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Massage therapy research

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Abstract

Massage therapy has been notably effective in preventing prematurity, enhancing growth of infants, increasing attentiveness, decreasing depression and aggression, alleviating motor problems, reducing pain, and enhancing immune function. This review covers massage therapy research from the last decade, as an update to the American Psychologist 1998 review paper. Models are presented for potential biochemical and physiological mechanisms underlying the massage therapy effects.

Keyword: Massage therapy

History of massage therapy research

In 400 BC, Hippocrates reputedly said that "medicine was the art of rubbing," a practice that came to be called massage therapy. Published research on massage therapy dates back to the 1930s when human and animal studies were fairly popular. Those studies typically documented increased blood flow and reduced muscle atrophy resulting from massage therapy. Although similar research questions have remained over the years, measurement technology has significantly improved. The early studies were limited by being either single cases or very small sample sizes. The samples were often comprised of self-selected, clinical patients undergoing treatment for various conditions. The researchers typically used physiological measures including heart rate, blood pressure, and temperature. Advances in technology now enable the testing of more expansive models and the exploration of underlying mechanisms.

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The lack of control groups was another methodological problem of the early studies. Without a control group, the effects of the massage could be "placebo" or attention-from-the-therapist effects. Control groups have been used more recently, but they were non-treatment control groups. Thus, the effects could still derive from attention by the therapist. Massage therapy was then compared to other therapies such as relaxation therapy. However, relaxation therapy requires work and concentration, so the relaxation participants often did not complete the therapy sessions. In addition, relaxation was often too difficult for young children because it required a certain amount of cognitive sophistication along with a reasonable attention span. Thus, we needed to use attention control conditions such as rocking the child, holding the child and playing with toys, or holding, and reading to the child. To solve that problem, sham massage (light pressure massage) groups are being used as control groups.

Moderate pressure seems to be necessary for massage therapy to be effective (Diego, Field, Sanders, & Hernandez-Reif, 2004; Field, Diego, Hernandez-Reif, Schanberg, & Kuhn, 2004c). Because of that we have been using light pressure massage therapy as a comparison group. The light pressure group receives exactly the same massage as the moderate pressure group except that lighter pressure is applied. This allows the participants to be free of any expectations regarding results of their particular treatment. The participants in each group would expect to receive some benefit from massage whether it was deep pressure (in the case of the real treatment group) or light pressure in the case of the SHAM group. This also allows "double blinding" or the possibility that the physicians who are providing the standard treatment and the massage therapists who are providing the massage therapy do not necessarily have expectations that light or moderate pressure massage is going to be more effective. In this way, the participants and the therapists are less biased about their treatment.

Selection of variables

Treatment research usually involves assessment of the immediate effects of the therapy session, and the longer-term effects are assessed at the end of the treatment period. Follow-up assessments are sometimes conducted at 1 or 2 months after the end of the therapy period. The immediate effects of therapy are usually measured by self-reports on anxiety level and mood state, and saliva samples are sometimes taken for a measure of cortisol (the most common stress hormone measured). Heart rate, blood pressure, and EEGs are the usual physiological measures of stress. Other measures are unique to the condition. For example, for children with juvenile rheumatoid arthritis, the response to a dolorimeter might be measured, a rod-like pressure gauge that determines the threshold beyond which the participant can no longer tolerate the pain of the pressure. In burn wound healing, as another example, the child registers itching on a temperature gauge of itchiness immediately following the treatment. Longer-term gold standards are often indexed by clinical measures such as the number of back pain-free days or migraine-free days, the glucose levels for diabetes or pulmonary measures for asthma. Often clinical improvement is accompanied by decreases in depression and urinary stress hormones/neurotransmitters (e.g., cortisol and norepinephrine).

Sleep/wake behavior observations have also been invaluable indicators of treatment and clinical changes. Typically, observers have been trained to conduct live observations or to code videotapes of the behaviors if they have been videotaped or to use activity bracelets to record sleep movement. Sleep deprivation appears to be an underlying mechanism in at least pain syndromes.

