ranging from 1-4), number of subjects in the study (ranging from 9-50), number of days over which measurements were taken (ranging from 2-5 days), as well as the techniques applied and therapist training. When massage is administered within a 2 hour window after eccentric activity, a significant reduction in soreness is first noted between 24-48 hours after

activity and continues until resolution of symptoms³² or the duration of the study.^{17, 25, 33} Studies to characterize techniques or duration of massage to optimize the soreness recovery have not been conducted, but from the current literature a 10-minute massage consisting of effleurage and petrissage strokes per body region is necessary to have a significant effect. Details regarding soreness recovery during the first 24 hours or the 24-48 hour period postexercise are poorly char-

acterized, but would be beneficial to understanding the time course of an effect.

In addition to increased muscle soreness, a reduction in the ability to generate force occurs after eccentric activity. A recovery period of 10 days may be necessary to attain baseline eccentric strength, although recovery of concentric and isometric force is more rapid and occurs in 4 days.²⁸ Three of the 4 studies reporting force recovery indicate that massage may be beneficial to this measure.^{17, 34, 35} Only one study measured recovery of eccentric strength; the authors failed to find an effect of massage, although baseline differences and the use of a physical therapy student as massage therapist weaken the conclusions.³³ Improvement in both isometric and isotonic strength has been noted, though not in the same study.^{17, 34, 35} A less certain effect of massage is the time course for strength recovery after an eccentric exercise bout. While peak torque deficits typically occur at 24-48 hours after activity and a return to baseline strength may take as long as 10 days, measurement of force recovery in the massage studies is only recorded over the 24-96 hour period postexercise. This proves problematic as force may not have started to recover before the end of measurement³³ or force may have only recovered to 80% of baseline during measurement.^{17, 34} Also problematic is an exercise regimen that only reduced maximal force to 92% of baseline making a recovery intervention unlikely to identify an effect.³⁵ Despite only a few days of measurement, Rodenburg *et al.* was able to detect a significantly greater rate of force recovery in subjects who received massage.³⁴ And, in subjects receiving a daily massage over 4 days, a trend for a more rapid isokinetic (600/s) strength return is apparent.¹⁷

In addition to study limitations previously mentioned, methodological concerns such as the use of the opposite leg as a control,^{17, 35} lack of therapist experience,^{33, 34} and an insufficient number of subjects to detect a difference^{17, 33, 35} are common weaknesses and limit clarification as to whether massage can facilitate force recovery. Despite the noted limitations and the unknowns regarding optimal treatment duration, frequency, and technique, the studies indicate that force recovery is increased with massage. Clearly, more research needs to be conducted to verify or refute whether massage can facilitate force recovery after eccentric exercise that induces DOMS, but positive trends are evident.

Muscle fatigue

Muscle fatigue can be defined as the inability to sustain a required or expected power or force output.¹¹ The ability of an athlete to recover from a physical effort is important during some sporting competitions or during physical preparation within training cycles. Much like the cause of DOMS is not fully characterized, the cause of muscle fatigue remains elusive and may consist of central or peripheral mechanisms.¹¹ Massage therapy may be an appropriate counter to fatigue onset due to an ability to influence fluid movement in deep tissue and thereby improving nutrient flow or waste removal, or by facilitating relaxation to promote normal recovery. A complete summary of the published research literature on massage and fatigue is presented in Table III.^{22, 24, 38-43}

Methodologically, research studies involving massage as a recovery intervention typically employ a test, intervention, and retest format. The limited amount of published research on this topic are mixed regarding an effect of massage on recovery from fatigue. Monedero *et al.* found that cycling time for a second 5 km maximal effort on a bicycle ergometer was not improved with a 15-minute recovery massage as compared to active recovery or passive rest.²² But, a combined recovery consisting of massage (7.5 min) and active cycling (7.5 min at 50% of $\dot{V}O_{2max}$) did significantly reduce the increase in cycling time for the second effort.²²

