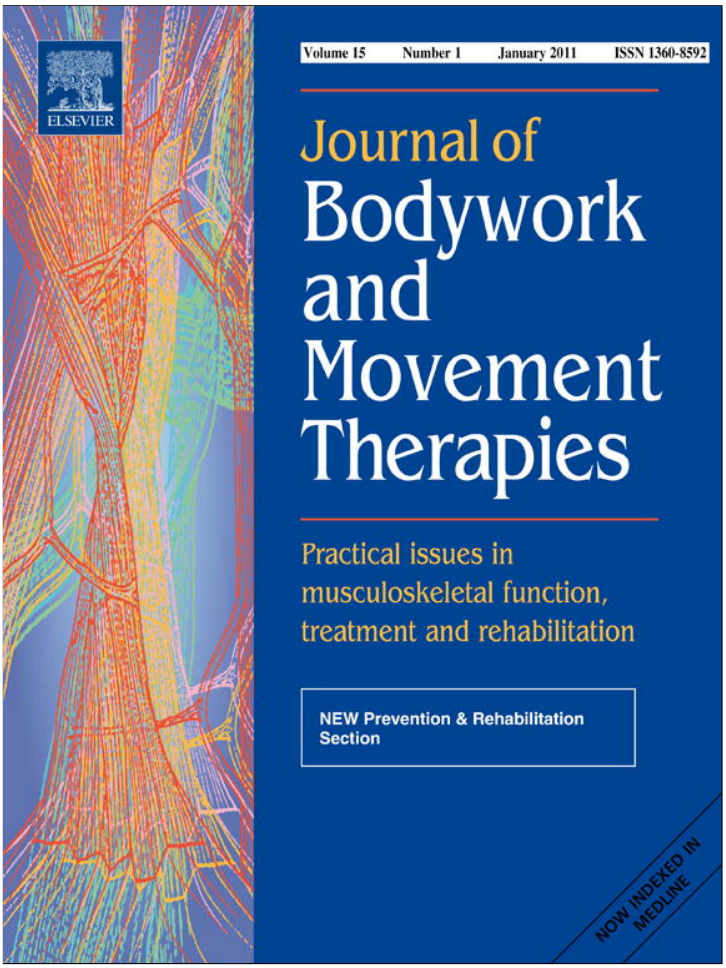

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Does massage therapy reduce cortisol? A comprehensive quantitative review

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Summary *Objectives:* It is frequently asserted that massage therapy (MT) reduces cortisol levels, and that this mechanism is the cause of MT benefits including relief from anxiety, depression, and pain, but reviews of MT research are not in agreement on the existence or magnitude of such a cortisol reduction effect, or the likelihood that it plays such a causative role. A definitive quantitative review of MT's effect on cortisol would be of value to MT research and practice.
Methods: After first performing a comprehensive literature search and retrieval, we use rigorous and conventional meta-analytic methods for calculating between-groups effect sizes. As a point of comparison, we also replicate an unconventional approach taken by other reviewers, in which MT recipients' within-group cortisol reductions are quantified as a percentage of change, despite the fact that this introduces numerous confounds not addressed by the first approach.
Results: Resultant between-groups effect sizes are almost all small (*d*s = 0.05–0.30) and nonsignificant. The lone exception is MT's multiple-dose effect in children, which is larger (*d* = 0.52) and statistically significant, but which is based on only three studies and vulnerable to the file-drawer threat. Within-group percentage reductions of cortisol in MT recipients are generally smaller than those found by other reviewers, and are generally inconsistent with the more rigorous between-groups results, which illustrates the unsuitability of this unconventional approach to assessment of treatment effects.
Conclusions: MT's effect on cortisol is generally very small and, in most cases, not statistically distinguishable from zero. As such, it cannot be the cause of MT's well-established and statistically larger beneficial effects on anxiety, depression, and pain. We conclude that other causal mechanisms, which are still to be identified, must be responsible for MT's clinical benefits.

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Massage therapy (MT), the manual manipulation of soft tissue to promote health and wellness, has several beneficial effects validated by research. Researchers generally agree that MT can lessen the pain associated with some specific conditions (e.g., low back pain, Furlan et al., 2008; arthritis, Beider and Moyer, 2007) and reduce anxiety and depression (Moyer et al., 2004; Field, 1998). Some evidence also suggests that MT may promote weight gain in premature infants (Field, 1998; Field et al., 2007; Scafidi et al., 1990), though more evidence is needed to establish cost-effectiveness (Vickers et al., 2004).

But despite the general consensus for these MT effects, there is much less consensus on their underlying causal mechanisms. This is especially true for the assertion that MT reduces bodily levels of cortisol, a hormone regulated by the hypothalamic-pituitary-adrenocortical axis that is associated with psychological, physiological, and physical health functioning. The possibility that MT's clinical benefits are brought about by the treatment's ability to reduce cortisol is frequently reported as established fact in the research literature (e.g., Field et al., 2005; Field, 1998), in the popular press (e.g., Lewis, 2007; Ehrenfeld, 2008; Gupta, 2008; Westlake, 2009; Yorio, 2009), and by professional MT organizations (e.g., American Massage Therapy Association, 2009), even though this assertion is contentious.

Six previous reviews have examined MT's effect on cortisol. These reviews, some narrative and some quantitative, are not in agreement despite the fact they draw on many of the same individual studies. We summarize their findings in the following paragraphs and in Table 1.

