The Journal of Pain, Vol 13, No 1 (January), 2012: pp 1-9
Available online at www.sciencedirect.com

American Pain Society

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PUBLISHED BY ELSEVIER

Critical Review

Effects of Yoga Interventions on Pain and Pain-Associated Disability: A Meta-Analysis

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Abstract: We searched databases for controlled clinical studies, and performed a meta-analysis on the effectiveness of yoga interventions on pain and associated disability. Five randomized studies reported single-blinding and had a higher methodological quality; 7 studies were randomized but not blinded and had moderate quality; and 4 nonrandomized studies had low quality. In 6 studies, yoga was used to treat patients with back pain; in 2 studies to treat rheumatoid arthritis; in 2 studies to treat patients with headache/migraine; and 6 studies enrolled individuals for other indications. All studies reported positive effects in favor of the yoga interventions. With respect to pain, a random effect meta-analysis estimated the overall treatment effect at SMD = −.74 (CI: −.97; −.52, $P < .0001$), and an overall treatment effect at SMD = −.79 (CI: −1.02; −.56, $P < .0001$) for pain-related disability. Despite some limitations, there is evidence that yoga may be useful for several pain-associated disorders. Moreover, there are hints that even short-term interventions might be effective. Nevertheless, large-scale further studies have to identify which patients may benefit from the respective interventions.

Perspective:* *This meta-analysis suggests that yoga is a useful supplementary approach with moderate effect sizes on pain and associated disability.

Key words: *Yoga, pain, disability, review, meta-analysis, mind body medicine, complementary medicine.*

Pain disorders are most commonly treated with potent drugs such as nonsteroidal anti-inflammatory drugs, opioid analgetics, systemic corticoids, tricyclic antidepressants, and several others.[8,24,26,32,33,40] However, chronic pain is not exclusively a physical condition but a complex syndrome including physical, psychological, and social processes. With respect to the multifaceted causes, there is need for interdisciplinary procedures in diagnosis and pain management.[34] In fact, current pain research considers also psychological and social factors with a significant influence on chronic pain.[16,18,28,31] There is evidence that intensive multidisciplinary bio-psycho-social rehabilitation improves pain and function in patients with chronic disabling low back pain,[16] while the evidence for short-term effects of behavioral therapy in back pain is much weaker.[18] Astin[1] concludes that mind-body approaches (including some combination of stress management, coping skills training, cognitive restructuring, cognitive-behavioral therapy, relaxation therapy, imagery, hypnosis, etc.) may be appropriate adjunctive treatments in the management of various chronic pain conditions.

One of the best known and frequently used mind-body interventions is yoga. Its conceptual background is originated from Indian philosophy, and there are numerous schools or types of yoga (ie, Iyengar, Viniyoga, Shivananda, etc.) with distinct priorities in terms of spiritual and physical practices. A typical yoga session with a specific sequence of postures (asanas of Hatha Yoga),

The authors did not receive external grants or funds to perform this analysis. The authors declare no conflicts of interest.

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1526-5900/$36.00

doi:10.1016/j.jpain.2011.10.001

breathing techniques (pranayama), and mental concentration/meditation (dhyana) lasts between 1 and 2 hours. For yoga practitioners, there is no need to adopt specific spiritual attitudes or specific religious behavior. Yoga practices (particularly the asanas) may increase patient's physical flexibility, coordination, and strength;[35] the breathing practices and mediation may calm and focus the mind to develop greater awareness and diminish anxiety;[25] thus resulting in higher quality of life. Other beneficial effects involve a reduction of distress, blood pressure, and improvements in metabolic regulation.[44]

A recent review on the effects of various nonpharmacological interventions found good evidence that cognitive-behavioral therapy, exercise, spinal manipulation, and interdisciplinary rehabilitation are moderately effective for chronic low back pain; moreover, there was fair evidence for acupuncture, massage, or yoga.[9] Recently, Haaz and Bartlett[17] published a scoping review on yoga and arthritis, indicating a reduction of symptoms and disability. Thus, yoga could in fact be a beneficial supportive intervention, but there is currently a lack of an adequate meta-analysis to assess its effectiveness with respect to pain symptoms. To assess its putative relevance in the treatment of patients with various pain conditions, we performed a meta-analysis of the current literature focusing on pain and pain-associated disability.