Three research articles measured the effect of massage on a second maximal force effort.^{24, 38, 39} Collectively, those studies conclude that massage does not alter force generation of the second effort. However, two of these studies are not typical of sports massage articles and require some explanation. In the study by Hemmings *et al.* 8 amateur boxers underwent 2 sets of 5 2-minute rounds of simulated boxing, with a 1-minute seated rest between rounds.³⁸ The average force from each 8 punch round was determined on a boxing ergometer. The two sets were separated by a 20-minute massage, which consisted of effleurage and petrissage strokes administered to the leg, back, shoulder, and arms by a sports massage therapist or a 20-minute rest. Punching force was reduced across the second set of 5 rounds at an equal rate for both massage and control groups. The complex act of punching requires coordinated movement of muscles in the back, shoulder, neck, and arm as well as abdominal and leg muscles. While the massage procedure used in this study includ-

TABLE III.—Summary table on recovery from muscle fatigue with massage therapy treatment.

Authors	Participants (age)	Study design	Method of fatigue	Therapist	Massage	Dependent measure	Results
Robertson <i>et al.</i> ³⁴	9 male field games players (20-22 y)	Crossover design: Massage or rest	6 30 s maximal efforts on a cycle ergometer	Physiotherapist	20 min stroking, effleurage and kneading (10 min/leg)	Peak and men power of second cycle set	No effect of massage on peak or mean power
Monedero <i>et al.</i> ³²	18 trained male cyclists (25 y)	Crossover design: 1. Passive (15 min) 2. Active (15 min @ 50% VO ₂ max) 3. Massage (15 min) 4. Combined (15 min)	5 km cycle time trial	Certified masseur	Group 3: 7.5 min/leg (effleurage and tapotement) Group 4: 3.75 min/leg + 7.5 min cycle @ 50% VO ₂ max	Time for second 5K time trial	Combined (massage and active recovery) significantly smaller gain in second time trial time
Hemming <i>s et al.</i> ³⁸	8 amateur male boxers (24.9 y)	Crossover design: Massage or rest	Five rounds of 80 boxing punches	Sports massage therapist	20 min effleurage/petrissage, 8 min legs, 2 min back, 10 min shoulder	Punch force on second set of 5 rounds	No effect of massage on punch force
Rinder <i>et al.</i> ⁴⁰	7 female, 13 male health club volunteers (35 y)	Crossover design: Massage or rest	Leg extension at 50% MVC, cycle ergometer, ski squat, leg extension at 50% MVC	Not specified	3 min/leg effleurage and petrissage	Total number of 50% MVC leg extensions	With rest number of 50% MVC decreased; with massage, number of 50% MVC increased
Carafelli <i>et al.</i> ³⁹	12 male (23.8 y)	Crossover design: Massage or rest	MVC (isometric), 4 X 70% MVC; repeat until MVC <70%	None	4 min percussive vibratory massage - electromechanical device	Rate of decrease in MVC force	Rate of fatigue similar for both groups
Abstracts Newman <i>et al.</i> ⁴²	20 male and female (21.6 y)	Crossover design: Massage or rest	Massage prior to any exercise	Not specified	11 min effleurage and petrissage	Ratio of first to last 5 of 30 maximal contractions	No difference in muscular endurance
Drews <i>et al.</i> ⁴¹	6 elite cyclists	Crossover design: Massage or diathermy	Daily 100 mile cycling event followed by massage; repeat for 4 days	Not specified	30 min	Split and event finish time	No difference in cycling performance
Ask <i>et al.</i> ⁴³	8 competitive male cyclists	Crossover design: Massage or rest	Cycling max test	Not specified	10 min effleurage, petrissage and tapotement	Average power at 50% MVC	Average power after massage 11% greater than after rest

MVC: maximal voluntary contraction

ed some of those body regions the effects of massage may be too diffuse with the time constraint to have a significant effect.