Field, 1998

This seminal article is the first attempt to comprehensively review MT effects in human recipients of all ages, and the theories that might explain those effects. Studies conducted by Field's Touch Research Institute (TRI) are emphasized, though some other studies are also included in support of MT's potential to facilitate growth, reduce pain, increase alertness, reduce depression, and enhance immune function. MT's effect on human cortisol levels is reported to be consistent across the range of studies reviewed, and is strongly asserted as a precursor to its beneficial effects. The assertion that cortisol reductions underlie MT's effects in human recipients is offered in conjunction with the observation that massage-like procedures performed on mammalian laboratory animals, especially procedures that apply firm rather than soft pressure, reduce the animals' stress hormone levels. With regard to human recipients, Field states that firm-pressure MT "may increase vagal activity, which in turn lowers physiological arousal and stress hormones (cortisol levels)" (p. 1278). This review is limited by its strictly narrative format, which does not quantify the magnitude, consistency, or statistical significance of the effects it describes, and by its emphasis on the findings of a single laboratory, which leaves open the possibility that other MT studies with contradictory findings have been omitted.

Table 1 Summary of previous reviews concerned with MT and cortisol reduction.

Review	Participant age range	Quantification of effect	Effect size	Conclusion
Field (1998)	All	None	n/a	*"Across studies, decreases were noted in… stress hormones (cortisol)"* (p. 1278).
Moyer et al. (2004)	Non-infant	Between-groups standardized mean difference	$g = 0.14$ (95% CI $= -0.10, 0.38$)	*"Cortisol… was not significantly reduced, a finding that contrasts with the conclusion previously reached by Field (1998)"* (p. 13).
Field et al. (2005)	All	Within-group percentage of change	31% mean decrease	*"Positive changes have been noted in biochemistry following massage therapy including reduced cortisol"* (p. 1411).
Beider and Moyer (2007)	Pediatric	Between-groups standardized mean difference	$g = 0.28$ (95% CI $= -0.27, 0.84$)	*"There is currently scant evidence that MT provides benefits by first reducing cortisol, as MT's effect on this stress hormone is seen to be small when analyzed correctly"* (p. 33).
Field et al. (2007)	All	None	n/a	*"To date, we can confidently say that stimulating pressure receptors under the skin leads to a cascade of events including… decreasing cortisol"* (p. 85).
Moraska et al. (2008)	Adult	None	n/a	*"A reduction in salivary cortisol was evident following a single massage treatment, yet salivary cortisol returns to initial values when assessed at a later time point, even if massage therapy was administered during the interim timeframe."* (p. 8).

Note. CI = Confidence interval.

Moyer et al., 2004

This article is the first wide-ranging meta-analysis of MT effects in human recipients other than infants. The authors conducted a systematic search of the MT research literature, converted the results of randomized controlled trials into standardized mean difference effect sizes that objectively compare the effect of MT against control treatments, and applied a trim and fill procedure (Duval and Tweedie, 2000) to explore the possibility that significant results were influenced by publication bias. These steps improve upon narrative review techniques by producing results that are objective, replicable, and quantifiable. Only seven studies that assessed the effect of MT on cortisol with data sufficient for meta-analysis were located; six of these seven studies were from TRI. Meta-analytic results indicate that MT recipients, on average, had cortisol levels that were only 0.14 standard deviations lower than recipients who had experienced a wait-list condition or a comparison treatment (e.g., engaging in progressive muscle relaxation), a small and nonsignificant (95% CI = −0.10, 0.38) effect. The authors concluded that cortisol levels were not significantly reduced by MT, and noted that this conclusion differs markedly from that reached by Field (1998).

Field et al., 2005

This article reviews the effects of MT on biochemistry, including cortisol levels. The authors identify 17 TRI studies that have examined the effect of MT on cortisol, and calculate the average percentage decrease in cortisol levels that were experienced by MT recipients during the treatment period. Combining these, they conclude that MT decreases cortisol levels an average of 31%. Limitations of this review are numerous and include (a) restriction to TRI studies; (b) equal weighting of all studies, despite the fact that they contain different numbers of participants; (c) using percentage of change as the measure of effect, instead of conventional and more rigorous meta-analytic effect sizes; and (d), omitting control group data from studies that randomized participants to both treatment and control groups. Each of these limitations has the potential to bias or invalidate the final conclusion, especially the last two. Total reliance on percentage of change as a measure of effect is potentially misleading, given this form of quantification presumes that zero is a realistic value for cortisol level, when it almost certainly is not. Further, no source that we know of advocates percentage of change as a statistically valid measure of effect. More egregious, however, is the decision to omit control group data from controlled studies. Possibly, the cortisol levels of control group participants decreased a similar amount, which would mean MT had no unique effect on cortisol. Alternately, if control participants' cortisol levels tended to increase, omitting these data would mean that MT's effect on cortisol would be significantly underestimated as a result. In addition, eliminating all control group data introduces numerous well-known threats to validity, including time, spontaneous remission, attention and placebo effects, and regression to the mean. Because all control group data has been omitted from this review, its potential to inform us of the effect of MT on cortisol is extremely limited.

Beider and Moyer, 2007

This review examines several MT effects in pediatric samples. The authors located only two studies that assessed the effect of MT on salivary cortisol with sufficient data to permit effect size calculation. Results indicated that MT recipients, on average, had posttest cortisol levels only 0.28 standard deviations lower than control participants, a small and nonsignificant (95% CI = −0.27, 0.84) effect that parallels the result for adults in Moyer et al. (2004). In addition, the authors found no evidence of an MT effect on immune system functioning in pediatric participants, an effect that other researchers do claim and ascribe directly to MT's cortisol reducing effect (Diego et al., 2001). A limitation of this pediatric review is its reliance on a very small number of studies.

Field et al., 2007

The authors of this narrative review state that it is an update of Field's 1998 narrative review (1998), and conclude that "we can confidently say that stimulating pressure receptors under the skin leads to a cascade of events including… decreasing cortisol, which may facilitate immune function" (p. 85). The limitations of this review are the same as those discussed in reference to the 1998 narrative review, and no mention of other researchers' contradictory findings is made.

