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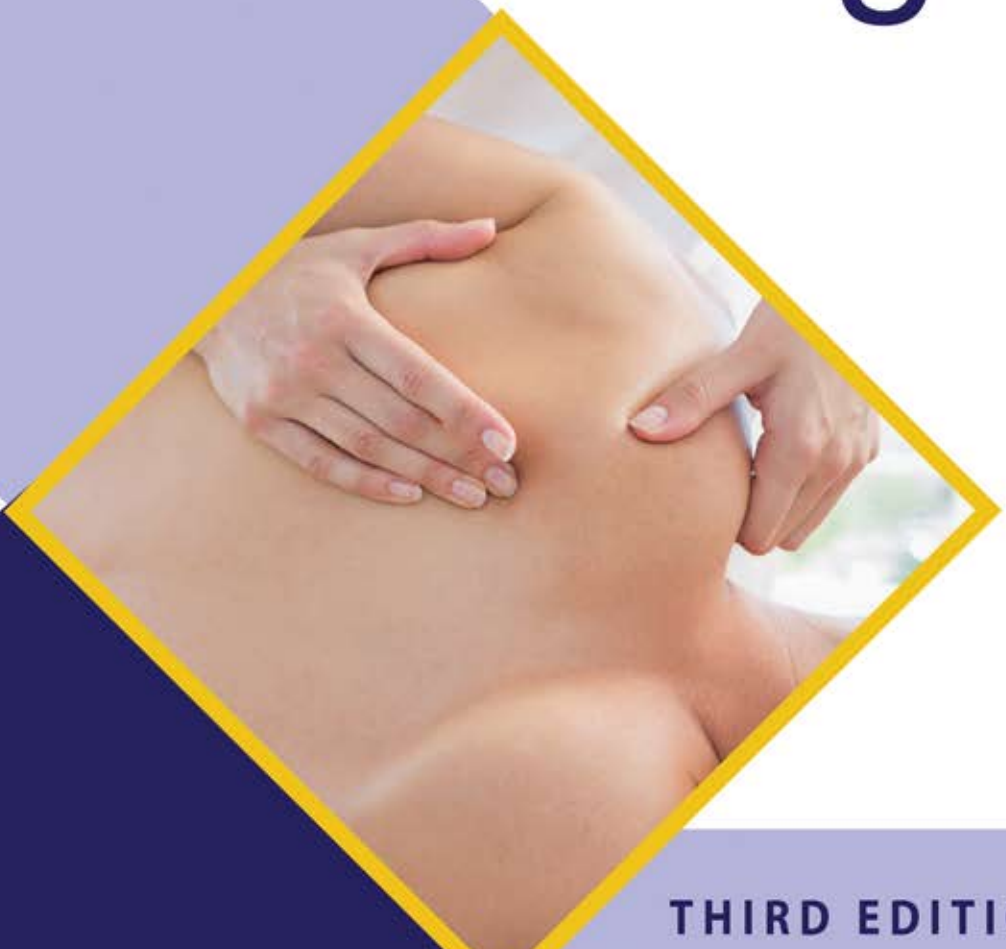
Principles & Practice of Therapeutic Massage



THIRD EDITION

Akhoury Gourang Sinha

Foreword
Bharati Bellare

JAYPEE

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CHAPTER 2

Physiological Effects

As a therapeutic modality, massage is being used for the relief of pain, swelling, muscle sprain, restricted movement, tension and anxiety associated with a large number of disorders, and afflicting muscular, nervous, cardiorespiratory and other systems.

The therapeutic value of massage lies in its numerous and combined physiological effects. The effect of massage of the body is very much technique dependent. Massage, be it manual or mechanical, imparts pressure and stimulates mechanically the various tissue approached at the time of application of a particular technique. It is the magnitude, duration, and the direction of force applied during a particular technique that determines the effects produced by that technique on the body.