Most of the recent research on massage therapy has been conducted at the Touch Research Institute, University of Miami School of Medicine. The early research of the TRI was reviewed in the American Psychologist in 1998 (Field, 1998). The more recent research is reviewed here including studies on prenatal and postnatal growth and development, attention deficit disorder, depression, pain syndromes, and immune conditions including HIV and breast cancer.

Growth and development studies

Pregnancy massage

Without pregnancy massage, as already noted, the incidence of prematurity is greater. Prematurity is a costly problem that may be caused by stress and depression of pregnant women. At 28 weeks gestation, corticotropic hormone has been noted to predict premature delivery (Wadwha, Porto, Garite, Chicz-DeMet, & Sandman, 1998). The prematurely born babies had significantly higher cortisol levels than those who were not born prematurely. In a study conducted by our group, the mothers' prenatal norepinephrine and cortisol during the second trimester were significant predictors of low birthweight and prematurity, respectively (Field et al., 2004b). This finding concurs with data showing that at least 40% of the mother's cortisol crosses the placenta (Glover, Teixeira, Gitau, & Fisk, 1999). Another study from our lab suggests that fetuses of depressed versus non-depressed mothers were also more active from the fifth to the seventh gestational month (Dieter et al., 2001), probably deriving from the mother's stress level. These data highlight the importance of interventions during pregnancy that can reduce stress and depression.

In our first study on pregnancy massage, the women were massaged by therapists twice a week over the last trimester of pregnancy (Field et al., 1999). The most important result was the reduction in prematurity. This pregnancy massage study on non-depressed women just described served as a model for the next study, which assessed the effects of massage therapy on depressed pregnant women using a more cost-effective form of massage therapy (Field et al., 2004c). This involved having the "significant other" instead of a massage therapist provide the massages. In addition, we assessed massage therapy effects on fetal activity which has been notably elevated in fetuses of depressed mothers (Field et al., 2004c). Massage therapy was expected to have positive effects on the prenatally depressed women by decreasing their stress hormones. After massage therapy, the women were also expected to have lower anxiety, less leg and back pain, and fewer obstetric complications, and their newborns were expected to be greater gestational age and perform better on the Brazelton Neonatal Behavior Assessment Scale (Brazelton, 1984).

In addition, we assessed a theoretical model derived from data suggesting relationships between prenatal maternal mood states and biochemistry, fetal activity, and neonatal outcomes (Field et al., 2004b; Glover et al., 1999; Lundy et al., 1998; Wadwha et al., 1998) and the effects of massage therapy on these factors (Field et al., 2004c). In this model, massage therapy increases serotonin and, in turn, decreases cortisol and depression. In addition, serotonin is noted to reduce leg and back pain. The massage therapy is also expected to increase dopamine and, in turn, decreases norepinephrine and anxiety. Ultimately, these two pathways may lead to reduced fetal activity and a lower rate of prematurity (see Fig. 1 for the proposed model).

The data analyses revealed: (1) increased serotonin levels, (2) decreased cortisol levels, (3) increased dopamine levels, and (4) decreased norepinephrine levels for the massage therapy group. Because of the increase in serotonin, it is not surprising that the massage group experienced decreased leg and back pain, and decreased depression and anxiety. Decreased fetal activity was also noted for the massage group and a lesser incidence of prematurity and low birthweight.

In the proposed model, massage therapy was expected to lead to increased serotonin (5HIAA) and dopamine. This hypothesis was derived from massage therapy effect data from several other studies (see Field, Hernandez-Reif, Diego, Schanberg, & Kuhn, 2005 for a review on the biochemical effects of massage therapy). Serotonin was expected to decrease depression and cortisol, which, in turn, would be expected to decrease the incidence of premature delivery (Field et al., 1999). The increased serotonin and decreased cortisol may have contributed to the better neonatal outcome in this study, providing support for the left pathway of the proposed model. Elevated serotonin (5H1AA) may have also contributed to the reduced leg and back pain, as serotonin is noted to decrease substance P and other pain-causing chemicals (Moldofsky, 1982).