Methods

Search Strategy

Until January 2010, we searched databases, ie, PubMed/Medline, the Excerpta Medica Database (EMBASE), and CAMbase for clinical studies focusing on yoga interventions and pain. English language search terms were "yoga * pain." To increase the chance to find all relevant publication describing the effects of yoga interventions on pain, there were no limitations in the initial search in terms of language, year, status, or design. Finally, we asked experts for gray literature not listed in the above mentioned databases, and checked the reference lists of relevant articles and authors.

Selection Criteria

All potentially eligible studies were retrieved and the full-text articles were reviewed to determine if they met the inclusion criteria.

Inclusion criteria were controlled clinical studies (randomized or nonrandomized) addressing the effects of yoga interventions on pain symptoms. The findings were analyzed with respect to 2 main outcome categories: 1) pain intensity/frequency (as measured with visual analogue/numeric rating scales, McGill pain questionnaire, or Cornell Musculoskeletal Discomfort Questionnaire); and 2) pain-induced disability (as measured with the Oswestry Disability Index, Pain Disability Index, Functional Disability Inventory, Roland Disability Index, Cornell Musculoskeletal Discomfort Questionnaire, Health Assessment Questionnaire, Maternal Comfort Questionnaire, or Sit-and-Reach Test).

We excluded case series, case reports, studies without a control group, expert statements, and theoretical reflections. We also excluded studies with complex interventions such as mindful-based stress reduction programs (which include yoga practices), because the contributing effects of the relevant elements are not distinguishable. Presentation of data follows the recommendation of the Moher's QUOROM and PRISMA statements.[29,30]

Data Extraction

Review authors (AB and TO) assessed studies for inclusion in the review. They took part in the extraction of data and independent assessment of methodological quality. Disagreements were resolved by consensus. We extracted study data on the following topics: general study design (prospective, multicenter etc.), treatment allocation (randomization, matched pairs, etc.), treatment concealment and blinding, treatments (yoga style and practices, duration and frequency, type of control intervention), patient characteristics (mean age, gender distribution), diagnosis, adherence to therapy (compliance, drop-outs, etc.), and outcome assessments.

To assess the methodological quality of the respective studies, we adopted the Jadad score, which refers to randomization (0 to 2 points), blinding of the assessor (statistician, physician, assessor or researcher, as cited in the original publications; 0 to 1 points) and dropout reporting (0 or 1 point) as indicators of methodological quality of a study.[22] Because it is impossible to also blind patients (double blind) in yoga studies, the maximum achievable Jadad score was 4 in our review. However, while it is clear what blinding of a statistician means, it is not very clear what blinding of researcher may mean; we assumed that this term refers to the outcome assessor.

Allocation concealment was assessed in accordance with the Cochrane guidelines[20]: A = adequate (telephone randomization or using consecutively numbered, sealed, opaque envelopes); B = uncertainty about the concealment (method of concealment is not known); C = inadequate (eg, alternate days, odd/even date of birth, hospital number).

Statistical Analysis

All relevant outcome data were extracted as they were given in the publication. They were converted into standardized mean differences (SMD) and their standard errors (SE) using standard formulas.[20] SMD < 0 indicate superiority of yoga treatment compared with control. SMDs $< -.5$ were regarded as putatively clinically relevant, and $< -.8$ as large effect.[43]

We performed various subgroup analyses with respect to condition, methodological quality, and duration of treatment. For pain outcomes we additionally performed a subset analysis for those studies which included a visual analogue scale (VAS) as an outcome parameter. Here, all VAS were linearly rescaled to 0 to 100 scoring and the analysis was based on weighted mean differences (WMD), calculated from the published mean changes for each group, instead of SMD to facilitate clinical interpretations.

Overall estimates of the treatment effect were obtained from random effects meta-analysis.[13] Heterogeneity between studies was assessed by standard χ^2–tests and the I^2 coefficient,[19] which measures the percentage of total variation across studies due to true heterogeneity rather than chance. Heterogeneity was further investigated by several subgroup analyses, formed by study quality (high: Jadad score = 4 and allocation concealment = A), moderate quality (scores 2–3), low quality (score 0–1), treatment duration (short, up to 4 weeks; intermediate, 6 to 10 weeks; long, 12 to 24 weeks), and type of control group (waiting list: routine care only; active treatment: any other intervention given additionally to routine care).

