Br J Sp Med 1994; 28(3)

Review

Massage – the scientific basis of an ancient art: part 2. Physiological and therapeutic effects

Geoffrey C. Goats PhD MCSP
School of Occupational Therapy and Physiotherapy, University of East Anglia, Norwich, UK

The physiological and therapeutic effects of massage are frequently questioned. This article reviews previous research into the effects of massage on blood flow and composition, oedema, connective tissue, muscle and the nervous system. Although further invetigations are clearly required in certain areas, the discussion demonstrates that the use of massage in sports medicine can be justified according to orthodox scientific criteria.

Keywords: Massage, physiological and therapeutic effects

Massage is commonly seen as a therapeutic art without scientific foundation. Further scientific investigation is certainly needed and our understanding is far from complete, but the literature indicates that an extensive body of research already exists[1,2]. This article reviews the physiological and therapeutic effects of massage. Sports therapists are concerned to promote healing, restore normal function following injury and achieve optimum performance from their clients. Massage can assist with each of these processes by acting upon arterial and venous blood flow, the blood clotting process, oedema, lymphatic drainage and the properties of connective tissue and muscle. The somatic and autonomic nervous systems are also affected and these are discussed with reference to pain and relaxation.

Circulatory and tissue fluids

Arterial blood flow

Massage dilates superficial blood vessels and increases the rate of blood flow[1,3]. This effect, first measured for gentle massage[4], supported conclusions from a previous experiment with local anaesthesia[5] that arteriolar dilation is primarily controlled by local axon reflexes[6].

Forceful massage in a healthy adult increases both local blood flow and cardiac stroke volume. The local vascular response is mainly due to histamine release, and increased stroke volume reflects improved venous return. These effects are longer lasting than those of gentle pressure[5] and represent a potent means to accelerate healing. Flow rates usually return to normal 1 h after deep massage. Vasodilator drugs administered at the same time as deep massage cause longer lasting hyperaemia[7].

Such effects upon blood flow also suggest that massage should improve the performance of fatigued muscle. Massaged muscle fibres display less spasm, an increased force of contraction and enhanced endurance compared with muscle simply rested. These massage effects are abolished by arterial occlusion[8].

Some massage techniques promote blood flow more effectively than others. Clearance studies with the radioisotope ^{133}Xe showed that moderate exercise was a less efficient way to improve blood flow in large muscle groups than tapotement ('hacking'). Petrissage ('kneading') had little effect[9].

When massage is applied to one limb, blood flow increases in the other[10]. This provides a useful way to promote muscle performance and healing in injured tissue that is too sensitive for direct massage. These referred effects are exploited extensively by techniques such as connective tissue manipulation (CTM), a specialized type of massage used extensively to increase blood flow to deeply seated organs. Here, skin over the thoracic and lumbar spine is vigorously stimulated manually, triggering cutaneovisceral reflexes[11–13], that cause vasodilation. Experimental observations support the hypothesis that CTM mainly affects sympathetic autonomic activity[14] and can have physiological effects that are independent of any change in blood flow. Less invasive conventional massage provokes a milder response but probably acts in a similar way.

Massage appears to be better for improving blood flow than other techniques routinely used for the purpose. Tracer experiments have shown that effleurage, one of the least penetrating massage techniques, significantly increased blood flow while shortwave diathermy and therapeutic ultrasound caused little change. Once effleurage ceased, blood flow slowed markedly and returned to normal after 2 min[15]. Patients with flaccid paralysis of a limb responded in the same way, indicating that this effect is not entirely dependent upon spinal reflexes[16,17].

Venous blood flow

Deep massage promotes venous return and will increase cardiac stroke volume[2]. The few attempts to

Address for correspondence: Dr G. C. Goats, School of Occupational Therapy and Physiotherapy, University of East Anglia, Norwich NR4 7TJ, UK

0306-3674/94/030153-04

measure this effect concern external pneumatic compression. An optimum regime expelling 80 ml blood per minute from the veins of the lower leg required a maximal pressure of 40 mmHg, rising at a rate of 8 mmHg s^{-1}, with an interval of 1 min between each cycle[18]. Firm manual massage may reasonably be expected to cause similar venous flow.