Although a more conventional method to measure maximal voluntary force was employed by Cafarelli *et al.*, an electromechanical device was used to administer massage.³⁹ Muscle fatigue was induced by a maximum voluntary contraction (MVC) followed by 4 isometric contractions at 70% MVC of the quadriceps; this procedure was repeated until the maximum force the participant could generate fell below 70% of the MVC. A 4-minute massage was next applied to the quadriceps with an

electromechanical vibratory device; the exercise was then repeated. The rate at which maximum voluntary strength fell to below 70% of maximum was calculated. No difference in rate of fatigue was detected between control and treated subjects. An electromechanical device is limited in function and it is doubtful that it can adequately simulate treatment by a trained massage therapist. This highly cited article is more telling of the effects of a massage apparatus than massage therapy.

A beneficial effect on endurance strength was noted from a 6-minute massage consisting of effleurage and petrissage strokes.⁴⁰ Subjects undertook an

involved quadriceps fatiguing regimen consisting of cycling, a squatting exercise, followed by leg extensions at 50% of the one repetition maximum until fatigue. Effleurage and petrissage massage (3-min/leg) followed immediately and the leg extension portion was repeated until failure. A significant pre to postinteraction was found; specifically, an increase in the number of leg extensions was reported for subjects receiving massage (31 to 32), but a decrease occurred in the non-treated control group (28 to 25).

Only one article, and that in abstract form, has been published with regard to massage and physical activity repeated over several days.⁴¹ In that study the authors failed to find a benefit of massage on cycling time, although the duration of activity may have been excessive (276 min/day for 4 days) or the subject pool too small (n=6) to find a reliable difference.

Few studies have been conducted on massage and muscle fatigue, and the research methodology has been varied, which makes a general conclusion regarding the effectiveness of massage impractical. Furthermore, ambiguous description of massage technique weakens the ability to evaluate effectiveness of technique for reducing muscle fatigue. Collectively, the interpretation of results to prolong fatigue with massage indicates that lower intensity activities may be a more promising area to investigate than maximal efforts. Thorough studies incorporating trained therapists, adequate massage duration, and unified methods for inducing fatigue are needed to conclude whether massage can facilitate recovery.

Psychological effect

One of the more intangible aspects of sporting competitions is the psychological component. Posturing by athletes to gain a competitive edge over competitors in sports such as boxing and track and field events is commonly observed. Furthermore, not all aspects of competition rely solely on strength; tactical maneuvering in cycling or an ability to focus on a task (e.g. gymnastics or golf) can also affect performance. Therefore, the psychological effect provided to an athlete by an experience such as massage may be of importance in a non-physiological manner.

In non-athletic populations, massage therapy has been reported to reduce psychological measures including anxiety,⁴⁴ tension,⁴⁵ stress,⁴⁶ depression⁴⁷ and increase mood⁴⁸ and quality of life,⁴⁹ all of which may

contribute to optimal athletic performance. These factors, as well as others such as locus of control, motivation, and perceptions of pain and fatigue can be very important to the performance of an athlete during training and competition. In the study on amateur boxers described earlier, a measure of perceived recovery was made by the subject rating their feeling on a linear scale for 4 items ("refreshed", "recharged", "rested", and "recovered") after an exercise bout that was followed by massage.³⁸ While punching force was not increased after massage, the perceived recovery was elevated compared to control subjects. Similarly, fatigue perception was reduced on the second effort in subjects who received a 20-minute massage administered between 2 maximal cycling efforts; despite no difference in mean or peak power.²⁴ How or whether this aspect affects competitive performance needs to be determined.

Only two other studies have been published on the psychological effect of massage in an athletic population. These studies include an abstract reporting no effect of massage therapy on mood as measured by the profile of mood states test given to cyclists before, during, and after a 4 day ultra-endurance cycling event,⁵⁰ and a brief report that suggests a 40-50 minute massage given to athletes may decrease anxiety.⁵¹ The benefit of an acute massage to the athlete may not be realized with a physiological change, but rather with a heightened alertness or tactical acuity. Well-conducted studies to investigate the psychological benefit of massage and how this affects performance are encouraged.