Moraska et al., 2008

This review examines stress-related physiological adjustments resulting from MT, including cortisol changes. A strength of this review is its systematic literature search. Because the review is not limited to studies that provide sufficient data for effect size calculation, the authors were able to include a larger sample of studies than some previous reviews. They located four studies that assessed only salivary cortisol, five studies that assessed only urinary cortisol, and four studies that assessed cortisol in both these ways. Based on these studies, they conclude that "hormonal variables associated with stress were largely unaffected by multiple massage treatments," but go on to note that "a reduction in salivary cortisol was evident following a single massage treatment… [however] salivary cortisol returns to initial values when assessed at a later time point, even if massage therapy was administered during the interim timeframe" (p. 8). This review is limited by its dependence on analyses and conclusions presented in the original studies, as opposed to conducting a systematic, quantitative analysis based on the original data. This is problematic because the quality of MT research varies greatly, and it is not unusual for original study authors to perform unsuitable analyses (e.g., pre-post within-group analyses that do not match a study's between-groups design) and, subsequently, to reach conclusions that are not supported by the data collected (Moyer, 2009).

Six reviews, then, which draw on an overlapping set of original studies, reach quite different conclusions. The aim of the current review is to address this controversy by rigorously and comprehensively quantifying the effect of MT on recipients' cortisol levels. Given the recent and rapid

increase in MT research (Moyer et al., 2009), we expect to improve on the number of studies that were able to be included in previous quantitative reviews. Further, we improve on narrative reviews, including the most recent ones, by (a) conducting a wide-ranging literature search to obtain the largest and least-biased possible sample of suitable studies; (b) objectively quantifying effects, as opposed to relying on a narrative format; (c) presenting the results of controlled, between-groups standardized mean difference effect sizes alongside the corresponding within-group percentage reductions of cortisol that were experienced by MT participants; and (d) transparently reporting whether cortisol was assessed via blood, saliva, or urine.

Methods

Operational definition

MT can take various forms and can be applied to various anatomical sites. In addition, it is not established that commonly used MT terms (e.g., Swedish) have precise or universally agreed upon meanings. The present review operationalizes MT as *the manual manipulation of soft tissue to promote health and wellness*. We systematically exclude self-massage and specific medical interventions (e.g., cardiac massage). Also excluded are combination treatments in which research participants receive MT in conjunction with some other form of treatment other than standard care. Use of lubricating oils or lotions and exposure to music are not considered part of combination treatment when used with MT, as these are commonly part of MT in ordinary practice.

Literature search and inclusion criteria

A search concluded on January 6, 2010, using the keywords *massage* and *cortisol*, yielded the indicated number of articles in the following databases: CINAHL, 28; *Dissertation Abstracts*, 5; Google Scholar, 1997; PsycINFO, 168; and PubMed, 86. The abstract of each article was examined to determine possible relevance, and only articles that were clearly irrelevant were discarded, which resulted in an initial database of 173 articles requiring closer inspection.

These 173 articles were scrutinized to determine if they (a) examined a treatment that fit our operational definition of MT, (b) provided graphical and/or numerical data on the effect of MT on cortisol levels in human recipients, (c) used random assignment of participants to an MT condition and one or more control conditions, and (d) reported results not duplicated in another retrieved article. This yielded 18 articles, containing 19 studies, that met all three criteria. The following information was then extracted, independently by two different raters, from those 18 articles and entered into a database: publication year, type of MT performed, site to which MT was administered, training of person(s) who administered MT, age of participants, duration of individual MT sessions, number of MT sessions, study duration, type of control(s) used, number of participants receiving MT or control treatment(s), form of cortisol assessment, and all relevant cortisol data. In cases where an article was suitable for inclusion but did not include sufficient data for effect size calculation (e.g., means are provided but standard deviations or standard errors are not), attempts were made to contact article authors to determine if the necessary data was available, but in no case was this effort fruitful.

Study details and data

Study coding

All data was coded by two raters independently. The lead author (C.A.M.) coded all studies, and three students (L.S., E.S.M., and L.M.J.) who received prior training from the lead author each coded a portion of the studies. Agreement rates (*AR*) were >92% for most categories; lower but acceptable agreement rates were attained for study *n*s (*AR* = 85%) and therapist training (*AR* = 82%). Discrepancies were resolved by first checking for coding or data entry errors, which were subsequently corrected. In the smaller number of instances where discrepancies represented a difference in judgment among coders, the first author (C.A.M.) conferred with the other rater before making a final determination.

Types of effects

MT effects can logically be divided into *single-dose effects*, which may result from a single session of treatment, and *multiple-dose effects*, which may result from a series of treatments (Moyer et al., 2004). MT's effect on cortisol has been researched in both of these ways, sometimes simultaneously, as illustrated by a study of MT for infants of depressed mothers (Field, Grizzle, et al., 1996). In that study, infant subjects were randomly assigned to receive twice-weekly 15-minute sessions of MT, or to be held and rocked in a rocking chair according to the same schedule, across a period of six weeks. Single-dose effects were examined by pretest and posttest assessments of salivary cortisol performed at the first session of MT or rocking. Multiple-dose effects were examined by assessments of urinary cortisol prior to the first session, and following the twelfth and final session, for both groups.

In some studies, the single-dose effect is examined twice; once at the first session in a series of treatments, and again at the last session in a series of treatments. This pattern makes it practical to separately examine the single-dose effects of a first session versus those of a last session. Beider and Moyer (2007) discovered that, for pediatric samples, the single-dose effect of a first MT session and those of a last MT session in a series are significantly different for state anxiety; both are effective, but the effect from the last session in a series is significantly larger. This suggests that there may be adaptive processes involved in receiving MT. For this reason, we examine the single-dose cortisol reducing effects of a first MT session in a series, and those of a last MT session in a series, separately. When primary studies administered only a single session of MT, as many do, we treat that single session as a first session in the current review. In all studies we examined, MT's single-dose effect on cortisol is assessed by means of a blood draw or a saliva sample, both of which are suitable for capturing a short-term change in cortisol (Lovallo and Thomas, 2000).

