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Review Article

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Touching Reduces Pain and Stress: A Narrative Review

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ABSTRACT

This narrative review involved entering the terms touching, massage, pain and stress on PubMed and PsycINFO literature search engines. The search yielded 47 studies that are summarized here. The prevalence of touching has varied widely across cultures from a low of 57% in China to a high of 100% in Austria. Touching has been more prevalent in relationships with partners and children and was more diverse in warmer, less conservative and religious countries and among younger, female and liberal people. The three predominant forms of touching that appear in this literature include handholding primarily for painful conditions, hugging (embracing) for stressful conditions and massaging for both painful and stressful conditions. Other less prevalent literature addresses the effects of COVID-19 on touching, touching by robots, and negative reactions to touching. Unlike earlier literature, most of the researchers have either measured or theorized underlying brain pathways for touching reducing pain and stress. Most of this research has been conducted in the laboratory as opposed to being naturalistic, so it is not clear how generalizable the data are to lifelike situations.

For this narrative review, the terms touching, massage, pain and stress were entered on the PubMed and PsycINFO literature search engines. Those literature searches yielded 47 studies that are summarized here. The research has focused on the prevalence of touching and three types of touching including handholding, hugging (embracing) and massaging. Most of the studies have been conducted in the laboratory. Although pain can be considered stressful and stress considered painful, most of the studies have focused on either pain or stress, except for massage research that has included its effects on both pain and stress. Handholding has been used more frequently in research assessing painful conditions, hugging in stressful conditions and massaging for both painful and stressful conditions. This review is accordingly divided into sections on prevalence, handholding, hugging and massage research.

Prevalence of Touching for Pain and Stress Reduction

The prevalence of touching has varied widely across cultures. In a study on 14,000 individuals from 45 countries, the participants were surveyed on the amount of embracing, stroking, kissing or hugging their partner, friends and children during the preceding week [1]. Touching was, not surprisingly, notably more prevalent in relationships with partners and children. Touching partners ranged from **a low of 57% in China to a high of 100% in Austria** (mean=93%). Touching children ranged from an even lower low of 24% in China to a high of 97% in Austria (mean= 91%). In this large global sample, touching was more diverse in warmer, less conservative and religious countries and among younger, female and liberal people. A survey from the U.S. suggested that Americans who are older than 14 engaged in kissing (87%), cuddling (70%) and massage (23%) [2]. These data, coming from only one country and primarily from younger romantic couples, are less generalizable than the 45-country sample data.

Handholding

The prevalence of handholding was, surprisingly, not included in the touch prevalence studies already summarized. The studies on handholding that are in the recent literature derive from laboratory pain or anxiety conditions, not from survey or naturalistic studies. They generally suggest that handholding reduces pain and anxiety in research that assesses those associations.

In a study on handholding effects on **pain and pain-related skin conductance responses,** handholding had greater effects than gentle stroking [3]. fMRI activity increased in the frontal-striatal area, suggesting "change in nociceptive signals". Individual differences in fMRI activity related to differences in handholding analgesia. Pain and pain-related skin conductance were decreased in both the participant and the partner. In a similar paradigm on **brain-to-brain** coupling during handholding, pain reduction was noted [4]. The coupling in this study was correlated with the magnitude of analgesia.

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In a paper entitled "Brain mechanisms of social touch-induced analgesia in females", 30 women were exposed to **thermal pain** while holding their partner's hand [5]. Pain was significantly reduced as well as fMRI activity in the pain region of the brain. The decrease in pain correlated with greater closeness to the partner and decreased brain circuitry associated with stress, including ventromedial and dorsomedial areas, the prefrontal cortex, the anterior cingulate, the amygdala/hippocampus, and the hypothalamus.

In a study that compared the combination of handholding, conversation and midazolam pre-medication versus medication alone on **preoperative anxiety,** the combination of handholding, conversation and medication was greater than the handholding and conversation condition, which, in turn, was greater than the medication alone in reducing anxiety and heartrate [6]. It is not surprising that the combination of three therapies would be greater than medication alone.