Blood clotting

Thrombosis frequently results from poor venous return and can be prevented by massage. Patients confined to bed are particularly at risk from venous stasis. Massage given unilaterally decreased the incidence of deep venous thrombosis (DVT) in the treated limb by 82% compared with that in the untreated leg[19]. These authors conclude that the observations are simply a result of improved blood flow, but a 20-min whole body massage also decreases both blood viscosity and haematocrit, indicating haemodilution[20].

The anticoagulant effects of massage are not, however, mediated entirely by mechanical processes because compression therapy appears to increase the concentration of fibrinolytic compounds in the blood[21]. This explains why an arm massage can reduce the incidence of DVT in the legs[22].

Blood enzyme concentrations

Deep massage causes sufficient muscle damage to elevate the serum concentrations of myoglobin[23] and the enzymes glutamic oxaloacetic transaminase, creatine kinase and lactate dehydrogenase. Manual therapy may therefore confound diagnoses or biochemical measures of performance based upon the concentration of these substances[24].

Oedema

Massage reduces swelling very effectively and is used widely for this purpose in sports therapy. The mechanism is uncomplicated. When a superficial valve-bearing vein or blind-ended lymph channel is compressed, fluid can only drain towards the heart[25,26]. Interstitial fluid can then enter the vessel more easily. Arteriolar congestion reduces further as the tissue fluid pressure is relieved and thus perfusion improves[1,2]. Some researchers believe that improved drainage restores the normal osmotic pressure of interstitial fluid and this effect is claimed to be more important to the healing process than any direct effect upon blood flow[17].

The effect of massage upon lymph flow has been measured experimentally. Elkins and associates[27] exposed the hindquarters of dogs to infrared radiation, shortwave or microwave diathermy, active or passive exercise, or massage for 30 min. Lymph flow only increased with kneading and stroking massage, and active or passive exercise. All the other treatments, including hacking, had no effect. Other studies[28] comparing massage, passive movement and electrical muscle stimulation again showed lymph flow to be greatest following massage. Some physiotherapists practise a specialized technique known as 'manual lymphatic drainage' designed specifically to improve flow within the lymphatic system.

Manufacturers of pneumatic compression equipment have supported much of the research that has improved our understanding of the effects of massage. Compression therapy, applied for 3 h daily, reduced generalized swelling of the lower limb and rapidly converted non-pitting swelling into the less troublesome pitting oedema. This consistent beneficial effect, of use in sports medicine for the treatment of chronic swelling, occurred if oedema was due to locally impaired drainage, cardiac failure or nephrotic syndrome[29]. Furthermore, the skin quality at sites of severe trauma became loose, comfortable and in good condition after only 7–10 days. Intermittent compression therapy and massage also greatly reduced postsurgical swelling and pain[30] when applied to surgical incisions and enhanced both rate and quality of healing[31]. Massage appears particularly effective for treating hand injuries[32].

Sports therapists should bear in mind that gentle active exercise remains the most effective means for improving tissue drainage. Massage remains valuable when treating athletes immobilized by injury.

Connective tissue

Most sports therapists acknowledge that preliminary 'warming up' exercises are a necessary preparation for safe athletic activity. Unfortunately, many sports people still prepare inadequately for exercise and risk connective tissue damage. Many 'warm-up' regimes include massage but few have been evaluated. One comparative study weighed the efficacy of a standard athletic warm-up programme against massage or stretching exercises. Stretching exercises produced the greatest flexibility in connective tissue around joints, although massage had a significant beneficial effect. The 'warm-up' exercises were least effective[33].

Friction massage is another powerful technique used to maintain or improve the mobility of ligaments, tendons and muscle; and prevent adherent scars forming[34]. Friction massage was pioneered by Cyriax, the father of modern manipulation technique, and deliberately causes limited tissue damage, hyperaemia and mild inflammation[35]. During the subsequent phase of accelerated healing, collagen fibrils are encouraged to realign in patterns better adapted to function by careful positioning and exercise[35–37]. Deep frictions used to treat athletes suffering from overuse injuries to the knee proved more effective for reducing pain than a conventional treatment regime of rest, ice, stretching exercises and ultrasound[38]. Manipulation combined with massage is an effective treatment for frozen shoulder[39].