Occasionally, the multiple-dose effect of MT on cortisol assessed in a specific study could be quantified in at least two ways. Urinary assessment of cortisol is most often used

across a series of treatments, but selective use of salivary assessments taken at the corresponding times might also be used to capture the multiple-dose effect. Using assessments of cortisol in blood and saliva in this way allows inclusion of a greater number of studies to examine the multiple-dose effect in the current review, because there are some studies that administer a series of treatments without assessing urinary cortisol. The decision to proceed in this manner is supported by findings in recent large scale quantitative reviews concerned with cortisol that find no effect related to method of assessment (Meewisse et al., 2007; Michaud et al., 2008). Nevertheless, we include information on the method of cortisol assessment for each individual study and also conduct a separate analysis of multiple-dose effects based only on the results of urinary cortisol assessments.

Multiple studies in a single document
In all but one case, each MT research document includes a single study. The exception is the study by Olney (2007) in which two different MT treatment groups are included. In this case, we treated those results as separate independent studies in the current review because we wished to retain the unique information provided by two different MT conditions (one which delivers a series of five 10 m sessions of MT, and one which delivers a series of ten 10 m sessions of MT) even though this violates the condition that individual study effect sizes should be statistically independent (Lipsey and Wilson, 2001). We also check the influence of this decision on our results by conducting secondary analyses in which the two study results from Olney (2007) are averaged to yield a single study result.

We also attempted to extract the following pieces of information from every study, as presented in Table 2. Exceptions were made when a category did not apply to a particular study.

Anatomical site to which MT was applied
Studies vary in the anatomical sites to which MT is applied. In some the site for MT is very limited and specific, while in others MT may be applied to the entire body. Based on our familiarity with the individual studies, we settled on the following descriptors: full body, upper body, back, neck and shoulders, feet.

MT type
We attempted to record information on the type of MT used in each study. However, at the conclusion of coding, we had to acknowledge that the MT terminology and methods of description in use to date are insufficient to yield usable information for this category. Eventually, the recent development and implementation of valid MT taxonomies (e.g., Sherman et al., 2006) may address this problem.

Therapist training
Most studies report having used a professional massage therapist for provision of treatment, while other studies report having used a layperson with only minimal MT training or provide no information on therapist training. We coded studies for therapist training in three ways; those that clearly used a professional massage therapist, those that used a minimally trained layperson, and those that provided no information on therapist training. In cases where it was difficult to distinguish whether the person providing MT was professionally or minimally trained, we coded the study as having used a person with minimal training.

Description of sample
This indicates important characteristics of the participants, including clinical conditions.

Sample age
Almost all studies provide information on the age of participants. Most often this is expressed as a mean, but occasionally a range is provided. This data permits us to calculate results separately for children and adult recipients. In separate analyses, we considered studies in which the mean age of participants was less than 18 years of age to be a study of MT for children.

Treatment minutes per dose
This is the duration of each individual MT treatment administered in the study.

Number of doses
This is the number of MT treatments administered to a participant during the course of the study.

Study duration
This is the interval of time across which multiple MT treatments were administered. This category does not apply to studies that examine the effect of a single MT treatment.

Description of control
This indicates the form of time-matched treatment or attention that control participants received.

MT and control N
These are the number of participants who received MT or a control treatment. These groups are exclusive.

Method of cortisol assessment
This indicates if cortisol levels were assessed in blood, saliva, or urine.

Quantification of effect
Between-groups comparisons of cortisol levels were converted to Cohen's *d* effect size. Cohen's *d*, calculated as (Group Mean 1 − Group Mean 2)/pooled standard deviation, estimates the number of standard deviations by which the average member of a treatment group differs from the average member of a control group for a given outcome. Individual study effect sizes were subjected to a correction for small sample bias, then weighted by their inverse variance and averaged to generate a mean effect size for each outcome variable. Positive values represent a more desirable effect (i.e., a lower cortisol level) for participants who received MT. Homogeneity analyses were performed on each mean effect size by calculation of the *Q* statistic, to determine if the dispersion of the individual effect sizes around their mean is greater than that expected due to sampling error alone (Lipsey and Wilson, 2001). Statistical significance of the mean effect sizes was assessed by

Table 2 Individual study details.

Study	Site	Train?	Sample	Age	Mns/ sess	#sess	Pd	Ctrl	Ns		Cort asmt	Between-groups Effect Sizes (*d*)		
									MT	Ctrl		SD, first	SD, last	MD
Arroyo-Morales et al. (2009)	FB	—	University students completing Wingate tests	21 yrs	40	1	—	Sham electrotherapy	32	28	S	0.13	—	—
Chin (1999)	B	—	Gynecologic surgery patients	42 yrs	10	2	2d	Attn	34[a]	29[b]	B	0.13	0.00	0.00
Ditzen et al. (2007)	NS	—	Heterosexual partnered women	26 yrs	10	1	—	Attn (n = 22), no treatment (n = 25)	20	47	S	−0.11	—	—
Field, Grizzle, et al. (1996)	FB	—	Infants of depressed mothers	39w	15	12	6w	Held + Rocking	20	20	S, U	0.20	—	0.82
Field, Ironson, et al. (1996)	UB	Y	Medical staff	26 yrs	15	10	5w	PMR	26	24	S	0.72	0.18	0.18
Field et al. (1997)	FB	N	Children with juvenile rheumatoid arthritis	10 yrs	15	30	30d	RT	*10*	*10*	S	0.70	0.55	0.55
Field et al. (2009)	FB	Y	Depressed pregnant women	25 yrs	20	6	6w	SC	22	21	S	—	0.18	0.18
Hernandez-Reif et al. (2000)	FB	Y	Hypertensive adults	52 yrs	30	10	5w	PMR	15	15	S, U	0.00	0.35	0.35
Hernandez-Reif et al. (2001)	FB	Y	Adults with low back pain	40 yrs	30	10	5w	RT	12	12	U	—	—	−0.38
Hernandez-Reif et al. (2002)	FB	Y	Parkinson's patients	58 yrs	30	10	5w	PMR	*8*	*8*	U	—	—	0.41
Hernandez-Reif et al. (2004)	FB	Y	Postsurgery breast cancer patients	53 yrs	30	15	5w	SC	18	16	U	—	—	0.08
Khilnani et al. (2003)	FB	Y	Children and adolescents with ADHD	13 yrs	20	9	4w	WL	15	15	S	0.00	0.14	0.14
Leivadi et al. (1999)	UB	Y	Female university dance students	20 yrs	30	10	5w	RT	15	15	S	0.15	0.11	0.11
Mackereth et al. (2009)	F	—	Multiple sclerosis patients	50 yrs	40	6	6w	PMR	25	25	U	0.04	0.00	0.00
McVicar et al. (2007)	F	—	Healthy individuals	16—59 yrs	60	1	—	Attn	10	10	S	−0.17	—	—
Menard (1995)	FB	Y	Gynecologic oncology patients	52 yrs	45	5	5d	SC	15	15	U	—	—	0.74
Olney (2007)	B	Y	Hypertensive and pre-hypertensive adults	49 yrs	10	5	2w	RT	13	14	S	—	—	−0.24