In a paper entitled "The value of handholding during **intravitreal injections"**, handholding with a glove was compared to handholding without a glove as well as no handholding in three different groups (N=195) [7]. The data suggested that handholding contributed to reduced anxiety whether it was with a glove or without a glove. Those findings were not surprising given that handholding both with and without the glove would be expected to stimulate pressure receptors in the hands and ultimately lead to higher serotonin levels (anti-pain neurotransmitter) [8].

In a paper entitled "I want to hold your hand: handholding is preferred over gentle stroking for **emotion regulation",** 4 studies were conducted via videos [9]. Based on Feedback Loop Theory which addresses two-way communication, holding hands was expected to be superior to gentle stroking for emotion regulation. As the author suggested, holding hands is ubiquitous, appears in monkey populations and is featured in a variety of cultures. These data, however, were based on videos, not live situations. Surprisingly, no mention was made of the stimulation of pressure receptors that would have occurred during handholding versus gentle stroking, and how gentle stroking can be arousing and therefore irritating for some participants [8].

A similar study entitled "The comfort in touch: immediate and lasting effects of handholding on emotional pain", handholding with a romantic partner was observed during recall of an **emotionally painful experience** (N=60) [10]. Holding the partner's hand was compared to squeezing a ball. Increased comfort occurred in the handholding condition and later memories paired with touch led to less emotionally painful experiences during the memory recall. The decrease in emotional pain was no different for handholding and squeezing the ball, likely because pressure receptors in the hands were being stimulated in both conditions.

Handholding has also **increased heart rate variability** [11]. In this study, heart rate variability increased in both patients with cancer and their family caregivers (N=74). Heart rate variability (vagal activity) typically increases during the stimulation of pressure receptors, so an increase would be expected during handholding [8]. A study on the pressure of handholding, the frequency of squeezing the other's hand during handholding and its relationship to intimacy would be informative.

Hugging

Hugging (embracing) has been defined as holding another person closely while putting one's arms around their neck or back. Hugs typically average three seconds, although the duration varies by culture. As already noted, hugging has been more frequently studied in the context of stress reduction in contrast to handholding being researched more often during painful conditions.

In a study that used a smart phone ecological momentary assessment (repeatedly collecting data on people's thoughts and behaviors) over seven days (N=94), hugging (embracing) was notably more frequent on weekends when it buffered against acute stress [12]. **Blood pressure** was decreased as well as infection risk which was related to decreased **pro-inflammatory cytokines**.

In a study entitled "Receiving a hug is associated with the attenuation of negative mood that occurs on days with interpersonal conflict", 404 adults were interviewed nightly for 14 days regarding conflicts, hugs and positive and negative affect [13]. Greater hugging was associated with **less conflict**. No differences were noted for the different genders and by marital status.

In a similar study, hugging was compared to self-soothing touch (placing one hand on the heart and the other hand on the abdomen) for 20 seconds in a randomized controlled trial (N= 159) [14]. The Trier Social Stress Test was administered, heart rate was recorded and cortisol was assayed. Although a decrease was noted in **cortisol levels** for both conditions, no changes were noted in heart rate or self-report. While twenty-second hugs may be preferable for partners, they were likely too long for strangers as some data have suggested that 5-second hugs are ideal for strangers.

In a paper entitled "Romantic partner embraces reduce cortisol release after acute stress induction in women not men", couples embraced for 20 seconds following the Socially Evaluated Cold Pressor Test [15]. Surprisingly, although there was a **decrease in cortisol for women,** men did not experience a decrease, possibly because women enjoy being hugged more than men do. Also, there was no difference in blood pressure, suggesting no change in sympathetic nervous system activity.

Right-handed bias has been noted during hugging in at least two studies. In one study entitled "Embracing your emotions: affective state impacts lateralization of human embraces", embracing was observed for negative (fear or sadness), neutral (greetings) and positive emotions (love and affection) [16]. In this study (N=2500), a right-handed bias was noted during embracing which the authors labeled "an interaction of motor and affective networks". Kissing has also been noted to have a right-handed bias in intimate relationships. Right-handed bias may in part relate to the prevalence of right-hand dominance and with the left hemisphere being associated with approach emotions.