Various authors have described the effects of massage in various ways. Hollis (1987) classified the effects of massage into two groups—mechanical and physiological, whereas Lehn and Prentice (1994) talked about reflex and mechanical effects of massage. However, during massage treatment, the effects produced are the combination of various mechanical, physiological, reflex, and psychological consequences of massage and in one way or the other are pronounced on some tissue system of the body. Thus, it is much rational to study the effects of this modality in reference to a specific system. This chapter discusses the effects of massage on the body as a whole. The effects associated with specific individual techniques are listed in Chapter 5, which presents a complete discussion on the individual techniques.

This chapter presents physiological effects of this modality on different systems of the body. The effect of massage on respiratory system is the specific effect of percussion and vibration, though they are included in this chapter in order to complete the discussion.

The physiological effects of massage can be discussed under the following headings:

- Effects on the circulatory system:
  - On the venous and the lymphatic flow
  - On the arterial flow.
- Effects on blood
- Effects on the exchange of nutritive elements
- Effects on metabolism
- Effects on the nervous system:
  - On sensory nervous system
  - On motor nervous system
  - On autonomic nervous system.
- Effects on the mobility of the soft tissue
- Effects on the respiratory system
- Effects on the skin

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- Effects on the adipose tissue
- Psychological effects
- Effects on immune system.

EFFECTS OF MASSAGE ON THE CIRCULATORY SYSTEM

On the Venous and the Lymphatic Flow

Massage aids in the mechanical emptying of the veins and the lymphatics. It facilitates the forward movement of the venous blood and the lymph and thereby reduces the chance of stagnation of the blood and the lymph in the tissue space.

The flow of the venous and the lymphatic channels from the extremities mainly depends on the activity of the smooth muscles present in the walls of the vessels. The contraction of these small muscles in conjunction with the valves present in the vessels acts as a strong pumping mechanism which keeps the tissue space clear from the free fluid. Other factors, such as the skeletal muscle pump, thoracic pump (i.e., aspiration of the lymph into the thorax during the inspiration), arterial pulsation adjacent to the lymphatics, and the force of gravity have a minor role in the normal circumstances but under the conditions where the normal lymph mechanism does not function properly, these factors become more important.

The contraction of the skeletal muscles compresses the blood vessels and exerts a pressure on the fluid present inside. This increase in intravascular pressure, which stimulates the contraction of the smooth muscles present in the wall of the vessels. Contraction of smooth muscles further increases the pressure inside the vessels. When this pressure increases beyond the threshold, the valves open up and the fluid moves onto the next segments. As the valves provide only unidirectional flow, the fluid cannot come back to the empty segment. When the muscles relax, the segment is refilled by the fluid from the distal segments. This way the venous and the lymphatic fluids are allowed to move only in one direction.

The mechanical action of massage resembles with that of normal muscular contraction. The different techniques of massage alternately compress and release the soft tissue. This facilitates the venous and lymphatic flow. The effleurage, kneading, and petrissage squeeze the veins and the lymphatic vessels and force the venous blood and the lymph toward the heart, causing an increased drainage of the blood and lymph from the massaged part/segment.

In case of fluid stagnation due to mechanical factors, the flow of venous and lymphatic fluid is obstructed. Massage facilitates the drainage, and reduces the stagnation of fluids and also speeds up the removal of waste products. According to Paikov (1986), the body contains 1,200–1,500 mL of lymph moving at the speed of 4 mm/sec and massage increases the speed to eight-folds.

On the Arterial Flow

Massage improves the blood supply of the area being massaged. A definite vasodilation along with an increase in the peripheral blood flow is usually observed after massage. This moderate, consistent, and definite increase in the arterial flow may be attributed to the following events happening during massage:

- Release of vasodilators
- Activation of axon reflex
- Decrease of venous congestion.

Release of Vasodilators

Massage acts as a succession of mild traumatization. It provokes and brings about the release of histamine and other substances by the stimulation of mast cells. This liberation of histamine

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plays an important role in the vasodilation produced during massage (Hollis, 1987). These substances increase the arterial diameter and are partially responsible for the axon reflex. The patent capillaries open up under the influence of these chemicals and bring about an increase in the blood flow to the part massaged.