Funnel plot asymmetry was assessed by Egger's test.[12]

Results

Search Results

We found 23 potentially relevant studies addressing the effects of yoga on pain (intensity, frequency) or pain-associated disability (affected function). Among them, 4 studies were excluded because they had no control group. Nineteen controlled studies were considered eligible for inclusion (Fig 1). However, 3 randomized studies had to be excluded: a feasibility study describing just the pretreatment results[21]; a study with inadequate control group comparing yoga with yoga plus tuina touching[11]; and a study which presented the outcome analyses as multilevel modeling data[7] and thus not suited for data extraction. Finally, 16 controlled studies provided sufficient data to extract SMDs and their standard deviations (Fig 1).

Description of Studies

All of the remaining 16 studies according to specifications in the articles had a prospective design. Five studies were single-blinded (ie, statistician, physician, assessor or researcher, as stated in the respective studies) and randomized and thus had a higher methodological quality (Jadad score 4), 7 studies were randomized (without blinding) and had a moderate (scores 2–3), while 4 were nonrandomized controlled studies with low quality (score 0–1; Table 1). Seven studies had a waiting-list design, other control interventions were physical activity and lectures, routine care and conversation, and in 1 study, anti-inflammatory drugs.

The number of patients enrolled varied considerably from 12 to 291 (mean ± SE: 63 ± 66); only 1 study enrolled >100 individuals (Table 1). Most studies included participants aged ≤50 years (among them 1 study enrolling exclusively adolescents, 26); only 1 study enrolled older patients (56 ± 8 years in the yoga group and 67 ± 6 years in the control group).

In 6 studies, yoga was used to treat patients with back pain; in 2 studies to treat rheumatoid arthritis; in 2 studies to treat patients with headache/migraine; and 6 studies enrolled individuals for other indications. Twelve studies described effects on pain intensity and frequency, and 12 studies on pain-related disability as outcome variables. Four studies were categorized as short-term (up to 4 weeks of treatment), 7 as medium term (6–10 weeks), and 5 as long-term treatment (12–24 weeks).

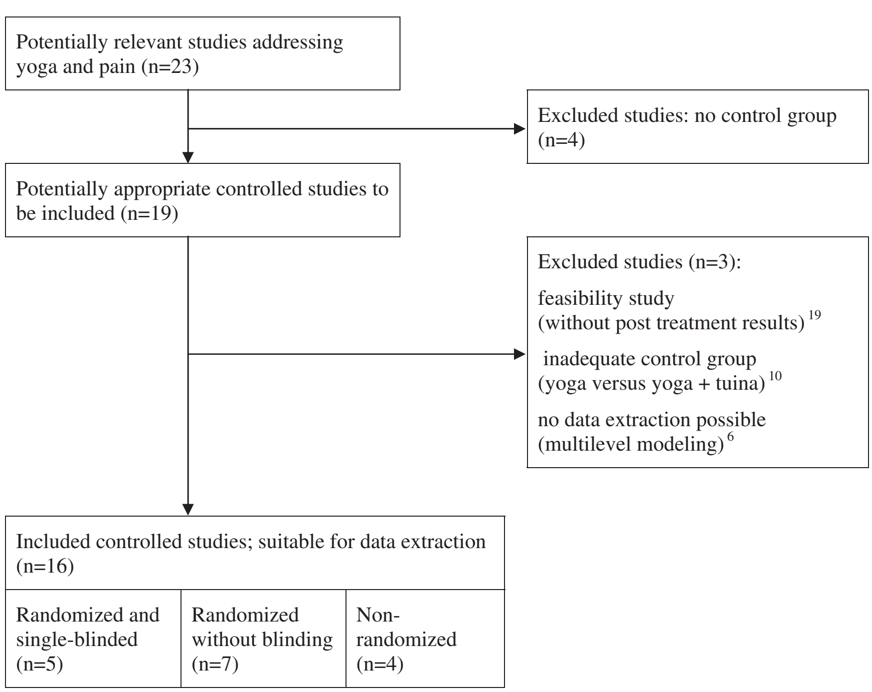

Figure 1. Flow diagram of study exclusion.