In the second study entitled "Hugs and kisses - the role of motor preferences and emotional lateralization for hemispheric asymmetries in human social touch", right hemisphere

dominance was noted for processing negative emotions and **left hemisphere dominance** for positive emotions [17]. Because hands are involved in social touch, motor preferences may lead to asymmetries, which may be modulated by asymmetries in emotional processing. EEG studies suggest greater activation in the left hemisphere during positive emotional processing and more activity in the right hemisphere during negative emotional processing. The left hemisphere has also been associated with approach emotions while the right hemisphere with withdrawal emotions.

Miscellaneous Studies on Touch for Reducing Stress and Pain

Some papers emerged in the recent literature on touch for reducing stress and pain that did not fit the handholding and hugging categories. These included a study on cuddling, a couple studies on robotic touch, a paper on negative reactions to touch and 4 papers on COVID effects.

In a paper entitled "The effects of **cuddling** on relational quality for married couples", 80 adults were randomly assigned to increase their cuddling time together, or they were requested to not change their cuddling time for a four-week period [18]. On average, four cuddles occurred per week and contributed to greater relation satisfaction. The cuddling usually lasted for 30 to 45 minutes. It was surprising that with all the cuddling groups, sessions and shops that have recently emerged around the world, only one study on cuddling appeared in this literature. Although it is a rare longitudinal study, it was also a naturalistic study, suggesting that potential confounds like hugging, kissing and massaging could not be known. And the research is also limited in its generalizability by including only same sex couples.

Several studies on **robotic-like hugging** have appeared in the literature since the development of robots. They have included inflatable garments and squeeze machines and have been named the Hug, teddy bear, robot, and a huggable sponge robot. The effective characteristics have been explored in a recent study entitled "Softness, warmth and responsiveness improve robot hugs" [19]. In this study, low, medium and high hug pressure was compared in hugs of five seconds duration. The participants (N =30 young, technical participants) preferred soft and warm versus hard and cold hugs, and they also preferred to be squeezed and released immediately when they were ready for the hug to end. 63% of them liked the hugs and preferred moderate pressure.

Another robot-like hugging device, called the Hugvie (a humanoid robot), reduced stress in adolescents and young adults with autism spectrum disorder (N=10) [20]. The participants also experienced a reduction in stress based on a clinician administered anxiety scale. That these effects were significant on such a small sample is surprising, but having a hug before having a conversation with an unfamiliar person would be expected to reduce that stress.

Negative reactions to touching have been described in a paper entitled “Exploring the association between unwanted affection, stress, and anxiety” [21]. In this study on a memory of unwanted affection and reactions to it, retrospective cognitive anxiety and stress were worse when experiencing unwanted affection from partners versus strangers. The study is limited by its recall and memory bias and self-report. A more objective measure such as a Fitbit could be used to record current experiences of unwanted reactions to being touched in order to bolster the external validity of these findings.

As for everything else, **COVID-19** has affected touching during the pandemic. Touching your kids and your partner, self-touching, and touch deprivation have had different effects on individuals during a COVID-19 lockdown [22]. In this Survey Monkey study conducted during a COVID-19 lockdown (N= 260 respondents), 26% said they were touch deprived a lot, 21% said they were touching their kids a lot, 33 % touching their partner a lot, and 32% self-touching a lot (e.g. yoga and stretching). Correlation analyses suggested that touch deprivation was related to scores on the Stress, Anxiety, Depression, Fatigue, Sleep Disturbances and PTSD scales. The three types of touching were positively related to scores on the Health Scale, at home projects, and outdoor exercising with others. Touching partner was also related to lower scores on the Stress, Depression, and PTSD Scales and Self-touching was related to lower scores on the Fatigue and Sleep Disturbance Subscales. The results of these data analyses are limited by the self-reported data from a non-representative, cross-sectional sample. Nonetheless, they highlight the negative effects of touch deprivation and the positive effects of touching your kids and partners and self-touch during a COVID-19 lockdown.

In a paper entitled "Social touch deprivation during COVID-19: effects on psychological well-being and craving interpersonal touch", an intimate, friendly and professional touch survey was conducted (N= 1746) [23]. The survey results suggested that there was greater anxiety and loneliness during COVID, even though intimate touch was still the most commonly experienced type of touch during COVID. More **craving for intimate touch** was noted and the more anxiously attached expressed more craving for touch while the more avoidantly attached expressed less craving for touch.