Activation of Axon Reflex

Massage activates the axon reflex which produces cutaneous vasodilation. When an area of the skin is firmly stroked, the sensory nerve ending is stimulated. The impulse is carried to the spinal cord by the peripheral nerves. In the way itself, a branch of the nerves may be stimulated and instead of going to the spinal cord, impulses return back to the periphery to produce its effects on the cutaneous vessels which are supplied by the branch of the same peripheral nerve **(Fig. 2.1)**. The effect is the relaxation of the smooth muscles of the arterial wall and the vasodilation (Chatterjee, 1985).

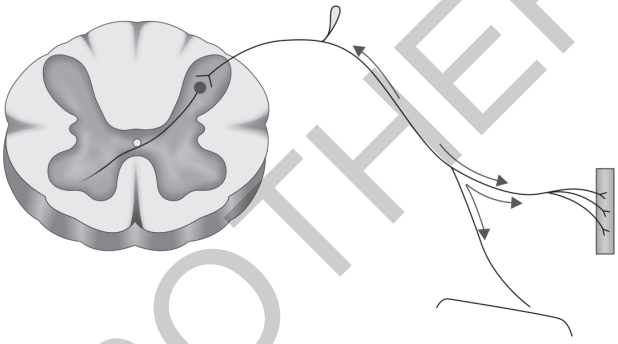

Fig. 2.1: Axon reflex.

So, the reflex arc of the axon reflex is completed by the two branches of the same sensory fibers. Through one branch, the impulse is received and through the other, it is transmitted back of the peripheral vessels causing vasodilation. This type of impulse is known as antidromic impulse. In fact, axon reflex is the only reflex that does not involve the central nervous system (CNS) (Choudhary, 1993).

Decrease of Venous Congestion

If any portion of the vessel is dilated, then the neighboring vessels also become constricted (axon reflex) (Chatterjee, 1985). The arterioles become compressed if the venous congestion is increased. The congested venous and lymphatic fluid exerts a compressive force on the arterioles. The lumen of the arterioles becomes narrow and so the blood supply to the part is reduced. It is a physiological process which the body adopts in order to relieve the congestion. As a result of this, the outflow from the veins exceeds the inflow to the constricted arterioles and the congestion is reduced.

Massage promotes the forward movement of lymph and blood and indirectly helps in restoring the arterial flow.

Research on the Circulatory Effects of Massage

Wolfson (1931) examined the effect of deep kneading massage on the venous blood on an animal model (dog). The venous blood flow was measured by anesthetizing the dog and by cannulation of the femoral vein. He found that massage caused a great initial increase with a fairly rapid decrease in the flow of blood to a rate less than normal. Immediately following massage, blood flow is slowly returned to normal. He concluded that the decrease in the blood flow is due to a more complete emptying of venous blood for a short period of time. Wakim (1949) used plethysmography technique to measure the flow of blood, and observed that deep stroking and kneading produced a consistent increase in the flow of blood of extremities in the subjects with flaccid paralysis. No such increase was found in the normal subjects, patients of rheumatoid arthritis, and subjects with spastic paralysis.

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With the advent of new techniques of measuring the blood flow, several studies have been carried out to determine the efficacy of massage on the blood flow. The results of these reports are at best conflicting at the moment.

Dubrovsky (1982) and Hensen and Kristensen (1973) used radioisotope of Xe^{133} to determine the flow of blood, reported an increased clearance rate of Xe^{133} after massage, and attributed it to the increase in the blood flow. However, Hovind and Nielsen (1974) founded that no net increase in the blood flow though the increase clearance rate of Xe^{133} was observed in their study which they attributed to the mechanical emptying and refilling of vascular bed.

Bell (1964) conducted plethysmographic studies and reported that the rate of blood flow was doubled during massage, which lasted for about 40 minutes after the termination of massage. Sereveni and Venerando (1967) even reported an increased blood flow in the nontreated homologous limb in response to deep massage in adults.

Recent studies with ultrasound Dopplerography, however, do not support the notion that massage leads to increase in the blood flow. Harichaux and Viel (1987) noted that slower massage was more beneficial for venous return than massage repeated at high frequency. Though the studies performed by Ek et al. (1985), Linde (1986), Shoemaker et al. (1997), and Tiidus and Shoemaker (1995) could not demonstrate any increase in blood flow of muscle and skin following massage. However, Ek et al. (1985) noted the individual and sexual variation in the effect of massage and reported that woman, more than men, increased their skin blood flow bilaterally after massage.