Olney (2007)	B	Y	Hypertensive and pre-hypertensive adults	49 yrs	10	10	4w	RT		15	14	S	—	—	−0.11		
Taylor et al. (2003)	FB	Y	Abdominal postsurgery women	56 yrs	45	3	3d	SC		34	36	U	—	—	−0.16		

Note. Dashes indicate that data were not reported, are not relevant, or could not be calculated. Site = Anatomical site to which massage therapy was applied; FB = Full body; B = Back; NS = Neck and shoulders; UB = Upper body; F = Feet. Train? = Use of professionally trained massage therapist; Y = Yes; N = No. Mns/sess = Length, in minutes, of individual massage therapy and control sessions. #sess = Total number of massage therapy and control sessions administered. Pd = Time period across which multiple sessions of treatment were distributed. Cort asmt = Method of cortisol assessment; B = In blood; S = In saliva; U = In urine. SD = Single-dose; MD = Multiple-dose; d = Days; w = Weeks; m = Months; SC = Standard care; Attn = Attention; RT = Relaxation therapy; PMR = Progressive muscle relaxation. ADHD = Attention-deficit hyperactivity disorder. Ns in italics indicate the original study reported only total *N*, and in these cases we assumed even distribution among massage therapy and control groups.

[a] = this *N* was only 31 at the last session of massage therapy.

[b] = this *N* was only 23 at the last control session.

Effect sizes are recorded such that positive values indicate a lower level of cortisol for the massage therapy group compared to controls.

calculating the 95% confidence interval (CI) for the population parameter. A significance level of 0.05 or better is inferred when zero is not contained within the CI. A random-effects model was used for the calculation of all between-groups mean effects.

As a supplement to the calculation of between-groups effects, and based on the same set of studies, we also present the within-group percentage-point reduction in cortisol level exhibited by MT recipients, which replicates the unconventional approach used in Field et al. (2005). This is calculated as (pretest cortisol value − posttest cortisol value)/pretest cortisol value, corresponding to the time interval of interest. Individual study's percentage-point reductions were then weighted by study size (*N* of MT recipients) and averaged to yield mean percentage-point reductions.

Results

Table 2 summarizes 19 studies, extracted from 18 reports, that provide quantifiable between-groups data on MT's cortisol effect. The present dataset comprises 704 individuals (614 adults), 359 of whom were randomized to an MT condition (including 314 adults). As predicted, this is considerably more (over two-and-a-half times as many studies, and participants) than were able to be included in a quantitative analysis of cortisol effects published in 2004 (Moyer et al., 2004). The average session length for MT, across all participants in the current dataset, was 26 and-a-half minutes (range 10—60 m).

Table 3 summarizes all of the following between-groups effects as well as the supplementary analysis of within-group percentage-point reductions of cortisol exhibited by MT recipients.

Between-groups effect sizes

Single-dose, first session

There were 460 participants across eleven studies who were randomly assigned to receive either a single-dose of MT that could be considered the first in a series of treatments, or a time-matched control treatment. Comparison of MT versus control posttest values indicates that MT did not reduce cortisol significantly more than control treatments ($d = 0.15$, 95% CI = −0.04, 0.34). These results are displayed graphically in Figure 1.

Examined separately, children's ($N = 90$) and adults' ($N = 370$) effect sizes were also both nonsignificant ($d = 0.23$, 95% CI = −0.19, 0.65; and $d = 0.13$, 95% CI = −0.08, 0.34, respectively). Homogeneity analyses for all three of these effects were nonsignificant (all three ps > 0.49), which suggests there is no more variability around these effects than that expected from sampling error.

Single-dose, last session

There were 307 participants across eight studies who were randomly assigned to receive either a single-dose of MT that could be considered the last in a series of treatments, or a time-matched control treatment. Comparison of MT versus control posttest values indicates that MT did not reduce cortisol more than control treatments ($d = 0.15$, 95% CI = −0.08, 0.37). These results are displayed graphically in Figure 2.

Table 3 Mean cortisol reductions across massage therapy studies.

	Between-groups effect sizes					Within-group reductions for MT
	d	95% CI	*N*	Study entries	*Q*	%
Single-dose, first in series	0.15	−0.04, 0.34	460	11	7.12	12.8
Children	0.23	−0.19, 0.65	90	3	1.41	20.7
Adults	0.13	−0.08, 0.34	370	8	5.51	10.8
Single-dose, last in series	0.15	−0.08, 0.37	307	8	1.67	18.6
Children	0.30	−0.27, 0.87	50	2	0.48	18.5
Adults	0.12	−0.13, 0.37	257	6	0.86	18.6
Multiple-dose	0.12	−0.05, 0.28	598	16	13.84	22.1
Children	0.52[a]	0.09, 0.95	90	3	1.88	35.0
Adults	0.05	−0.13, 0.22	508	13	7.88	19.8

[a] $p < 0.05$.