In a similar survey, but on unmarried and romantically, partnered adults (N =585), greater physical distancing led to less touch for non-cohabitors but greater touch for cohabitors [24]. For those cohabiting, greater touch resulted in greater **affect regulation** and less touch led to more psychological distress. Physical distancing may have facilitated more positive relationship behavior in those who were cohabiting due to greater touching and affect regulation. The variety of touch was not clear in this paper, as, for example, the most effective type of touching. In another study (N= 1982) greater duration and severity of COVID was related to greater longing for touch [25]. Those who experienced greater longing rated videos of touch as more pleasant.

In still another paper on COVID effects entitled "A comparison of hugging frequency and its association with mood before and during COVID-19 using ecological momentary assessment", two independent cohorts were seen prior to and during COVID (N=94, mean age =26 in the pre-COVID cohort and N =104, mean age= 32 in the during COVID cohort) [26]. A positive correlation was noted between mood and hugging that was stronger during COVID. This was based on a five-point Likert scale. Problems with the study include that most of the participants (N=74) were in romantic relationships, and although a **decrease in hugging** was noted during the pandemic, directionality could not be

determined. In addition, the samples were very different on their age and romantic relationship status.

Massage Therapy for Stress Reduction

Unlike the studies on handholding that have focused on pain reduction and the hugging studies that have documented pain reduction, massage therapy studies have focused on both pain and stress reduction.

In a randomized controlled study, 80 adults (age 50-75) were randomly assigned to a chair massage or a control group [27]. Serum **cortisol** levels were reduced by the massage, suggesting **decreased stress**. Given that cortisol is considered a more objective measure of stress and given the low expense of saliva assays of cortisol, it is surprising that this was the only research group that assayed cortisol.

In a study on massage in adults with **generalized anxiety disorder,** the participants received massage two times per week and completed the Hamilton Anxiety Rating Scale at six and twelve weeks [28]. Surprisingly, the shorter period (six weeks) was more effective. Compliance may lessen with the duration of studies due to the inconvenience of travel to the massage therapy sessions and the data from the less compliant participants could account for the lesser effects over time.

In a randomized controlled trial focused on **anxiety** and **sleep**, post-menopausal women received foot massage [29]. The results suggested that the massage group experienced more sleep (mean=eight versus seven hours), lower scores on the Beck Anxiety Inventory (mean=26 versus 36), and lower scores on the Fatigue Severity Scale (mean=5.5 versus 23). Anxiety, fatigue and sleep are clearly related variables, but without a regression or structural equation modeling, it is difficult to know the relative significance of these variables.

In a review on randomized controlled trials of massage and relaxation therapy for cancer survivors, four massage trials were compared to three relaxation therapy trials [30]. Massage therapy improved self-reported **sleep** and accelerometer recordings suggested longer sleep episodes. These effects were not noted for the relaxation therapy trials. Relaxation therapy has often been used as a control group which has been criticized as it is not an active control group and requires more compliance and effort of the participants. A more balanced comparison might be between a self-massage and a relaxation therapy group. The massage effects might still be better due to the stimulation of the pressure receptors lowering the stress hormone (cortisol) levels.

Pain is Reduced by Massage Therapy

Most of the adult massage therapy studies have involved research on pain. These include pain from several different conditions including pain following liver transplant, chemotherapy -related neuropathy pain, abdominal pain, back pain, and knee arthritis pain.

In a paper entitled "Expectations affect pain sensitivity changes during massage", a randomized controlled trial was conducted (N=56) on receiving positive or negative **expectation instructions** followed by a pain-inducing or pain-free massage [31]. The pressure pain threshold was greater at three and four minutes for positive expectation participants receiving pain-inducing massage. It is not surprising that the pain tolerance would be higher after receiving positive expectation instructions resulting in attitudes like “grin and bear it”, but it is surprising that an institutional review board would approve a pain induction massage because of the potential risks for the participants.

In a randomized controlled trial on patients following **liver transplant** (N=80), hand massage resulted in decreased pain and anxiety [32]. It is not clear why hand massage was used when the hand is so distal from the liver. However, other distal massages like foot massage have even affected fetuses [33].