Hinds et al. (2004) compared the effects of massage against a resting control condition upon femoral artery blood flow, skin blood flow, and skin and muscle temperature after dynamic quadriceps exercise. Thirteen male volunteers were participated in 3 × 2 minutes bouts of concentric quadriceps exercise followed by 2 × 6 minutes bouts of deep effleurage and petrissage massage or a control (rest) period of similar duration in a counterbalanced fashion. Blood flow and temperature, blood lactate concentration, heart rate, and blood pressure were taken at baseline, immediately after exercise, as well as at the midpoint and end of the massage/rest periods. They observed that massage to the quadriceps did not significantly elevate femoral artery blood flow, but the skin blood flow and temperature were found elevated which was not accompanied by any significant deviation of other parameters as compared to the resting control. Similar increase in the skin blood flow confined to the local massaged area has also been reported by Mori et al. (2004).

In an elegant study, Wiltshire et al. (2010) reported that contrary to common believe, massage impairs postexercise muscle blood flow and impairs the lactate removal. Using Doppler and echo ultrasound of the brachial artery, they measured forearm blood flow (FBF) every minute for 10 minutes and after 2 minutes of strenuous isometric handgrip exercise under three conditions: Passive rest, active recovery (rhythmic exercise at 10% maximum voluntary contraction), and massage. Massage maneuvers consisted of firm effleurage for the first and the last 2.5 minute intervals with petrissage during the 5 minute period in between. They reported that during passive rest, pulsatile flow of brachial artery was uninterrupted, whereas during active recovery and massage, rhythmic retrograde brachial artery blood velocity (negative velocity) was observed which was consistent with compression produced by muscle contraction and passive compression of massage strokes. With petrissage and effleurage, consistent retrograde flow with each massage stroke was followed by increase in blood flow velocity during brief pauses. They concluded that massage results in severe impairment to blood flow during the massage stroke, and this impairment has a net effect of decreasing muscle blood flow early in the recovery period after strenuous exercise. They also reported a reduced lactic acid efflux during massage which they viewed as a direct consequence of impairment to blood flow.

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On the other hand, Franklin et al. (2014) reported that lower extremity massage enhances brachial artery flow-mediated dilation (FMD) both in presence and in absence of exercise-induced muscle injury to lower limb. 30 minutes massage was performed on the bilateral lower extremity muscle groups using Swedish massage techniques of superficial stroking, effleurage, and petrissage varying in depth from superficial to deep. Brachial artery FMD and flow were measured at 90 minutes, 24 hours, 48 hours, and 72 hours after the intervention. They reported that 90 minutes after the intervention, FMD increased from baseline and remaining elevated until 72 hours.

Definitely, more well-controlled and defined studies are required before we approve or disapprove the circulatory effects of massage. For the time being, clinical as well as experimental result in terms of decrease in edema and increased muscle clearance rate following massage are beyond doubt (Kresge, 1988). Though much needs to be done to pinpoint whether these are due to increased blood flow, increased lymphatic drainage, or due to more complete emptying and refilling of the vessels.

EFFECTS ON BLOOD

Few studies are available on the effect of massage on the blood cells. Wood and Becker (1981) quoted Mitchell to state that RBC count increased after massage both in health and in anemia. Schneider and Havens (1915) also reported an increase in red blood cells and hemoglobin count following abdominal massage. This increase in RBC and hemoglobin count may increase the oxygen carrying capacity of blood.

Increase in the platelets count after massage has been reported in an animal model (Lucia and Rickards, 1933). They performed massage on the ear of 5 rabbits in gentle, but firm manner for 5 minutes. The ear was then punctured and the first drop of blood was studied. They found an increase in the blood platelets count of the massaged ear, but found no change on the opposite unmassaged ear.