Table 1. Overview on Identified Clinical Studies

First Author [Study-ID]	Year	Pain Condition	N	Age (Years)	Yoga Style	Control Intervention	Duration of Treatment	Methodo-logical Quality*	Pain			Disability		
									Instrument	SMD	SD	Instrument	SMD	SD
Bhatia [1][3]	2007	Headache	12	18–50 (most 25–35)	Not specified	Anti-inflammatory drugs	Short	0	VAS†	−.94	0.57	/	/	/
Tekur [4][38]	2008	Back pain	91	49 ± 4/48 ± 4	LAYT	Physical activity, lecture	Short	4	/	/	/	ODI	−1.25	.23
Yurtkuran [6][45]	2007	Hemo-dialysis	40	38 ± 14/10 ± 10.0	Not specified	Physical activity	Inter-mediate	4	VAS†	−.20	0.31	/	/	/
John [7][23]	2007	Headache	72	34 ± 9/34 ± 10	Not specified	Educational sessions (briefing and handout)	Long	3	MPQ (T-PRI)	−.62	0.24	/	/	/
Kuttner [8][27]	2006	Irritable bowel syndrome	28	14 ± 2/14 ± 2	Hatha/Iyengar	Waiting list	Short	3	VAS,† Checklist	−.54	0.37	FDI	−.73	.38
Sherman [9][37]	2005	Back pain	71	44 ± 12/42 ± 15	Viniyoga	Physical activity, book, lecture	Long	3	/	/	/	RDS	−.33	.24
Williams [10][42]	2005	Back pain	44	49 ± 11/48 ± 2	Iyengar	Physical activity, lecture	Long	4	PPI, VAS†	−.76	0.31	PDI	−1.40	.33
Boyle [12][5]	2004	Muscle soreness	24	22–53 (38 ± 2.6)	Hatha	Physical activity	Short	0	VAS	−.87	0.35	SRT	−1.31	.46
Galantino [14][14]	2004	Back pain	22	30–65	Hatha	Waiting list	Inter-mediate	2	/	/	/	ODI	−1.18	.45
Garfinkel [15][15]	1998	Carpal tunnel syndrome	51	17–70 (mean 49)	Iyengar	Waiting list	Inter-mediate	2	VAS†	−.63	.28	/	/	/
Telles [17][39]	2009	Healthy PC user	291	33 ± 9/32 ± 10	Not specified	Waiting list	Inter-mediate	4	CMDQ	−1.20	.13	CMDQ	−1.01	.12
Saper [19][36]	2009	Back pain	30	44 ± 13/44 ± 11	Hatha	Waiting list	Long	2	VAS†	−1.34	.40	RDS	−.70	.37
Bosch [21][4]	2009	Rheumatoid arthritis	20 (16)	56 ± 8/67 ± 6	Hatha	Other	Inter-mediate	1	VAS†	−.27	.43	HAQ	−.38	.43
Williams [22][41]	2009	Back pain	90	48 ± 2/48 ± 2	Iyengar	Waiting list	Long	4	VAS	−.52	.21	ODI	−.34	.21
Chuntharapat [23][10]	2008	Labor pain	74	18–35	Not specified	Routine care, conversation	Inter-mediate	2	VAS	−.52	.23	VAS maternal comfort	−.50	.23
Badsha [24][2]	2009	Rheumatoid arthritis	47	44 ± 10/ 46 ± 11	Raj	No treatment (waiting list)	Inter-mediate	1	/	/	/	HAQ	−.63	.29

Abbreviations: VAS, visual analogue scale; ODI, Oswestry Disability Index ; MPQ, McGill pain questionnaire; HAQ, Health Assessment Questionnaire; FDI, Functional Disability Inventory; RDS, Roland Disability Scale; PDI, Pain Disability Index; PPI, Present pain Index; SRT, Sit-and-Reach Test; CMDQ, Cornell Musculoskeletal Discomfort Questionnaire; HAQ, Health Assessment Questionnaire.

*Jadad score.

†Linearly rescaled (0–100).

Effect Sizes Pain

As shown in Table 1, all studies reported positive effects in favor of the yoga interventions. With respect to pain, the effect sizes ranged from −.20 ± .31 to −1.34 ± .40 (Fig 2). Heterogeneity of study results was moderate (I^2 = 44%). A random effect meta-analysis estimated the overall treatment effect at SMD = −.74 (CI: −.97 to −.52, $P < .0001$), indicating a moderate overall effect.