Examined separately, children's ($N = 50$) and adults' ($N = 257$) effect sizes were also both nonsignificant ($d = 0.30$, 95% CI = −0.27, 0.87; and $d = 0.12$, 95% CI = −0.13, 0.37, respectively). Homogeneity analyses for these three mean effects were nonsignificant (all three *p*s > 0.49), which suggests there is no more variability around these effects than that expected from sampling error.

Multiple-dose

There were 598 participants across sixteen studies who were randomly assigned to receive either a multiple-dose series of MT treatments or a time-matched control treatment. Comparison of MT versus control posttest values indicates that, across all participants, MT did not reduce cortisol more than control treatments ($d = 0.12$, 95% CI = −0.05, 0.28). These results are displayed graphically in Figure 3. Averaging the results of the two studies contained in Olney (2007) as a single study, as opposed to treating them as statistically independent studies, has little influence on this result ($d = 0.13$, 95% CI = −0.04, 0.29).

We also conducted a supplementary analysis of multiple-dose effects based only on the results of urinary cortisol

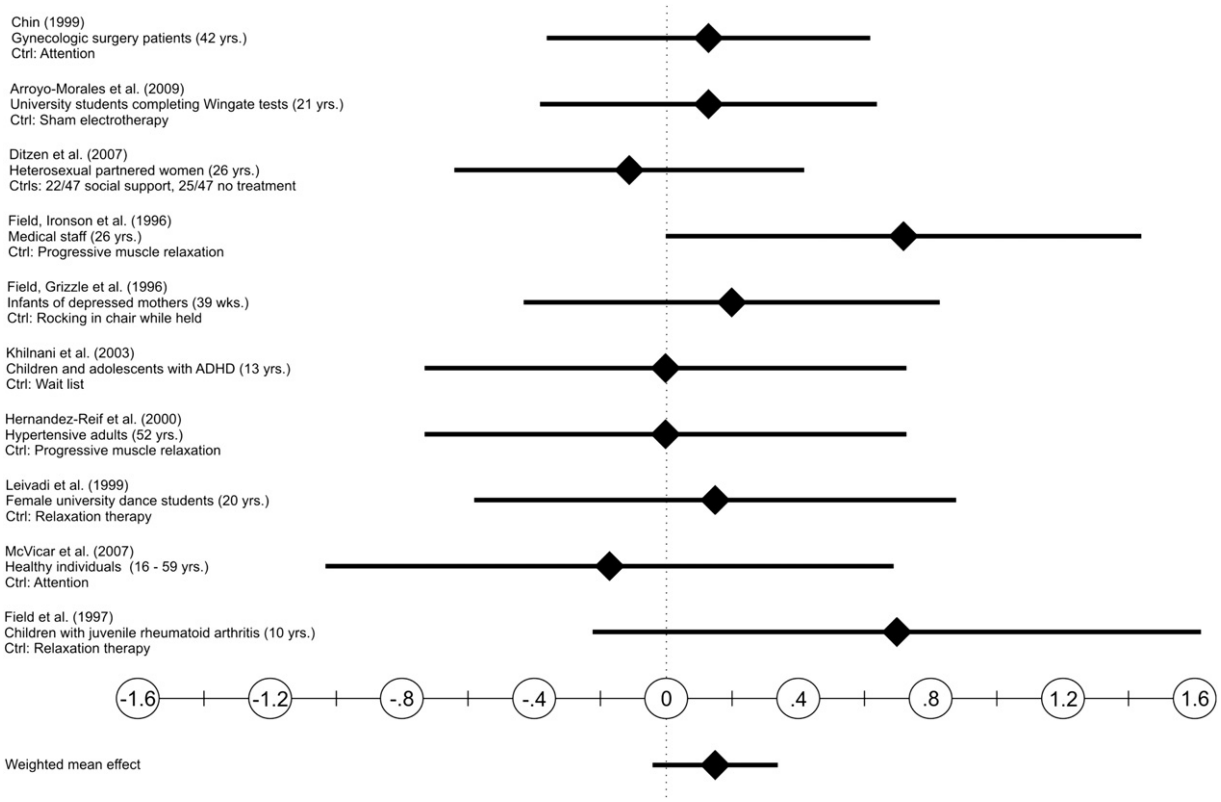

Figure 1 Single-dose, first in series effect sizes and 95% confidence intervals.