Smith et al. (1994) have demonstrated an increase in the neutrophil count following 30 minutes of massage performed 2 hours after intense exercise. However, Viitasalo et al. (1995) found no effects of 20 minutes underwater water-jet massage, after exercises, on the circulating lymphocytes, neutrophils, or monocytes.

Hilbert et al. (2003) also did not observe any change in the neutrophil count following 20 minutes of massage. Though of late, a number of studies have reported alteration in the leukocyte counts following massage in patients afflicted with AIDS and cancer patients (Hernandez-Reif et al., 2005; Zeitlin et al., 2000).

No satisfactory explanation is available in the literature as to why these changes occur after massage. According to Kresge (1989), massage raises the RBC count by mobilizing stagnant blood cells in the splanchnic circulation rather than by increased production. Malone (1990) is of opinion that secondary to mechanical stimulation, the body reacts by increasing the cellular component in the blood. Smith et al. (1994) have postulated that increase in neutrophil count may have the potential to retard the inflammatory changes associated with strenuous exercises which may be of some use in the management of delayed-onset muscle soreness.

Studies have also reported beneficial effects of massage on inflammatory markers. Crane et al. (2012) in a novel study reported that massage attenuated the production of the inflammatory cytokines like tumor necrosis factor-a (TNF-a) and interleukin-6 (IL-6) and reduced heat shock protein 27 (HSP27) phosphorylation, though it had no effect on muscle metabolites (glycogen, lactate). Further, they observed that massage activated the mechanotransduction signaling pathways, such as focal adhesion kinase (FAK) and extracellular signal-regulated kinase 1/2 (ERK1/2), potentiated mitochondrial biogenesis signaling [nuclear peroxisome proliferator-

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activated receptor-gamma coactivator 1alpha (PGC-1α)], and mitigated the rise in nuclear factor-kappa beta p65 (NF-kB p65) nuclear accumulation caused by exercise-induced muscle trauma. These observations made them to conclude that massage therapy appears to be clinically beneficial by reducing inflammation and promoting mitochondrial biogenesis. Objective of this study was to assess the influence of massage within muscle that had performed a bout of intense exercise. The acute aerobic cycling exercise (where subject after completing 30 minutes at 60% of their predetermined VO_2 peak, intermittently increased the speed to reach 85% VO_2 peak, and continued till exhaustion) in unconditioned individuals (eleven healthy, recreationally active males) was used to cause contraction-induced muscle damage. Immediately after exercise, subjects were allowed to recover for 10 minutes while massage oil was lightly applied to both quadriceps. Thereafter, a single leg was randomized to receive massage treatment for 10 minutes from a registered massage therapist. The massage treatment was composed of effleurage, petrissage, and slow muscle to knee extensor muscles. The muscle biopsies were obtained at rest, immediately after administration of massage and after a 2.5 hours period of recovery and targeted real-time reverse transcription-polymerase chain reaction (RT-PCR), protein signaling analysis, and metabolite quantification were performed to characterize the processes within skeletal muscle that are influenced by massage.

Rapaport et al. (2010) reported that a single session of Swedish massage of 45 minutes duration increased the number of circulating lymphocytes, CD25P lymphocytes, CD56P lymphocytes, CD4P lymphocytes, and CD8P lymphocytes. The same research group in a subsequent publication (Rapaport et al., 2012) observed that twice-weekly massage was associated with increased production of proinflammatory cytokines.

More studies with proper design and statistical analysis are required to explore the effect of massage on blood cells in both healthy and diseased subjects.

EFFECTS ON THE EXCHANGE OF METABOLITES

Massage promotes rapid disposal of waste products and the replenishment of the nutritive elements. Massage also increases the movement of liquids and gases in the body (Hollis, 1987). The increased arterial blood flow following massage brings more oxygen and nutritive elements and also causes more rapid oxygenation of the blood. Massage speeds up the lymphatic and venous flow which promotes rapid disposal of the waste products of metabolism. These changes make the exchange of waste products between the blood and the tissue at cellular level more efficiently. This may overall improve the trophic condition of the part being massaged. However, Gupta et al. (1996) did not find any difference in the rate of lactate removal between massage-assisted recovery and simple passive recovery from a supramaximal exercise bout in 10 male athletes. Their subject received 10 minutes of massage consisting of kneading and stroking of upper and lower limbs. They concluded that short-term massage is ineffective in enhancing lactate removal following supramaximal exercise.