In another randomized controlled study, patients with chemotherapy-induced peripheral **neuropathy pain** (N= 71) received massage for three times per week for four weeks versus two times per week for six weeks [5]. Again, the shorter period of massage (four weeks) was more effective. The symptoms of chemotherapy-induced peripheral neuropathy pain were decreased for the affected area receiving Swedish massage for the shorter period of time (four weeks versus six weeks). The shorter period of massage was also more intense or greater dose (3 times per week versus 2 times per week) suggesting that frequency and duration are confounded in this study. That pain was reduced in the affected area is also noteworthy. More research is needed both on the dose of massage and comparisons between massage being applied on affected versus distal areas of the body.

Most of the pain studies have targeted **arthritis** which is among the most common pain syndromes. In a randomized controlled study from Taiwan, patients with rheumatoid arthritis engaged in self-aromatherapy massage (N=102) [34]. Not surprisingly, the massage not only reduced pain but also enhanced sleep quality.

In another randomized controlled study, Swedish massage was conducted for 30 minutes two times a week for the first four weeks and three times a week for the second four weeks on 60 patients with rheumatoid arthritis [30]. Pain and pain killer consumption decreased immediately after the first week of massages. The decrease in both pain and painkiller consumption continued even one month after the last session. Typically, the effects of massage are not sustained after the massage is discontinued, so this result was surprising. It is possible that the patients continued to receive massage or applied self-massage during the month after the end of the study, which could explain the continuing decrease in pain and pain killer consumption.

In a review of 12 studies on pain (N=737 participants), massage was provided for adults with **knee osteoarthritis** [35]. After 1 to 4 weeks of therapy, decreased pain and stiffness were noted. After 6 to 8 weeks of therapy, a further decrease in pain was reported and functionality improved. Aromatherapy massage was not superior to massage alone, which was not surprising given that massage effects typically derive from the stimulation of pressure receptors not aroma receptors. Once again, positive effects were noted after short term therapy. As in several of these reviews, the results are limited by the small sample sizes and variability in the methodology of the different studies.

Back pain has been the focus of at least two randomized controlled studies. In one study, classical massage and connective tissue

massage were compared for their effects on mechanical low back pain [36]. Classical massage led to greater pain relief at the end of the second week. But both types of massage involved the stimulation of pressure receptors, so it is not surprising that they both increased body temperature and they were equivalent on their positive effects on sleep and autonomic responses. The pain relief effects may have related to the increased serotonin (pain-relieving transmitter) levels that are typically noted after massage therapy [37].

In the other randomized controlled study "High force versus low force" massage (moderate versus low pressure massage) were compared for their effects on **low back pain** (N=56 females) [38]. The participants received six 30-minute sessions with 10 minutes being focused on the lower back. The high versus low force massage alleviated pain as reported on visual analogue scales. The greater effects of moderate pressure (high force) massage would be expected, as already mentioned. The absence of follow-up effects would also be expected as the massage (stimulation of pressure receptors) was discontinued.

One randomized controlled study, and one meta-analysis appeared in this recent literature on massage therapy for **post-surgical pain**. In the randomized controlled trial, a massage therapy group was compared to a placebo control group following cardiac surgery (N=31) [39]. The massage group received 10-minute foot massages twice within 30 minutes after receiving an opioid medication. The massage group experienced less pain and less anxiety. This effect would be expected given that the control group was a “placebo” control. Massage therapy needs to be compared to more active control groups. Nonetheless, the enhancement of opioid effects by massage has rarely been reported and would clearly have clinical relevance.

In the meta-analysis on massage therapy effects on **pain following surgery,** 33 randomized controlled trials were included [40]. Massage therapy resulted in reduced pain in both the short and the long-term (4 to 6 weeks after massage therapy). The effects were greater for adults and greater for C-section and heart surgery than for orthopedic surgery patients, possibly because casting following orthopedic surgery would obviate the positive effects of massage on the affected area. Surprisingly, no effects were noted for the length of session nor the dose nor the different types of massage therapy.

Potential Underlying Mechanisms

Potential underlying mechanisms have been suggested for the effects of touching on stress and pain. These have included somatosensory mechanisms and activated areas and pathways of the brain.