Massage therapy also contributed to increased dopamine which has been noted to dampen norepinephrine levels. Norepinephrine and its associated anxiety state (Glover et al., 1999) decreased. These, in turn, may have also contributed to the lesser incidence of

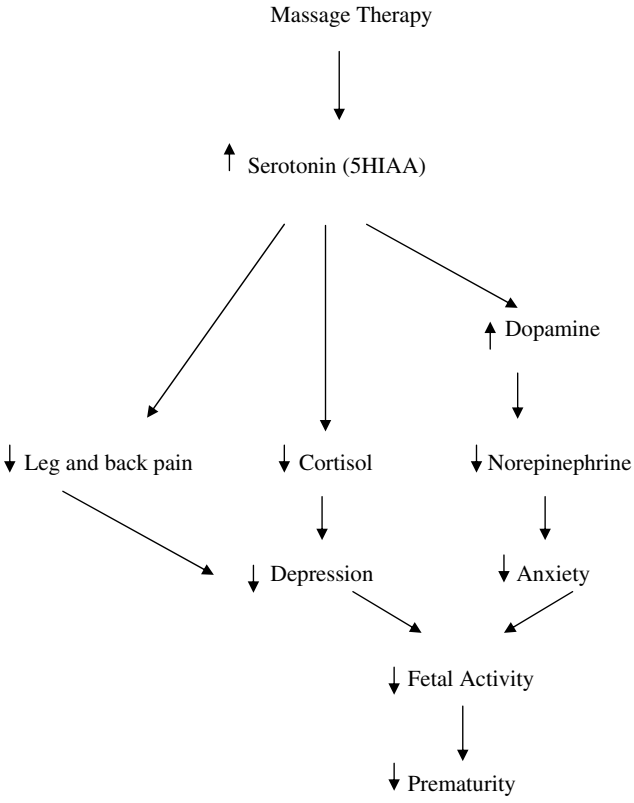

Fig. 1. Proposed model on pregnancy massage therapy effects on prenatal and neonatal outcomes.

prematurity and low birthweight. Dopamine may have reduced other related obstetric complications, as it has been shown to improve renal function (Nasu, Yoshimatsu, & Anai, 1996) and urine output in postpartum women with high blood pressure (Mantel & Makin, 1997), suggesting that increased dopamine may have some clinical significance for specific pregnancy problems, such as preeclampsia. Reduced fetal activity may have also resulted from reduced anxiety and stress hormones (Nasu et al., 1996).

Unfortunately, although these data provide empirical evidence for the effects noted in the proposed model, our sample was too small to conduct path analysis to test the relative significance of the pathways. Other limitations of the study include the reliance on subjective self-reports and deriving obstetric and postnatal complications data from medical records which are often inaccurate. Further, a better design would have been a comparison of different forms or intensities of massage. However, we found that it was too difficult to control or monitor different types or different pressure massages when they were conducted by significant others. Also, although the relaxation group may have been less compliant, the group differences favoring the massage group suggest that at least the significant others were compliant in providing massages. Nonetheless, these data confirm and extend our previous study results (Field et al., 1999). Overall, the findings suggest that massage therapy is effective for reducing pregnant women's stress hormones, stressful mood states, leg and back pain, and for reducing prematurity and low birthweight. They also suggest the efficacy of using significant others as massage therapists (Field et al., 2004c).

Infant growth and development

Approximately 13% of infants in the US are born prematurely at less than 37 weeks gestation. Those infants are hospitalized in neonatal intensive care units for sometimes 2–5 months. When the newborn is no longer considered medically unstable, the primary agenda for the infant is to gain enough weight to be discharged. At this time, we have introduced preemie massage. The massage protocol includes three 15-min massages a day for a 10-day period which led to a 47% greater weight gain in our first study (Field et al., 1986).