For pain outcomes, we additionally performed a subset analysis for those studies which included a VAS as an outcome parameter. As the outcome scales were comparable in this subset, they were based on WMDs calculated from the published mean changes for each group instead of SMD to facilitate clinical interpretations. As measured on a 100-mm VAS, the group difference was estimated at WMD = −12 mm (CI: −17; −7; $P < .001$; I^2 = 19%).

Further subgroup analyses indicate that neither duration of treatment nor methodological quality was associated with better or worse study outcome (Table 2). However, studies with higher methodological quality had a better outcome as compared with studies with low quality; moreover, studies with a waiting-list design had somewhat higher effect sizes (and higher heterogeneity) than studies with others controls (Table 2). Restrictions to randomized controlled trials only yielded a SMD = −.82 (CI: −1.20; −.53; $P < .0001$; I^2 = 54%). With respect to the pain conditions, the 3 studies with healthy individuals had the highest effects sizes (SMD = −1.14) as compared with studies enrolling patients with chronic pain conditions (Table 3). In fact, the effect sizes for back pain or rheumatoid arthritis (SMD = −.69) were better as compared with various other pain conditions (SMD = −.54).

Overall, larger effects were observed in studies with higher methodological quality, passive wait list control, and in studies enrolling healthy individuals.

Effect Sizes Pain Related Disability

With respect to the improvement of pain related disability, the single studies' effect sizes ranged from −.33 ± .24 to −1.40 ± .33 (Fig 3). Heterogeneity of study results was high (I^2 = 54%). A random effect meta-analysis estimated the overall treatment effect at SMD = −.79 (CI: −1.02 to −.56, $P < .0001$), indicating a moderate effect. Subgroup analyses showed that short-term interventions yielded stronger effects than long treatments, while the methodological quality of the study or the respective control group had no remarkable impact on study outcome (Table 3). With respect to the pain conditions, the 3 studies with healthy individuals had somewhat higher effects sizes as compared with studies enrolling patients with pain conditions (Table 3). Here, the effect size of studies with chronic back pain and rheumatoid arthritis were similar to the overall effect size of the whole sample (Table 3).

Overall, the strongest effects on pain-associated disability were observed in studies with shorter duration.

Effect Sizes Mood in Pain

Although it was not our primary aim to analyze, 6 studies also reported effects on patients' mood stages (Fig 4). The moderate effects in favor of the yoga interventions (SMD = −.65 [CI: −.89 to .42]) are in congruence with the described effects on pain and pain disability.

Funnel Plot Analyses

Formal inspections of the funnel plot did not reveal any significant asymmetry (Fig 5) which might indicate a publication bias (pain: asymmetry coefficient AC = .67, $P = .48$; mood: AC = −1.09, $P = .42$; pain-related disability AC = −.47, $P = .68$).

Discussion

Our findings suggest yoga as a useful supportive intervention for a broad range of pain-associated diseases. Four studies described strong effects of yoga on patients' pain intensity/frequency, 6 studies moderate effects, and 2 weak effects; moreover, 5 studies reported strong effect sizes for pain-associated disability, 4 moderate effects, and 3 weak effects in favor of the yoga intervention (Table 1). With respect to chronic back pain and rheumatoid arthritis, the respective studies had moderate effects in favor of the yoga intervention (SME

Study or Subgroup	Std. Mean Difference	SE	Weight	Std. Mean Difference IV, Random, 95% CI
[01] Bhatia, 2007	-0.94	0.57	3.4%	-0.94 [-2.06, 0.18]
[06] Yurtkuran, 2007	-0.2	0.31	8.3%	-0.20 [-0.81, 0.41]
[07] John, 2007	-0.62	0.24	11.0%	-0.62 [-1.09, -0.15]
[08] Kuttner, 2006	-0.54	0.37	6.6%	-0.54 [-1.27, 0.19]
[10] Williams, 2005	-0.76	0.31	8.3%	-0.76 [-1.37, -0.15]
[12] Boyle, 2004	-0.87	0.35	7.1%	-0.87 [-1.56, -0.18]
[15] Garfinkel, 1998	-0.63	0.28	9.3%	-0.63 [-1.18, -0.08]
[17] Telles, 2009	-1.2	0.13	16.6%	-1.20 [-1.45, -0.95]
[19] Saper, 2009	-1.34	0.4	5.9%	-1.34 [-2.12, -0.56]
[21] Bosch, 2009	-0.27	0.43	5.3%	-0.27 [-1.11, 0.57]
[22] Williams, 2009	-0.52	0.21	12.3%	-0.52 [-0.93, -0.11]
[23] Chuntharapat , 2008	-0.87	0.4	5.9%	-0.87 [-1.65, -0.09]
Total (95% CI)			**100.0%**	**-0.74 [-0.97, -0.52]**