Different sensory signatures and functions of affectionate touch were the focus of a study that involved "coloring of body maps” (N= 161) [41]. Although much of the recent literature has claimed that affectionate touch effects are limited to the hairy skin, more recent studies are suggesting that the effects involve all of the skin. A linear discrimination analysis categorized the colorings with 91% accuracy, showing that each touch action has a unique **somatosensory topography**. Touch actions differed in their comfort and frequency as a function of the closeness of the interaction partners.

A simulation of calming touch has been achieved by an **oscillating compression sleeve** designed for the leg and arm [42]. This sleeve that has typically been used to reduce edema was noted to activate regions that respond to stroking and those that do not. The pressure applied here was similar to that noted for hugs and massage, so it's not surprising that it had calming effects.

Although the **frontal-striatal area** has been noted to be activated during comforting touch, for example, during handholding, others have suggested that multiple areas of the brain are activated by comforting touch [3]. In a paper entitled "Getting in touch: a neural model of comforting touch", physical, social and emotional pain and stress have been notably associated with activation of the **dorsal anterior cingulate cortex** [43]. Comforting touch has been noted to modulate this activation. Surprisingly, there was no mention of the possibility that handholding stimulates pressure receptors, as in the oscillating pressure sleeve.

In a review paper entitled "The calming effects of touch in human, animal and robotic interaction", several examples have been given including handholding, massage and pressure provided by animals and robots. The suggested mechanism for these calming effects involves the inhibition of the amygdala via **activation of the posterior insula and the prefrontal cortex** [44]. Other mechanisms suggested by these authors include the dampening of stress and the cortisol response to stress by **oxytocin and dopamine** as well as the **heart rate variability** increase noted in response to stress.

Similar mechanisms have been noted after handholding during thermal pain [5]. These authors referred to decreased pain being correlated with decreased brain circuitry in several areas associated with stress, including the **ventromedial, dorsomedial and prefrontal cortex, anterior cingulate, amygdala/hippocampus and the hypothalamus.**

A similar hypothesis has been advanced by the authors of the study on heart rate variability already described [11]. In interpreting their findings, they suggested that handholding stimulation is projected to the somatosensory area of the cerebral cortex by the brainstem reticular formation through cutaneous sensation. Then the **hypothalamus** stimulates the internal organs, including the heart and lungs, via the autonomic nervous system, causing fluctuations in heart rate.

Still others have noted the association between hugging and **pro-inflammatory cytokines** [45]. In this study, daily hugging was recorded over 14 days in 20 individuals, and saliva assays were conducted. Hugging was inversely related to two pro-inflammatory cytokines including IL-1B and TNF-alpha. Associations were also noted between hugging and IL -6 and IL-8 in the same direction but these negative correlations were not significant. Unfortunately, this was a small sample study and only the frequency of hugging was noted, not the duration, pressure, body position and number of different huggers. In addition, other pro-inflammatory markers could have been measured including C-reactive protein.

Strikingly absent from the literature on handholding and hugging is the potential mechanism of **stimulating pressure receptors** that

has been extensively studied by researchers of massage therapy [8]. As has been documented in a few studies on moderate pressure massage, the moderate pressure that is applied during hugging and handholding would be expected to increase **vagal activity**. This slowing of the nervous system would include decreased heart rate, blood pressure and brain waves associated with arousal (i.e. beta waves). In turn, stress hormones like cortisol would be reduced, **serotonin** (the brain's transmitter for reducing pain and for depression) would be increased and, in turn, pro- inflammatory cytokines would be decreased as has been already noted [45]. Increased serotonin has also been reported in a critical review of 11 studies. The effects on cortisol varied according to the amount of pressure. Moderate pressure elicited a parasympathetic response (increased vagal activity and a slowing of the nervous system) in contrast to light touch that elicited a sympathetic response (arousing the nervous system).

Other pain-associated hormones like substance P may have also been decreased, although substance P has not been measured. In turn, immune function would be expected to improve including increased natural killer cells (that kill bacterial, viral and cancer cells) that has been documented following moderate pressure massage [8]. Surprisingly, the massage therapy data have not been considered as a model for the handholding and hugging research. Handholding and hugging would seemly have similar underlying mechanisms for their effects on the reduction of pain and stress. And, directionality cannot be determined in these cross-sectional studies. The potential underlying mechanisms may instead be effects of the stimulation provided by the handholding, hugging and massage.