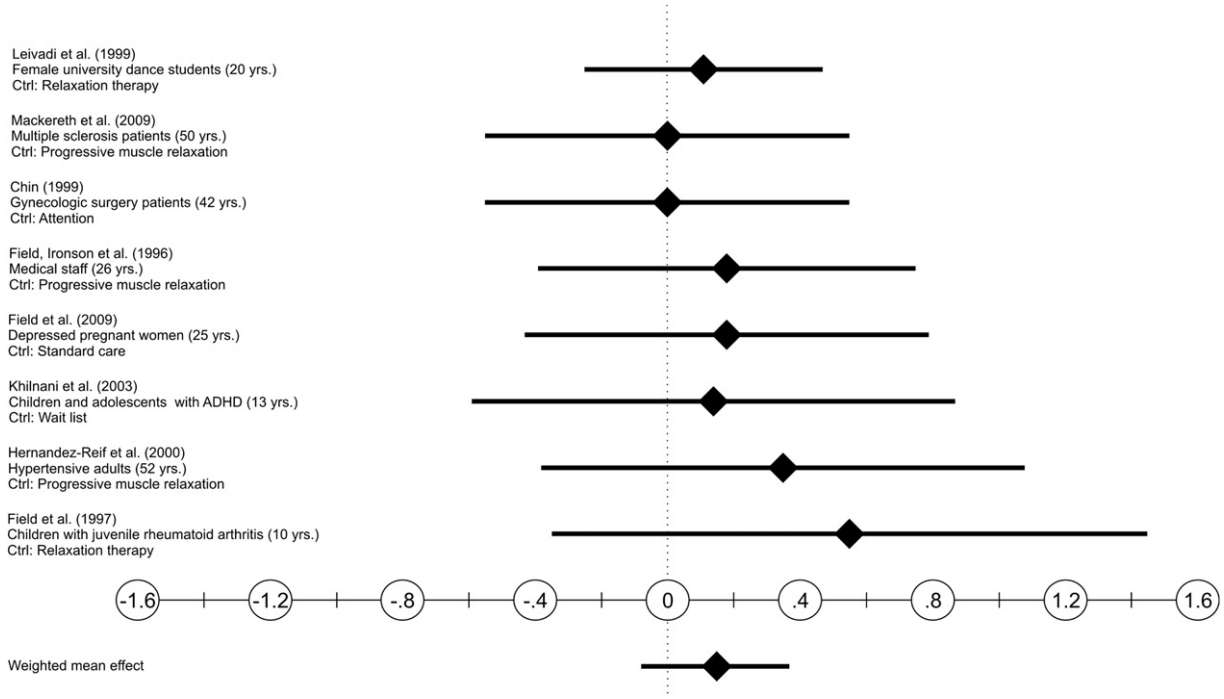

Figure 2 Single-dose, last in series effect sizes and 95% confidence intervals.

assessments. The result from this smaller subset of six studies and 249 participants is essentially the same mean effect bracketed by a wider confidence interval ($d = 0.15$, 95% CI $= -0.11, 0.41$).

When multiple-dose effects are examined individually according to the age range of participants, results diverge. The result for adults ($N = 508$) is very small and nonsignificant regardless of whether the results from Olney (2007) are treated as two independent studies ($d = 0.05$, 95% CI $= -0.13, 0.22$) or averaged as a single study ($d = 0.06$, 95% CI $= -0.12, 0.23$). In contrast, children's ($N = 90$) cortisol was reduced significantly more by multiple doses of MT than by control treatments ($d = 0.52$, 95% CI $= 0.09, 0.95$, $p < 0.05$). Homogeneity analyses for all three multiple-dose effects were nonsignificant (all three ps > 0.39), which suggests there is no more variability around these effects than that expected from sampling error.

Within-group percentage reductions of cortisol exhibited by MT participants

Though we do not wish to emphasize them as our primary findings, we also calculated the within-group effect on cortisol evidenced by massage therapy participants, expressed as percentage-point reductions. Our motivation for doing this was to permit direct comparisons with the results of Field et al. (2005), and with the current between-groups results. MT recipients in these between-groups studies exhibit mean reductions of cortisol that range from 10.8% (single-dose reduction from a first treatment in adults) to 35.0% (multiple-dose reduction in children). Eight of these nine means are lower than the 31% mean cortisol reduction reported by Field et al. (2005), a difference that is probably attributable to using an overlapping but not identical set of studies, and to our decision to weight these reductions by sample size prior to averaging.

There are numerous discrepancies between the between-groups and within-group results. For example, most of the within-group reductions cluster near a 20% reduction (six of them are between 18.5% and 22.1%), but the corresponding between-groups effects for these studies exhibit a six-fold range ($d = 0.05$—0.30). Further, the correlations between individual studies' between-groups effect sizes and their within-group percentage-point reductions do not attain values indicative of good reliability ($r = 0.42$ for single-dose, first session; $r = 0.25$ for single-dose, last session; $r = 0.73$ for multiple-dose). Because the meta-analytic procedures for calculating standardized mean effects such as d have been widely used and refined, and are recommended by many methodologists (Lipsey and Wilson, 2001; Hunter and Schmidt, 2004; Rosenthal, 1998), and also because quantifying treatment effects only from the treatment group data collected in controlled trials introduces numerous well-known confounds (e.g., time, spontaneous remission, attention and placebo effects, and regression to the mean), we conclude that the general lack of correspondence between the between-groups and within-group effects demonstrates the latter's unsuitability as an index of treatment effectiveness.

Discussion

The assertion that MT significantly reduces cortisol levels is refuted by the results of this review. These results are highly consistent with the results of prior quantitative reviews, and the methods by which they have been reached