Detailed discussion on the effect of massage on lactate removal is presented in the Chapter 10.

EFFECTS ON METABOLISM

Traditionally, massage has been applied for the purpose of promoting the general status of well-being. By virtue of increasing arterial blood flow and venous lymphatic drainage, theoretically massage may accelerate the various metabolic processes of the body. However, very little research has been done in this area with conflicting reports. Some 70 years ago, Cuthbertson (1933) in a review article summarized the various studies and reported an increase in the output of urine, increase rate of excretion of nitrogen, inorganic phosphorus, and sodium chloride

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following massage. He reported no effect either on the acid-base balance of the blood, or on the basal consumption of O_2.

Recently, Boone and Cooper (1995), while investigating the effect of massage on oxygen consumption at rest on 10 healthy adult males, also observed no significant change in O_2 consumption, heart rate, stroke volume, cardiac output, and a-VO_2 during the massage.

Zelikovski (1993) using a pneumatic sequential device found no difference in the blood level of lactate, pyruvate, ammonia, bicarbonate, and pH before and after massage. However, Flore et al. (1998) reported a slight increase in maximum O_2 consumption after a special massage protocol called biokingeriga (BK).

Danneskiold et al. (1983) stated that massage performed in the area of regional muscle tension and pain increased muscle myoglobin and this increase is proportional to the degree of muscle tension. They suggested that this could be related to the loss of oxidative metabolic capacity within the muscle. The increase in serum myoglobin was also reported by Viitasalo et al. (1995). However, Rodenburg et al. (1994) could not find any change in the myoglobin concentration in the blood of the subjects who received massage after an extensive eccentric exercise program, although they have found a significant change in the creatine kinase (CK) activity in the blood.

Smith et al. (1994) also reported a significant decrease in the rise of plasma creatine in massaged subject compared to the control group.

Reduction of blood CK concentration is considered as a marker for reduction in muscle damage and a faster recovery after exercise (Clarkson and Hubal, 2002; Sorichter et al., 2007; Bishop et al., 2008). Of late, several studies (Bakar et al., 2015; Kargarfard et al., 2016; Zainuddin et al., 2005) have reported a significant reduction in serum creatine kinase level in subjects who received massage therapy after intense exercise. Bakar et al. (2015) reported a more rapid fall of the lactate dehydrogenase (LDH), CK and myoglobin (Mb), muscular enzymes of LDH, CK, and myoglobin in participants who received manual lymph drainage massage for 30 minutes after strenuous exercise. These enzymes are the biochemical markers of muscle damage and manual lymph drainage (MLD) is a massage technique that involves the skin surface only and follows the anatomic lymphatic pathways of the body. Kargarfard et al. (2016) examined the effect of massage on the performance of bodybuilder . After five repetition sets at 75–77% of 1 RM of knee extensor and flexor muscle groups, the experimental group received 30 minutes massage, whereas the control group underwent normal passive recovery. Plasma CK level was measured over 6 time periods: Baseline, immediately after the delayed-onset muscle soreness (DOMS) inducing protocol right after the massage, and 24 hours, 48 hours, and 72 hours after the massage. They reported that massage decreased the CK level at 48 hours and 72 hours in male bodybuilders after intense exercise.

In a meta-analysis of eleven articles involving 504 participants, Guo et al. (2017) noted that the serum CK level was reduced when participants received massage intervention after intense exercise. Dupuy et al. (2018) in a meta-analysis aimed at comparing the effects of the most commonly used recovery techniques (active recovery, massage, compression garments, immersion, contrast water therapy, and cryotherapy) observed that massage was the most effective recovery technique for reducing the concentrations of circulating CK and IL-6 in the blood after exercise. However, Behringer et al. (2018) observed that CK response after 30 minutes of massage was no different than simple rest. They assessed CK along with h-FABP, neutrophil granulocytes, and the perceived muscle soreness before, immediately after, and 1 hour, 4 hours, and 24 hours after the exercise and reported that the time course of these parameters did not differ between the treatments. In this experiment, 30 minutes of manual lymphatic drainage type massage was compared with local cryotherapy and rest of same duration.