At least a dozen studies from around the world have now established that preterm infants gain more weight after being given a period of massage therapy during their hospital stay (see Field, 2004 for a volume of these studies). Others have also documented an increase in bone mineralization, bone density, bone length, and increased head circumference (Moyer-Mileur, Luetkemeier, Boomer, & Chan, 1995). Other studies have documented the positive effects of massage therapy on full term infants including less irritability and less sleep disturbance (Field et al., 1996a). The challenge for this field of research is to find potential underlying mechanisms that may be contributing to these growth effects and changes in behavior so that massage therapy might be adopted into hospital practice for preterm and full-term infants. In addition, finding cost-effective ways to deliver the massage, for example teaching the parents infant massage, may enhance the possibility of massage therapy being adopted into practice.

In a recent study, we were able to demonstrate a more cost-effective massage therapy. In this study, massage therapy had positive effects on weight gain in preterm infants after only 5 days of therapy as opposed to the 10 day therapy period that had been previously used by researchers (Dieter, Field, Hernandez-Reif, Emory, & Redzepi, 2003). In another study we conducted, parents massaged their full-term newborns from day one to the end of the first month (Field et al., 2004d). Here, we found that those infants gained more weight and

more length as well as experienced less sleep disturbance and performed better on the Brazelton Neonatal Behavior Assessment Scale by the end of the month that the parents provided the massage. This study highlighted the potential cost-effectiveness of parents rather than therapists delivering the massage therapy.

The mechanism question of how massage therapy facilitates weight gain in preterm infants remains unanswered. One hypothesis was that massage leads infants to consume more calories. However, preterm infants who received massage did not consume more formula or calories than the control preterm infants (Dieter et al., 2003; Ferber et al., 2002; Field et al., 1986; Jinon, 1996; Wheeden et al., 1993). A second hypothesis was that massaged infants saved more calories by sleeping more. However, the massaged infants were more alert and spent more time in active awake states than control infants, suggesting that enhanced weight gain was not achieved by saved calories (Scafidi, Field, & Schanberg, 1993).

A third and more favored hypothesis is that moderate pressure massage stimulates vagal activity, with the vegetative branch of the vagus facilitating the release of food absorption hormones, such as insulin, and increasing gastric motility, leading to more efficient food absorption (Field, 1988). This hypothesized mechanism is based on our own work showing increased vagal activity and insulin levels in preterm infants following massage therapy (Field, 1988), on the rat data of Saul Schanberg showing that moderate pressure stroking is critical for stimulating the release of ornithine decarboxylase (ODC being an index of growth hormone) (Pauk, Kuhn, Field, & Schanberg, 1986; Schanberg & Field, 1987), and the data of Uvnas-Moberg in both the rat and human models, showing that stimulation of pressure receptors in the intra-oral cavity increases vagal activity and the release of food absorption hormones (Uvnas-Moberg, Widstrom, Marchini, & Windberg, 1987).

Our findings that moderate versus light pressure massage is effective suggest the involvement of pressure receptors. Animal studies also indicate that pressure receptor stimulation activates the vagus, in turn, releasing food absorption hormones (Uvnas-Moberg, 1993) and ODC (Pauk et al., 1986; Schanberg & Field, 1987). Further, a recent study indicated that as compared to light pressure stimulation, moderate pressure stimulation reduced heart rate and central nervous system arousal in adults (Diego et al., 2004), and an infant massage study indicated more optimal growth and development across the first few months following moderate versus light pressure massage (Field et al., 2004d). In a mechanism study, we reported enhanced vagal activity and gastric motility in preterm infants receiving massage therapy (Diego, Field, & Hernandez-Reif, 2005). The vagus (one of the 12 cranial nerves) is noted to have extensive branches to various organs in the body including the gastrointestinal tract. The gastrointestinal system is thought to be affected by the vagus in two ways. The vagus is thought to help release food absorption hormones such as glucose and insulin, and to stimulate gastric motility or movement of the wall to facilitate food absorption. In this study, we reported that vagal activity and gastric motility were both enhanced by massage therapy. Consistent with our model, the increased vagal activity elicited by massage therapy was related to increased gastric motility. And, both vagal tone and gastric activity were, in turn, related to average daily weight gain across the 5 day treatment interval. This suggests that infants who show increased vagal activity and increased gastric activity are more likely to benefit from massage therapy. In fact, the 12 preterm infants who showed an increase rather than a decrease in vagal activity during the massage gained on average over twice as many grams (18 g vs 8 g) during treatment compared to baseline than the four infants who exhibited a decrease in vagal activity.