Range of motion, injury recovery, and tissue healing

Injury is perhaps one of the greatest concerns to the competitive athlete. The inability to compete, loss of quality training time, and loss of self worth are among the concerns of athletes experiencing an injury. Proper maintenance of muscle and connective tissues through nutrition, rest, and stretching are encouraged in the literature, however, due to the demands of athletic training and competition a soft tissue injury is often difficult to avoid. Therefore, injury prevention and optimizing tissue healing after injury are important components in career longevity of the professional as well as recreational athlete.

Adequate flexibility and range of motion are generally believed to be beneficial to injury prevention and

optimal muscular performance.⁵² Soft tissue limitations, such as adaptive shortening of muscles and improper body alignment, can result in over-compensation by muscles in other regions, which is associated with injury.⁵³ Massage therapy may increase range of motion and flexibility by affecting both the muscular and connective tissues. The type of bodywork frequently includes stretching, as a component of the treatment, therefore isolating the effect of a massage-only treatment on range of motion is difficult or perhaps misleading.

Surprisingly, little research has been published with regard to massage and range of motion. Range of motion at the hip with regard to hamstring tightness has been investigated with opposing results reported.^{54, 55} Crosman *et al.*⁵⁵ found that massage increases hip flexion by over 10 degrees, whereas Wiktorsson-Moller *et al.*⁵⁴ found that contract-relax stretching exercises, but not massage, increased range of motion at the hip. Duration of massage was similar in the two studies (approximately 12 min) and participants in both studies considered themselves as active. But, several differences between the two studies may explain the dichotomy in results. Crosman *et al.*⁵⁵ had a larger subject pool (34 vs 8) that consisted of women, whereas the Wiktorsson-Moller *et al.*⁵⁴ study included only men. Unfortunately, details regarding the massage procedure in the Wiktorsson-Moller *et al.*⁵⁴ study are insufficiently presented to compare with the detailed procedure presented by Crosman *et al.*⁵⁵

Few studies have actually addressed management of soft tissue injury in humans with the use of massage. One cause of injury may be due to myofascial trigger point activity. Myofascial trigger points (MTrPs) are tightly contracted regions within muscle tissue characterized by a hyperirritable taut band with defined pain referral patterns.⁵³ These tightly contracted, ischemic regions result in muscle shortening and limit strength and function of the muscle as a whole. Manual therapies, such as massage, have been shown to reduce or eliminate MTrP activity.⁵³ Additionally, it has been suggested that MTrP activity may be responsible for muscle cramps during exercise.⁵⁶ MTrP therapy was successfully used to treat tennis players suffering from chronic shoulder impingement syndrome.⁵⁷ Athletes were able to avoid surgery and return to active competition within 11 weeks by having active trigger points treated with massage. And, runners diagnosed with anterior compartment syndrome of the lower leg reported significantly less pain after exercise as well

as greater total work done to onset of pain with 5 weeks of massage (6 30-minute massages to the legs) and stretching exercises.⁵⁸ Although only a few studies have been published, the research into the treatment of soft tissue injuries with massage appears promising.

Physiologically, there is evidence that manual therapy facilitates healing of soft tissue. A soft tissue mobilization technique (mechanical massage) was used to speed healing in collagenase treated Achilles tendons in rats.⁵⁹ Pressure was applied to the tendon for 3 min on days 21, 25, 29, and 33 postcollagenase treatment. Histologically, a significantly greater density and activity of fibroblasts was found in the massaged tendon than the control. Importantly, functional differences including stride length and frequency returned to preinjury levels more rapidly in rats receiving soft tissue mobilization. While a mechanical device may stimulate tissue differently than manual therapy, the healing process in injured soft tissues may be accelerated by physical manipulation.