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Several studies, of late, have reported that infant massage resulted in significant reduction in bilirubin level of neonates suffering from hyperbilirubinemia and ameliorates neonatal jaundice (Chen et al., 2011; Moghadam et al., 2012; Lin et al., 2015; Basiri-Moghadam et al., 2015; Dalili et al., 2016; Eghbalian et al., 2017).

Chen et al. (2011) in a controlled clinical trial examined the effects of gentle baby massage on neonatal jaundice in 42 full-term breastfed newborns who were not receiving phototherapy. 20 infants included in the massage group received 15–20 minutes of baby massage, twice daily 1 hour after the morning mid-day feeds from day 1 to day 5 after birth. Baby massage consisted of gentle massage of face, chest, abdomen, upper and lower limbs, and back. They reported that mean stool frequency of the massaged infants on day 1 and day 2 (4.6 and 4.3) was significantly ($p < 0.05$) higher than that of the control group (3.3 and 2.6). The transcutaneous bilirubin levels on the second to fifth day and serum total bilirubin levels on fourth day were significantly decreased in the massage group (11.7 = 2.8) in comparison to control group (13.7 = 1.7).

Using the similar technique of massage, Basiri-Moghadam et al. (2015) in a study of 40 newborns (20 in each group) observed a significant difference in the number of times of defecation ($p = 0.002$) and in the level of bilirubin ($p = 0.003$) between the groups with those in the massage group having a higher number of defecations as well as a lower level of transcutaneous bilirubin. The mean difference in bilirubin between the first day and fourth day was 7.56 ± 1.36 mg/dL and 4.79 ± 1.84 mg/dL for the control and the massage groups, respectively.

Lin et al. (2015) in randomized clinical trial of 56 full-term neonates with jaundice, admitted for phototherapy at a regional teaching hospital reported that on the third day, the massage group showed significantly higher defecation frequency (4.6 ± 1.3 vs 3.9 ± 1.3) and significantly lower bilirubin levels (10.8 ± 0.9 mg/dL) compared with the control group (12.2 ± 1.8 mg/dL). Each massage therapy session started on the first day of phototherapy lasted for 15–20 minutes per session, and was conducted twice daily (between meals) for 3 consecutive days. Phototherapy was stopped for the 15–20 minutes during which neonates received massage therapy. The leg and foot were massaged first before progressing to the abdomen, hands, and finally, the back.

Dalili et al. (2016) evaluated the effects of baby massage on transcutaneous bilirubin levels and stool frequency on 50 healthy term newborns. The massage group received massage therapy for 4 days from the first day postnatal. They reported significant difference in the TCB levels between two groups with those in the massage group having lower bilirubin levels; however, they did not observe any difference in the defecation frequency between the group.

In a randomized double-blind clinical trial involving 134 patients, Eghbalian et al. (2017) concluded that massage therapy combined with phototherapy is an effective method for reducing serum total bilirubin in infants with neonatal jaundice. They reported significant differences between the groups in serum total bilirubin levels and frequency of daily bowel movements.

On the other hand, Seyyedrasooli et al. (2014) have not observed any significant reduction in skin bilirubin of massaged infant when compared with control group. However, with respect to the defecation frequency, they reported significant difference between two groups on the 4th day with the frequency of defecation in the massage group was higher. In this study, 43 healthy term infants, with 1st day bilirubin levels of less than 5 mg/dL were randomly allotted to two groups. Control group received routine care, whereas the massage group received 4 days of Vimala massage which is a combination of Indian and Swedish massages techniques. This massage is performed on term infants from head to toe and from center to periphery.

In a meta-analysis of six randomized clinical trials (RCTs) involving 357 patients, Zhang et al. (2018) reported that massage therapy can significantly reduce serum bilirubin level and transcutaneous bilirubin level.

It is proposed that massage leads to stimulation of vagus nerve and intestinal movement that contributes to increased defecation frequency resulting in expulsion of greater amounts of

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