Methodological Limitations

Several methodological limitations can be noted for this literature. They include the exclusive focus on handholding as reducing pain and hugging reducing stress, as if they are uniquely expected to be comforting for those specific conditions. **No comparisons** have been made between these two touching modalities and the two conditions of stress and pain.

The studies have been **experimental versus naturalistic**. This limits their generalizability because it is not clear whether the laboratory results generalize to life-like situations. The naturalistic research on these behaviors may have been limited over this period due to social distancing during the COVID-19 pandemic.

All the studies have been focused on adults even though hugging and handholding are noted to be critical for infancy and early childhood development and notably prevalent during the romantic relationships of adolescents. And, the therapeutic aspects of hugging and handholding for older adults cannot be overlooked, although studies on that age group have not appeared in this recent literature.

The massage therapy studies are entirely **focused on clinical samples,** likely because they are convenience samples that can be readily recruited from hospitals and medical centers. As such, the findings have often been confounded when the massage has been an add-on therapy. For example, massage therapy has frequently been added to physical therapy. Without assessing separate control groups, the results have been confounded. In addition, this has amounted to massage therapy research being focused exclusively on intervention rather than prevention studies.

Many of the randomized controlled massage studies unfortunately involve placebo or inactive control groups rather than active control groups. For example, massage therapy has been compared to relaxation therapy that requires more compliance and effort on the part of the participants, making the comparison imbalanced. And the results then merely confirm earlier studies.

Although many different types of massage have been included in the meta-analysis studies, the individual style massages are rarely compared. When the data are grouped for meta-analyses, it appears that those therapies involving moderate pressure are effective while those featuring light pressure are not.

Although significant advances have been made in measurement technology, for example the fMRIs used in several of the hugging studies, the massage researchers have continued to use self-report scales or visual analogue measures. And even inexpensive measures like saliva cortisol assays have rarely been used.

Of course, massage therapy research can never be double-blind research because participants receiving massage expect or know that massage is going to be effective. This has biased them to give positive ratings, the bias referred to as "faking good" or "social desirability". The study on expectations highlights this problem [31].

Surprisingly, although immune measures were included in massage therapy studies many years ago, as for example, natural killer cell assays in studies on breast cancer and HIV, immune measures have not been included in recent studies. The immune studies informed research on potential underlying mechanisms and mechanism research is also missing from the recent literature. Nonetheless, more rigorous randomized controlled trials and meta-analyses in this literature have supported earlier research, highlighting the positive effects of massage therapy.

Most of the touching for stress and pain reduction studies in the recent literature have been conducted in Germany which has historically been viewed as a low touch culture. This potential **cultural specificity** again suggests the limited generalizability of these data.

Several **fMRI studies** have been conducted and/or are reviewed in this recent literature. But those are limited to identifying the location in the brain not the function or potential underlying mechanisms.

Of some concern is that **no intervention studies,** aside from the massage therapy studies, have appeared in this literature except perhaps the oscillating pressure sleeve study which was designed as a pressure measurement study rather than an intervention study [42]. Researchers have perhaps assumed that handholding and hugging are occurring in natural life and do not need formal interventions to show their effects on pain and stress reduction [46,47].

Conclusion

This narrative review involved entering the terms touching, massage, pain and stress on PubMed and PsycINFO literature

search engines. The search yielded 44 studies that are summarized here. The prevalence of touching has varied widely across cultures from a low of 57% in China to a high of 100% in Austria. Touching has been more prevalent in relationships with partners and children and was more diverse in warmer, less conservative and religious countries and among younger, female and liberal people. The three predominant forms of touching that appear in this literature include handholding primarily for painful conditions, hugging (embracing) for stressful conditions and massaging for both painful and stressful conditions. Other less prevalent literature addresses touching by robots, negative reactions to touching and the effects of COVID-19 on touching. Unlike earlier literature, most of the researchers have either measured or theorized underlying brain pathways for touching reducing pain and stress. Most of this research has been conducted in the laboratory as opposed to being naturalistic, so it is not clear how generalizable the data are to lifelike situations.

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