Conclusions

Sports massage research is in its infancy. Although conclusive evidence for the efficacy of massage to the athlete is limited, this is due more to the scarcity of quality research rather than research not supportive of an effect. Accurate interpretation of the sports massage research is made difficult by the large percentage of studies with methodological deficiencies including number of subjects, therapist training, or duration of massage. These limitations are problematic for accurate interpretation of research and complicate the understanding of sports massage.

The tremendous, but unscientific, demand by professional and amateur athletes for massage and the willingness of national or Olympic organizations to support massage for athletes suggest a greater effect than palliative care.⁶⁰ Professional sports teams spend thousands of dollars on equipment to reduce performance time in events by a fraction of a second, yet care for the athlete is often secondary. The current state of sports massage research indicates a potential for therapeutic benefits to the athlete, but better controlled research studies need to be conducted to confirm and extend the current understanding in this field.

Acknowledgements.—The author would like to recognize the Massage Therapy Foundation for their financial support in the completion of this review. The assistance of Clint Chandler, C.M.T., B.S., for his guidance on massage techniques is greatly appreciated.

References

1. Tiidus PM. Manual massage and recovery of muscle function following exercise: a literature review. *J Orthop Sports Phys Ther* 1997;25:107-12.
2. Tiidus PM. Massage and ultrasound as therapeutic modalities in exercise-induced muscle damage. *Can J Appl Physiol* 1999;24:267-78.
3. Ernst E. Does post-exercise massage treatment reduce delayed onset muscle soreness? A systematic review. *Br J Sports Med* 1998;32:212-4.
4. Callaghan MJ. The role of massage in the management of the athlete: a review. *Br J Sports Med* 1993;27:28-33.
5. Cafarelli E, Flint F. The role of massage in preparation for and recovery from exercise. An overview. *Sports Med* 1992;14:1-9.
6. Fritz S. *Mosby's fundamentals of therapeutic massage*. St. Louis, Missouri: David Dushimer; 1995.
7. Futral KK. How to get involved with professional sports. *Massage Therapy Journal* 2002;40:2,44,48,50,52,54,56.
8. Benjamin PJ, Lamp SP. *Understanding sports massage*. Champaign, IL: Human Kinetics; 1996.
9. Warren J. Pedal power. Massage gives cyclists the competitive edge. *Massage Magazine* 2002;63:6,68-70,73-4.
10. Jones NL, Heigenhauser G. Effects of hydrogen ions on metabolism during exercise. Perspectives in exercise science and sports medicine. Indianapolis, IN: Benchmark Press; 1992.
11. Maclaren DP, Gibson H, Parry-Billings M, Edwards RH. A review of metabolic and physiological factors in fatigue. *Exerc Sport Sci Rev* 1989;17:29-66.
12. Stamford BA, Weltman A, Moffatt R, Sady S. Exercise recovery above and below anaerobic threshold following maximal work. *J Appl Physiol* 1981;51:840-4.
13. Hovind H, Nielsen SL. Effect of massage on blood flow in skeletal muscle. *Scand J Rehabil Med* 1974;6:74-7.
14. Hansen TI, Kristensen JH. Effect of massage, shortwave diathermy and ultrasound upon ¹³³Xe disappearance rate from muscle and subcutaneous tissue in the human calf. *Scand J Rehabil Med* 1973;5:179-82.
15. Mortimer PS, Simmonds R, Rezvani M, Robbins M, Hopewell JW, Ryan TJ. The measurement of skin lymph flow by isotope clearance: reliability, reproducibility, injection dynamics, and the effect of massage. *J Invest Dermatol* 1990;95:677-82.
16. Trubetskoy VS, Whiteman KR, Torchilin VP, Wolf GL. Massage-induced release of subcutaneously injected liposome-encapsulated drugs to the blood. *J Control Release* 1998;50:13-9.
17. Tiidus PM, Shoemaker JK. Effleurage massage, muscle blood flow and long-term post-exercise strength recovery. *Int J Sports Med* 1995;16:478-83.
18. Shoemaker JK, Tiidus PM, Mader R. Failure of manual massage to alter limb blood flow: measures by Doppler ultrasound. *Med Sci Sports Exerc* 1997;29:610-4.
19. Hinds T, McEwan I, Perkes J, Dawson E, Ball D, George K. Effects of massage on limb and skin blood flow after quadriceps exercise. *Med Sci Sports Exerc* 2004;36:1308-13.
20. Mori H, Ohsawa H, Tanaka TH, Taniwaki E, Leisman G, Nishijo K. Effect of massage on blood flow and muscle fatigue following isometric lumbar exercise. *Med Sci Monit* 2004;10:CR173-8.