Muscle

Muscle spasm is extremely uncomfortable, being both the product and the cause of pain. Massage reduces discomfort, relieves the associated muscle spasm and permits improved function[40]. Postexercise effleurage reduces subsequent muscle soreness by rapidly reducing the concentration of lactate in the muscle cells. This is a more effective treatment than

either rest or a conventional active warm-down programme[41]. Percussive massage, once advocated as part of postexercise therapy, fails to influence the rate at which muscle recovers from fatigue[42] and is unlikely to assist the athlete.

Massage can also be used to prevent denervated muscle from losing both bulk and contractile capability, thus assisting subsequent rehabilitation. Denervated cat muscle treated with effleurage and petrissage for 10 min daily for a month showed a slight weight loss but retained an almost unimpaired ability to generate force[43]. These results appear significantly better than those seen for conventional electrical stimulation. Although the evidence is somewhat contradictory[44], therapists faced with rehabilitating a nerve-injured athlete should consider the potential benefits of massage.

The nervous system

Pain

Massage has traditionally been used to relieve pain[45] although research has only recently provided an acceptable physiological explanation of this observation.

Massage produces short-lived analgesia by activating the 'pain gate' mechanism[46]. Cutaneous mechanoreceptors are stimulated by touch and transmit information within large nerve fibres to the spinal cord. These impulses block the passage of painful stimuli entering the same spinal segment along small, slowly conducting neurons[47, 48]. The many physical therapies acting upon this mechanism include thermal and electrical treatments[49], CTM[13] and joint manipulation[35, 50]. Massage is a potent mechanical stimulus and a particularly effective trigger for the pain gate process.

Longer lasting pain control appears to be mediated in large part by the 'descending pain suppression mechanism'[51, 52]. Unpleasant cutaneous sensations stimulate nuclei within the midbrain. These nuclei in turn initiate activity in the descending spinal tracts that release endogenous opiates (inhibitory neurotransmitters) within the spinal segment receiving the painful input. This diminishes the intensity of pain transmitted to the higher centres. Vigorous manipulation and massage can reinforce a naturally occurring discomfort, cause much greater release of opiates and achieve more profound pain suppression. CTM results in a moderate release of β-endorphin lasting for about 1 h[53]. Clearly the many other treatments that cause discomfort, including vigorous conventional massage, transverse frictions[34] and certain percussive techniques, will act in similar manner.

Relaxation

Manual therapy is a well documented aid to relaxation. Massage has long been used to relax the sick or prepare those about to undertake some demanding physical task and most people know of the pleasurable relaxation that follows a gentle massage. Physical relaxation, whether induced for enjoyment or the treatment of pain, can improve blood flow, reduce muscle tone and tension in connective tissue, and thus accelerate physical repair[54, 55]. Relaxation will also increase individual tolerance to further, less comfortable, therapy or athletic trial[56, 57].

Summary

Massage is an ancient therapy enjoying renewed interest, particularly in sports medicine. The techniques remain an art but research continues to clarify physiological mechanisms that underpin the various therapeutic effects. Massage is indicated in sports therapy when inflammation fails to resolve or healing is delayed, and when tissue drainage or perfusion appear inadequate. Shortened or adhered connective tissue can be mobilized and elongated. Massage will help to reduce pain, restore normal muscle activity and thus re-establish normal function. The close physical contact that massage requires between therapist and client facilitates accurate assessment of dysfunction. This is responsible, in part, for the therapeutic success of these techniques.

The contraindications to massage are few and primarily designed to prevent a precipitate drop in blood pressure or the spread of some harmful factor in the body fluids.

A safe, low-technology therapy, massage is a valuable treatment option poised to grow once again in importance as the scientific principles upon which it is founded are clarified.