Taken together, these findings provide strong support for our hypothesized model (Fig. 2) indicating that moderate pressure massage results in increased vagal activity which, in turn, results in enhanced gastric motility (and potentially the release of food absorption hormones). This is one potential pathway for the massage therapy/weight gain relationship that has been consistently observed across preterm infant massage studies.

Attention and attention disorders

The vagus nerve may also be responsible for mediating the effects of massage therapy on attentiveness. In many studies, increased vagal activity has been accompanied by decreased heart rate and blood pressure. Increased attentiveness is typically associated with decreased heart rate. The vagus nerve has a branch to the heart and effectively slows heart rate (Porges, 2003). A particular pattern of EEG is also associated with enhanced attentiveness. This pattern is usually an elevation of theta, alpha, and beta activity and a decrease in delta activity (Field et al., 1996b). In a number of studies, we have researched attentiveness and related performance on cognitive tasks by infants, preschoolers, school age children, adolescents, and adults. In a study on infants, a brief period of massage was given prior to a visual attention task (Cigales, Field, Lundy, Cuadra, & Hart, 1997). The massaged infants showed more visual attentiveness on the task and habituated or learned the stimulus properties faster than those who did not receive massage. In a study on preschool-age children, some preschoolers were massaged and others played briefly before taking an IQ test (Hart, Field, Hernandez-Reif, & Lundy, 1998). Those preschoolers who received the brief massage were noted to perform better, particularly on the block and peg tasks of the IQ test.

In a study on children with autism, massage therapy was provided by the parents every night before bedtime, and the children were noted not only to have better sleep patterns but also to show more on task behavior in the classrooms (Escalona, Field, Singer-Strunk, Cullen, & Hartshorn, 2001; Field et al., 1997b). In a similar study on attention deficit disorder adolescents, massages led to less hyperactive behavior and more on-task performance in the classroom (Field, Quintino, Hernandez-Reif, & Koslovsky, 1998c). In a study assessing EEG patterns associated with massage therapy, moderate pressure massage versus light pressure massage was associated with enhanced attentiveness, including slower heart rate and EEG patterns associated with enhanced attentiveness (Diego et al., 2004).

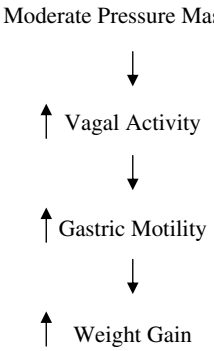

Fig. 2. Proposed model for weight gain.

Vagal activity and EEG patterns are reliable indicators of attention. Stimulation of the vagus (the 10th cranial nerve) is critical for attention. Slower heart rate and increased vagal activity accompany attention. Vagal activity is the sinus arrhythmia of heart rate. Thus, heart rate recordings can be easily converted to vagal activity by a computer program. EEG patterns that accompany attentiveness include increased beta and theta, and decreased delta. This EEG pattern of heightened alertness/attentiveness was noted in an earlier study following 15-min chair massages in the participants' offices (Field et al., 1996b). The EEG alertness/attentiveness pattern following the massage sessions was accompanied by improved performance on math computations including being able to perform them in less time with greater accuracy.