21. Dolgener F, Morien A. The effect of massage on lactate disappearance. *J Strength Cond Res* 1993;7:159-62.
22. Monedero J, Donne B. Effect of recovery interventions on lactate removal and subsequent performance. *Int J Sports Med* 2000;21:593-7.
23. Gupta S, Goswami A, Sadhukhan AK, Mathur DN. Comparative study of lactate removal in short term massage of extremities, active recovery and a passive recovery period after supramaximal exercise sessions. *Int J Sports Med* 1996;17:106-10.
24. Robertson A, Watt JM, Galloway SD. Effects of leg massage on recovery from high intensity cycling exercise. *Br J Sports Med* 2004;38:173-6.
25. Bale P, James H. Massage, warmdown and rest as recuperative measures after short term intense exercise. *Physiother Sport* 1991;13:4-7.
26. Clarkson PM, Nosaka K, Braun B. Muscle function after exercise-induced muscle damage and rapid adaptation. *Med Sci Sports Exerc* 1992;24:512-20.
27. Armstrong RB. Initial events in exercise-induced muscular injury. *Med Sci Sports Exerc* 1990;22:429-35.
28. Cheung K, Hume P, Maxwell L. Delayed onset muscle soreness: treatment strategies and performance factors. *Sports Med* 2003;33:145-64.
29. Clarkson PM, Sayers SP. Etiology of exercise-induced muscle damage. *Can J Appl Physiol* 1999;24:234-48.
30. Friden J. Muscle soreness after exercise: implications of morphological changes. *Int J Sports Med* 1984;5:57-66.
31. Armstrong RB, Ogilvie RW, Schwane JA. Eccentric exercise-induced injury to rat skeletal muscle. *J Appl Physiol* 1983;54:80-93.
32. Smith LL, Keating MN, Holbert D, Spratt DJ, McCammon MR, Smith SS *et al*. The effects of athletic massage on delayed onset muscle soreness, creatine kinase, and neutrophil count: a preliminary report. *J Orthop Sports Phys Ther* 1994;19:93-9.
33. Hilbert JE, Sforzo GA, Swensen T. The effects of massage on delayed onset muscle soreness. *Br J Sports Med* 2003;37:72-5.
34. Rodenburg JB, Steenbeek D, Schiereck P, Bar PR. Warm-up, stretching and massage diminish harmful effects of eccentric exercise. *Int J Sports Med* 1994;15:414-9.
35. Farr T, Nottle C, Nosaka K, Sacco P. The effects of therapeutic massage on delayed onset muscle soreness and muscle function following downhill walking. *J Sci Med Sport* 2002;5:297-306.
36. Hasson S, Cone M, Ellison C, Goehrs L, Hall L, Van Vyven E. Effect of retrograde massage on muscle soreness and performance. *Phys Ther* 1992;72:S100.
37. Wenos J, Brilla L, Morrison M. Effect of massage on delayed onset muscle soreness. *Med Sci Sports Exerc* 1990;22:S34.
38. Hemmings B, Smith M, Graydon J, Dyson R. Effects of massage on physiological restoration, perceived recovery, and repeated sports performance. *Br J Sports Med* 2000;34:109-14; discussion 115.
39. Cafarelli E, Sim J, Carolan B, Liebesman J. Vibratory massage and short-term recovery from muscular fatigue. *Int J Sports Med* 1990;11:474-8.
40. Rinder AN, Sutherland CJ. An investigation of the effects of massage on quadriceps performance after exercise fatigue. *Complement Ther Nurs Midwifery* 1995;1:99-102.
41. Drews T, Kreider R, Drinkard B, Cortes C, Lester C, Somma C *et al*. Effects of post-event massage therapy on repeated ultra-endurance performance. *Int J Sports Med* 1990;11:407.
42. Newman T, Martin D, Wilson L, Perrin D. Massage effects on muscular endurance. *J Athl Train* 1996;31 Suppl:S-18.
43. Ask N, Oxelbeck T, Lundeberg T, Tesch PA. The influence of massage on quadriceps function after exhaustive exercise. *Med Sci Sports Exerc* 1987;19:S3.
44. Moyer CA, Rounds J, Hannum JW. A meta-analysis of massage therapy research. *Psychol Bull* 2004;130:3-18.
45. Weinberg R, Jackson A, Kolodny K. The relationship of massage and exercise to mood enhancement. *The Sport Psychologist* 1988;2:202-11.
46. Rexilius SJ, Mundt C, Erickson Megel M, Agrawal S. Therapeutic effects of massage therapy and handling touch on caregivers of patients undergoing autologous hematopoietic stem cell transplant. *Oncol Nurs Forum* 2002;29:E35-44.
47. Jones NA, Field T. Massage and music therapies attenuate frontal EEG asymmetry in depressed adolescents. *Adolescence* 1999;34:529-34.
48. Hernandez-Reif M, Field T, Hart S. Smoking cravings are reduced by self-massage. *Prev Med* 1999;28:28-32.
49. Birk TJ, McGrady A, MacArthur RD, Khuder S. The effects of massage therapy alone and in combination with other complementary therapies on immune system measures and quality of life in human immunodeficiency virus. *J Altern Complement Med* 2000;6:405-14.
50. Drews T, Kreider R, Drinkard B. Effects of post-event muscle massage