References

1 Scull CW. Massage – Physiologic Basis. *Archives of Physical Medicine* 1945; **26**: 159–67.
2 Wakim KG. Physiologic effects of massage. In: Licht S. ed. *Massage, Manipulation and Traction.* Huntington, New York, USA: R.E. Krieger, 1976: Chapter 2.
3 Wilkins RW, Halperin MH, Litter J. The effects of various physical procedures on circulation in human limbs. *Ann Intern Med* 1950; **33**: 1232–45.
4 Pemberton R. Physiology of massage. In: Council of Physical Medicine. *Handbook Of Physical Medicine.* 4th ed. Chicago, Illinois, USA: American Medical Association, 1945.
5 Carrier EB. Studies on the physiology of capillaries. V. The reaction of the human skin capillaries to drugs and other stimuli. *Am J Physiol* 1922; **61**: 528–47.
6 Leroy MR. La vie du tissu conjonctif et sa defense par le massage. *Revue Medicale De Paris.* 1941; **58**: 212.
7 Severini V, Venerando A. Effect on the peripheral circulation of substances producing hyperaemia in combination with massage. *Europa Medicophysica* 1967; **3**: 184–98.
8 Graham D. *Massage, Manual Treatment, Remedial Movements. History, Mode of Application and Effects, Indications and Contraindications.* Philadelphia, Pennsylvania, USA: J.B. Lippincott 1913.
9 Hovind H, Nielsen SL. Effect of massage on blood flow in skeletal muscle. *Scand J Rehabil Med 1974;* **6**: 74–7.
10 Severini V, Venerando A. The physiological effects of massage on the cardiovascular system. *Europa Medicophysica* 1967; **3**: 165–83.
11 Ebner M. *Connective Tissue Manipulation: Theory and Therapeutic Application,* 3rd ed. Malabar, Florida, USA: R.E. Krieger, 1975.
12 Gifford J, Gifford L. Connective tissue massage. In: Wells PE, Frampton V, Bowsher D, ed. *Pain: Management and Control in Physiotherapy.* London, UK: Heinemann Medical, 1988: Chapter 14.
13 Goats GC, Keir K. Connective tissue massage. *Br J Sports Med* 1991; **25**: 131–3.