Reducing depression and aggression

EEG in the frontal region of the brain is typically more activated on the right side in depressed individuals (Henriques & Davidson, 1990). During some treatments, EEG has been noted to shift to the left side, which is more responsible for processing positive, approach emotions like happiness. Massage has been noted to shift predominant right frontal EEG activity to symmetry (in the center) or towards the left frontal region (a positive shift in EEG). EEG asymmetry, specifically greater relative right frontal EEG activation, is associated with negative affect. Depressed adults show stable patterns of this asymmetry. Frontal EEG asymmetry shifted from right to left in depressed adolescents following massage therapy (Jones & Field, 1999).

Massage therapy has also attenuated EEG asymmetry in infants of depressed mothers (Jones, Field, & Davalos, 1998). These findings are surprising given that frontal EEG asymmetry is believed to be stable (Tomarken, Davidson, Wheeler, & Kinney, 1992). Previously, depressed adults, for example, showed greater relative right frontal EEG activation even when they were in remission or no longer showing behavioral symptoms (Henriques & Davidson, 1990), suggesting that right frontal EEG is a physiological marker for depression, independent of depressed behavior.

In a study on aggressive adolescents, those who received massage therapy reported feeling less anxious after the first 20-min massage session (Diego et al., 2002). This is consistent with previous studies showing that, for children and adolescents, anxiety and stress hormone levels decreased following massage therapy (Field et al., 1992). Aggression and hostility also decreased in the adolescents who received massage therapy, which may relate to the reduction in their anxiety levels. They may have had lower arousal levels and therefore better control over their impulsive and aggressive behavior. Future studies should document the effects of massage therapy on aggressive adolescents' neurochemical and psychophysiological responses to the therapy.

Improving neuromuscular function

Massage therapy might be expected to improve range of motion and increase muscle strength, inasmuch as it involves direct application of pressure on the muscle tissue. In at least five studies, we have demonstrated an increase in range of motion and/or increased strength and improved neuromuscular function. In a study on dancers, we were able to show that massage therapy increased shoulder abduction (Leivadi et al., 1999). In a study on spinal cord patients, we documented enhanced muscle strength in the upper limbs in

those who were experiencing paralysis of the lower half of their body (paraplegia) (Diego et al., 2002). Massage therapy led to a decrease in hypertonicity in the arms and legs of children with cerebral palsy (Hernandez-Reif et al., in press-a), and, decreased hypotonicity in the arms and legs of children with down syndrome (Hernandez-Reif et al., in press-b). In a study on Parkinson's, which is generally accompanied by uncontrolled, disorganized facial movements, we were able to show that exerting pressure against the skin in the form of massage therapy led to a reduction in these uncontrolled movements (Hernandez-Reif et al., 2002).

Reducing pain

Massage therapy is most popularly used with pain syndromes. One of the most common mechanisms used to explain the massage therapy effects on pain syndromes is the Gate theory. In that theory, pain is noted to stimulate shorter and less myelinated (or less insulated) nerve fibers so that the pain message takes longer to reach the brain than the pressure message, which is transmitted by nerve fibers that are more insulated and longer and therefore able to transfer the stimulus faster. The message from the pressure stimulation reaches the brain prior to the pain message and, thereby, "closes the gate" to the pain stimulus. This, of course, is a metaphor for the electrical and chemical changes that occur. Another theory is that massage therapy enhances deep sleep or restorative sleep. In deep sleep, less substance P is emitted, leading to less pain (given that substance P causes pain).

The "enhanced deep sleep leading to less substance P" theory was more directly tested in our study on fibromyalgia patients (Field et al., 2002). In that study, the amount of deep sleep was recorded, using an activity monitor, and substance P was assayed in saliva samples. Notably, following a period of massage therapy, more time was spent in deep sleep, and lower levels of substance P were noted. In our study on carpal tunnel syndrome, the patients received massage therapy from a therapist once a week and gave themselves the massage the other days of the week (Field et al., 2004a). Following a period of massage therapy, the nerve conduction velocity or the speed with which electrical stimuli could be transmitted across the neuron was more rapid, suggesting an improved carpal tunnel syndrome condition.