- therapy on psychological profiles of exertion, feeling, and mood during a four-day ultracycling event. *Med Sci Sports Exerc* 1990;23:S119.
51. Tyurin AM. The influence of different forms of massage on the psycho-emotional state of athletes. *Soviet Sports Rev* 1986;21:126-7.
 52. Shrier I, Gossal K. Myths and truths of stretching. *Phys Sportsmed* 2000;28:57-63.
 53. Simons DG, Travell JG, Simons LS. *Travell and Simons' myofascial pain and dysfunction : the trigger point manual*. 2nd ed. Baltimore, MD: Williams & Wilkins; 1999.
 54. Wiktorsson-Moller M, Oberg B, Ekstrand J, Gillquist J. Effects of warming up, massage, and stretching on range of motion and muscle strength in the lower extremity. *Am J Sports Med* 1983;11:249-52.
 55. Crosman L, Chateauvert S, Weisberg J. The effects of massage to the hamstring muscle group on range of motion. *J Orthop Sports Phys Ther* 1984;6:168-72.
 56. Bentley S. Exercise-induced muscle cramp. Proposed mechanisms and management. *Sports Med* 1996;21:409-20.
 57. Ingber RS. Shoulder impingement in tennis/racquetball players treated with subscapularis myofascial treatments. *Arch Phys Med Rehabil* 2000;81:679-82.
 58. Blackman PG, Simmons LR, Crossley KM. Treatment of chronic exertional anterior compartment syndrome with massage: a pilot study. *Clin J Sport Med* 1998;8:14-7.
 59. Davidson CJ, Ganion LR, Gehlsen GM, Verhoestra B, Roepke JE, Sevier TL. Rat tendon morphologic and functional changes resulting from soft tissue mobilization. *Med Sci Sports Exerc* 1997;29:313-9.
 60. Galloway SD, Watt JM. Massage provision by physiotherapists at major athletics events between 1987 and 1998. *Br J Sports Med* 2004;38:235-6; discussion 237.