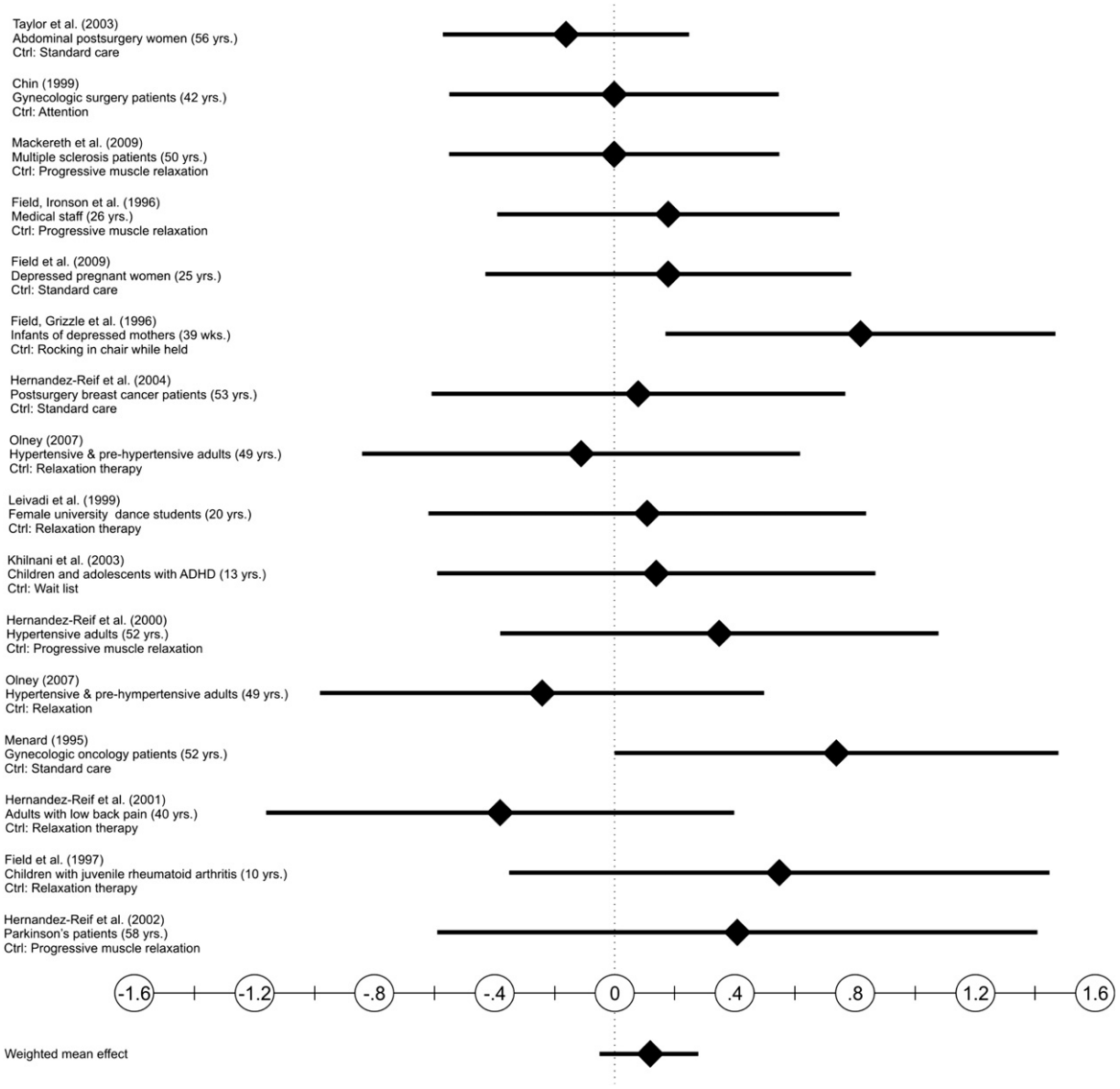

Figure 3 Multiple-dose effect sizes and 95% confidence intervals.

are transparent and much less prone to bias than those of narrative reviews. As such, we confidently recommend that the current results, and the conclusions to which they lead, should replace those reached in narrative reviews concerned with the effect of MT on cortisol. MT's mean effect on cortisol is very small and, in most cases, not statistically distinguishable from zero.

The exception to this is the multiple-dose effect of MT on the cortisol levels of children. This effect does reach statistical significance, though we hasten to add that it is based on a very small number of studies and participants, and so is vulnerable to the file-drawer threat (the likelihood that even a small number of relevant but unpublished, and therefore irretrievable, studies with null findings are languishing in the desk drawers of the researchers who conducted them). In addition, this effect combines the results of an infant study (mean subject age 39 weeks) with those of two studies on more developed children (mean participant ages 10 and 13 years), and the effect contributed by the infant study is the largest by a considerable margin. It is possible that MTs effect on the cortisol levels of infants is distinct from its effect on other age populations, but currently available data do not permit this possibility to be examined further.

The results of studies conducted with adults, on the other hand, are based on larger numbers of studies and participants, are highly uniform, and have reasonably narrow confidence intervals. In addition, the homogeneity analyses for these effects indicate that there is no more variability among the individual study effects than that expected from sampling error, which gives little reason to believe that some sizable cortisol reduction associated with MT performed for a certain duration, in a certain way, to a certain anatomical site, or under certain conditions, is being washed out by other forms of MT that do not reduce cortisol. In other words, the various

forms of MT being combined in these analyses appear to be equally ineffective in reducing cortisol levels.

However, it should not be concluded from this that MT is ineffective. MT has already been shown to have some significant and sizable clinical effects, especially for reducing anxiety, which may prove to be its most useful clinical effect and the basis of several of its other effects (Moyer, 2008). Rather, what the results of this review make apparent is that MT cannot be generating its sizable and proven reductions of state and trait anxiety, depression, and some types of pain by first reducing cortisol. Indeed, it is likely that the very small mean effect that MT has on cortisol — in most cases a reduction only 0.15 standard deviations better than control — is a clinically insignificant downstream effect, not the fundamental upstream cause, of MT's large effect on anxiety.

How does MT actually provide its verified clinical benefits?

While this review answers the question "does MT reduce cortisol?' — to which the answer is "very little, if at all" — in other ways it raises more questions than it answers. If MT does not provide its proven clinical benefits by first impacting the endocrine system in this way, how then does it work? Does it work primarily in one way, perhaps by first reducing anxiety, which carries over to other outcome categories, such as depression and pain, or is there a unique MT mechanism for reducing each of these? Will it be more fruitful to examine the impact of MT on the relatively faster-acting branches of the nervous system, as opposed to the relatively slower-acting endocrine system, to determine the biological underpinnings of MT benefits? Does it make sense to search for uniform biological mechanisms enacted by MT, or will it be necessary to construct explanatory models that emphasize the interaction of biological processes with psychological phenomena and social contexts that are associated with MT?

We do not yet know the answers to these questions. But we do know that they need to be researched, and we are concerned that they tend to be ignored when a competing explanation has been repeatedly and overconfidently asserted without supporting evidence, as has been the case with MT and cortisol reduction. We hope that the current review might stimulate other researchers' interest in the unknown causal mechanisms of MT's clinical effects, as it has for us.

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Conflict of interest

The authors have no conflict of interests to declare.

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