Other pain syndromes have benefited from massage therapy including burn trauma and back pain. In our study on burn patients massage therapy before the procedure led to higher thresholds during the painful "skin brushing" procedure (Field, 2001). Massage therapy may have led to increased pain thresholds, enabling the patients to endure that procedure with less difficulty. In our study on low back pain, patients experienced fewer days of low back pain and increased range of motion following a period of massage therapy (Hernandez-Reif, Field, Krasnegor, & Theakston, 2001).

These findings concur with earlier massage studies on pain syndromes including fibromylagia (Sunshine, Field, Quintino, & Fierro, 1996), chronic fatigue syndrome (Field et al., 1997c), and juvenile rheumatoid arthritis (Field, 2001) and suggest that massage therapy effectively reduced pain and anxiety and improved mood. In addition, special effects unique to each condition were noted. For example, in the low back pain study, the massage therapy group also experienced immediate changes in trunk flexion and displayed improved trunk flexion across the study period. Increased range of motion has been correlated with significant pain reduction following physical therapy (Mooney, Saal, & Saal, 1996). Other effects included lower depression scores and less disturbed sleep by the end of the study,

not unlike the findings for other pain syndromes following massage (Field et al., 2002, 2004a; Sunshine et al., 1996). Increased serotonin following massage therapy in the low back pain study is encouraging in that serotonin levels may become depleted in individuals with chronic pain (Jhingran, Cady, Rubino, & Miller, 1996; Solomon, Skobieranda, & Genzen, 1995). The increased dopamine may also be related to the improved mood and pain reduction. Data from animal studies reveal increased dopamine concentration as a result of circulating opiates (Bergstrom et al., 1998).

Enhancing immune function

In several studies, natural killer cells have increased following massage therapy. This finding suggests improved immune function, given that natural killer cells are the front line of the immune system, warding off viral cells and cancer cells. In our study on HIV infected adolescents, natural killer cells increased following a period of massage (Diego, Hernandez-Reif, Field, Friedman, & Shaw, 2001). This suggested a better clinical course inasmuch as NK cells are sometimes noted to substitute for CD4 cells (the cells that are destroyed in HIV). The CD4 cells were also increased in the adolescents, suggesting an improved clinical condition. Finding increased CD4 cells in the study on adolescents but not in our study on adults with HIV (Ironson et al., 1996) might be explained by the adolescents being less immune-compromised. Also, the adolescents had high levels of depression. Depression has been linked to immuno-suppression through decreased CD4 number and the CD4/CD8 ratio (Ravindran, Griffiths, Merali, & Anisman, 1995). Massage therapy, then, by reducing depression might improve CD4 number and the CD4/CD8 ratio in HIV infected adolescents.

In a similar study on leukemia in children, lymphocytes (another index of improved immune function) increased following a period of massage therapy (Field et al., 2001). This change indicated improved clinical condition in the children with leukemia. In the leukemia study, we found an additional benefit in the decreased parental anxiety and depressed mood following their massaging their child. This is not surprising inasmuch as similar effects have been reported after elderly volunteers massaged children (Field, Hernandez-Reif, Quintino, Schanberg, & Kuhn, 1998b), highlighting the positive effects on the massager. Also not surprising were the decreased anxiety and depressed mood in the children, given similar data for children with other chronic illnesses including asthma (Field et al., 1998a) and diabetes (Field et al., 1997a). The increased white blood count and neutrophil count following massage therapy suggests the usefulness of this therapy for maintaining optimal immune function over the course of cancer treatment.

Finally, in our studies on breast cancer, natural killer cells again increased, suggesting improved immune function (Hernandez-Reif et al., 2004; Hernandez-Reif et al., 2005). The pivotal findings in our breast cancer studies were the consistent increases in NK cells and lymphocytes for the women with breast cancer who received massage therapy. Their clinical condition would be expected to improve inasmuch as NK cells are noted to destroy tumor cells (Brittenden, Heys, Ross, & Eremin, 1996). Stimulation of pressure receptors via massage therapy might be the underlying mechanism for the increased NK cells and lymphocytes. Stimulation of pressure receptors, such as in friction and stroking from massage, may decrease sympathetic and increase parasympathetic activity (vagal tone), leading to enhanced immune function (Diego et al., 2001).