14 Barr JS, Taslitz N. The influence of back massage on autonomic functions. *Phys Ther* 1970; **50**: 1679–91.
15 Hansen TI, Kristensen JH. Effect of massage, shortwave diathermy and ultrasound upon ^{133}Xe disappearance rate from muscle and subcutaneous tissue in the human calf. *Scand J Rehabil Med* 1973; **5**: 179–82.
16 Wakim KG, Martin GM, Terrier JC, Elkins EC, Krusen FH. The effects of massage on the circulation in normal and paralysed extremities. *Archives of Physical Medicine* 1949; **30**: 135–44.
17 Wakim KG, Martin GM, Krusen FH. Influence of centripetal rhythmic compression on localized edema of an extremity. *Archives of Physical Medicine* 1955; **36**: 98–103.
18 Cotton LT, Roberts VC. The prevention of deep vein thrombosis, with particular reference to mechanical methods of prevention. *Surgery* 1977; **81**: 228–35.
19 Sabri S, Roberts VC, Cotton LT. Prevention of early deep vein thrombosis by intermittent compression of the leg during surgery. *BMJ* 1971; **4**: 394.
20 Ernst E, Matrai A, Magyarosy I, Liebermeister RGA, Eck M, Breu MC. Massages cause changes in blood fluidity. *Physiotherapy* 1987; **73**: 43–5.
21 Allenby F, Boardman L, Pflug JJ, Calnan JS. Effects of external pneumatic intermittent compression on fibrinolysis in man. *Lancet* 1973; **ii**: 1412–14.
22 Knight MTN, Dawson R. Effect of intermittent compression of the arms on deep venous thrombosis in the legs. *Lancet* 1976; **ii**: 1265–7.
23 Danneskiold-Samsoe B, Christiansen E, Lund B. Regional muscle tension and pain (fibrositis): effect of massage on myoglobin in plasma. *Scan J Rehabil Med* 1983; **15**: 17–20.
24 Bork K, Korting GW, Faust G. Serum enzyme levels after whole body massage. *Arch Dermatol Forsch* 1971; **240**: 342–8.
25 Starling EH. The influence of mechanical factors on lymph production. *J Physiol* 1894; **16**: 224–67.
26 Yoffey JM, Courtice FC. *Lymphatics, Lymph and Lymphoid Tissue: Their Physiological and Clinical Significance*. 2nd ed. London, UK: Arnold, 1956.
27 Elkins EC, Herrick JF, Grindlay JH, Mann FC, De Forest RE. Effect of various procedures on the flow of lymph. *Archives of Physical Medicine* 1953; **34**: 31–9.
28 Ladd MP, Kottke FJ, Blanchard RS. Studies of the effect of massage on the flow of lymph from the foreleg of the dog. *Archives of Physical Medicine* 1952; **33**: 604–12.
29 Pflug JJ. Intermittent compression in the management of swollen legs in general practice. *The Practitioner* 1975; **215**: 69–76.
30 Pflug JJ. Intermittent compression: a new principle in treatment of wounds. *Lancet* 1974; **ii**: 355–6.
31 Melrose DG, Knight MTN, Simandl E. The stripping of varicose veins: a clinical trial of intermittent compression dressings. *Br J Surg* 1979; **66**: 53–5.
32 Flowers KR. String wrapping versus massage for reducing digital volume. *Phys Ther* 1988; **68**: 57–9.
33 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.
34 Chamberlain GJ. Cyriax's friction massage: a review. *The Journal of Orthopaedic and Sports Physical Therapy* 1982; **4**: 16–22.
35 Cyriax J. *Textbook of Orthopaedic Medicine. Treatment by Manipulation, Massage and Traction*. 11th ed. London, UK: Baillière Tindall, 1984.
36 Glick JM. Muscle strains: prevention and treatment. *Physician and Sportsmedicine* 1980; **8**: 73–7.
37 Stearns ML. Studies of the development of connective tissue in transparent chambers in the rabbit ear: 2. *American Journal of Anatomy* 1940; **67**: 55–97.
38 Schwellnus MP, Mackintosh L, Mee J. Deep transverse frictions in the treatment of iliotibial band friction syndrome in athletes: a clinical trial. *Physiotherapy* 1992; **78**: 564–8.
39 Zumo L. 235 cases of frozen shoulder treated by manipulation and massage. *J Trad Chin Med* 1984; **4**: 213–15.
40 Nordschow M, Bierman W. Influence of manual massage on muscle relaxation: effect on trunk flexion. *Phys Ther* 1962; **42**: 653.
41 Bale P, James H. Massage, warm-down and rest as recuperative measures after short term intense exercise. *Physiotherapy in Sport* 1991; **13**: 4–7.
42 Cafarelli E, Sim J, Carolan B, Leibesman J. Vibratory massage and short-term recovery from muscular fatigue. *Int J Sports Med* 1990; **11**: 474–8.
43 Suskind MI, Hajek NA, Hines HM. Effects of massage on denervated skeletal muscle. *Archives of Physical Medicine* 1946; **27**: 133–5.
44 Wood EC, Kosman AJ, Osborne SL. Effects of massage in delaying atrophy in denervated skeletal muscle of the dog. *Physical Therapy Review* 1948; **28**: 284–5.
45 Jacobs M. Massage for the relief of pain: anatomical and physiological considerations. *Physical Therapy Review* 1960; **40**: 93–8.
46 Bowsher D. Modulation of nociceptive input. In: Wells PE, Frampton V, Bowsher D, eds. *Pain: Management and Control in Physiotherapy*. London, UK: Heinemann Medical, 1988: Chapter 13.
47 Melzack R, Wall PD. Pain mechanisms: a new theory. *Science* 1965; **150**: 971–9.
48 Watson J. Pain mechanisms: a review. 1. Characteristics of the peripheral receptors. *Australian Journal of Physiotherapy* 1981; **27**: 135–43.
49 Goats GC. Interferential current therapy. *Br J Sports Med* 1990; **24**: 87–92.
50 Grieve GP. *Common Vertebral Joint Problems*. Edinburgh, Scotland: Churchill Livingstone, 1981.
51 Basbaum A, Fields H. Endogenous pain control mechanisms: review and hypothesis. *Ann Neurol* 1978; **4**: 451–2.
52 Watson J. Pain mechanisms: a review. 3. Endogenous pain mechanisms. *Australian Journal of Physiotherapy* 1982; **27**: 135–43.
53 Kaada B, Torsteinbo O. Increase of plasma β-endorphins in connective tissue massage. *Gen Pharmacol* 1989; **20**: 487–9.
54 Longworth JCD. Psychophysiological effects of slow stroke back massage in normotensive females. *Advances in Nursing Science* 1982; **July**: 44–61.
55 Valentine KE. Massage in psychological medicine – modern use of an ancient art. *New Zealand Journal of Physiotherapy* 1984; **12**: 15–16.
56 Kamenetz HL. History of massage. In: Licht S, ed. *Massage, Manipulation and Traction*. Huntington, New York, USA: R.E. Krieger, 1976: Chapter 1.
57 Simpson J. Massage. Positive strokes in palliative care. *New Zealand Nursing Journal* 1991; **July**: 15–17.