Summary

Thus, massage therapy has been effective in promoting growth, decreasing depression, enhancing attentiveness, reducing pain, and improving immune function. Although the clinical changes are unique to each condition that has benefited from massage, for example, pulmonary functions in asthma and glucose levels in diabetes, there appear to be some changes common to conditions such as decreased depression and cortisol levels, enhanced sleep, and increased serotonin and dopamine levels. Increasing empirical data have also helped delineate the critical features of massage, i.e., the moderate pressure stimulation, and will ultimately lead us to understand the underlying mechanisms for the therapeutic effects.

Knowing underlying mechanisms is essential for alternative therapies, such as massage therapy, to be adopted into practice by our traditional medical community. Having shown effectiveness by the clinical gold standards for the conditions, such as improved pulmonary functions in asthma and decreased glucose levels in diabetes, has not been sufficient. Documenting what happens under the skin, bioelectrically and biochemically, will be enabled by newer, non-invasive technology such as functional magnetic resonance imaging and continuous plasma sampling. The saliva sampling techniques (e.g., the paper "litmus" test) and the newer assays for saliva (e.g., for substance P and testosterone, for studying pain and aggression, respectively) will also facilitate this underlying mechanism research.

To date, we can confidently say that stimulating pressure receptors under the skin leads to a cascade of events including: (1) stimulating the vagus (increased vagal tone); (2) activating the many branches of the vagus including the smart vagus (decreased heart rate, as in attentiveness and increased intonation of the voice and animation of facial expressions in depressed individuals), as well as the vegetative vagus (increased release of food absorption hormones and increased gastric motility in preemies); (3) increasing serotonin and dopamine and decreasing substance P which may help alleviate depression and pain; (4) decreasing cortisol, which may facilitate immune function i.e., increased natural killer cells, inasmuch as cortisol is noted to kill natural killer cells, and natural killer cells ward off viral and cancer cells; and (5) altering brain activity, as in shifts to greater relative left frontal EEG activation in depressed individuals and enhanced attentiveness patterns, facilitating cognitive function (increased beta, alpha, theta, and decreased delta accompanying the faster and more accurate mathematic computations).

These are important findings, but we need "connective tissue" or pathways that connect these processes. Greater technology for human and animal research are promising for this. The animal research of Michael Meaney, for example, has helped us to understand that touch deprivation can lead to a corticosteroid cascade with significant impact on the hippocampus and memory function. The rat model of Saul Schanberg has introduced the growth gene that can only be "turned on" by moderate pressure stimulation.

Research on other forms of similar moderate pressure stimulation may also help inform the underlying mechanisms questions. For example, clinically effective acupuncture seems to involve stimulation of pressure receptors, inasmuch as deep needle insertion is more effective than the often used SHAM or shallow needle insertion. Yoga, a form of self-massage in the rubbing of limbs against each other and against hard surfaces, shares a number of effects with massage, for example, decreased cortisol. Exercise

that involves stimulation of moderate pressure receptors, for example running and fast walking stimulating pressure receptors in the feet, has led to increased serotonin. Studies in which these different therapies/activities are compared may enhance our knowledge of underlying mechanisms.

Still another research direction would be cross-modality comparison studies. Aromas and music are often used with massage therapy. Aromatherapy (such as lavender) (Fernandez et al., 2004) and music (such as rock music for adolescents) (Jones & Field, 1999) have been noted to shift EEG from right to left frontal EEG activation, not unlike massage therapy. How do these different forms of stimulation directed at different sense organs elicit similar responses, and are they cumulative/additive in their effects.

These, then, are some suggested future directions for research. The clinical effects of massage therapy have been established for dozens of psychological and medical conditions. Although many conditions have not yet been studied using this form of therapy, underlying mechanism research is critical for the field to move into clinical practice. With increasing research technology, that should be possible.

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