Heterogeneity: Tau² = 0.06; Chi² = 19.73, df = 11 (P = 0.05); I² = 44%
Test for overall effect: Z = 6.49 (P < 0.00001)

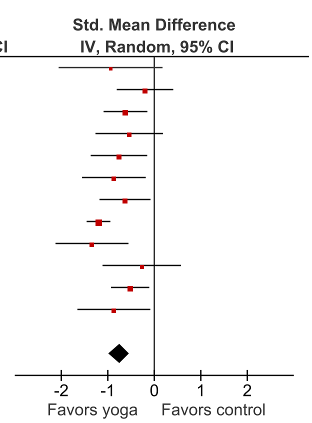

Figure 2. Standardized mean differences on pain. The size of circles represents the weight of the study in meta-regression.

Table 2. Subgroup Analyses on Pain

Subgroup	Enrolled Studies (ID Numbers)	Overall SMD	95% CI	I†
Overall	1,6,7,8,10,12,15,17,19,21,22,23	−.74	−.97; −.52	44%
Randomized Controlled Trials	6,7,8,10,15,17,19,22,23	−.82	−1.20; −.53	54%
Duration of treatment				
Short	1,8,12	−.75	−1.21; −.30	0%
Intermediate	6,15,17,21,23	−.69	−1.14; −.23	70%
Long	7,10,19,22	−.70	−.98; −.41	13%
Jadad score				
High	17,22	−.88	−1.55; −.21	87%
Intermediate	7,8,15,19,23	−.73	−1.01; −.45	0%
Low	1,12,21	−.69	−1.17; −.21	0%
Control group				
Waiting list	8,15,17,19,22	−.85	−1.22; −.48	65%
Other controls	1,6,7,10,12,21,23	−62	−.87; −.37	0%
Pain condition				
Chronic pain*	10,19,21,22	−.69	−1.06; −.32	30%
Other†	1,6,7,8,15	−.54	−.82; −.27	0%
Healthy‡	12,17,23	−1.14	−1.36; −.91	0%

*Chronic back pain and rheumatoid arthritis.
†Migraine/headache, carpal tunnel syndrome, irritable bowel syndrome, hemodialysis, carpal tunnel syndrome.
‡Labor pain, PC user, muscle soreness.

Disability = −.76; SME Pain = −.69). However, particularly healthy individuals with labor pain, personal computer usage, or induced muscle soreness had the strongest effects. Interestingly, also in adolescents with irritable bowel syndrome, the yoga intervention resulted in moderate effect sizes.[27] Patients with headache/migraine had effect sizes ranging from −.62[23] to −.94,[3] indicating a beneficial effect in principle. Particularly, the study with application of anti-inflammatory drugs as control had a strong effect in favor of the yoga group—albeit this headache study had a very low methodological quality. Nevertheless, there is evidence that yoga may influence pain and/or pain-associated disability.

In contrast, 1 high-quality study addressing the effects the yoga intervention had on pain intensity in hemodialysis patients with end-stage renal disease[45] revealed just weak effect sizes in favor of the intervention (albeit several other parameters significantly improved). Less positive conclusions were also reached in the treatment of patients with rheumatoid arthritis during a 10-week period, with weak effect sizes for both pain and disability[4]; however, the study enrolled just 20 patients (16 completers) and thus we cannot draw any valid conclusion. Several other indications with at least 1 study with positive outcome would encourage further clinical trials.

It is an important finding that the methodological quality of the studies (which was, in general, moderate) had no relevant impact on the study outcome; of note, studies with higher quality had a better pain outcome as compared with studies with low quality, an association

Table 3. Subgroup Analyses on Pain-Related Disability

Subgroup	Enrolled Studies (ID Numbers)	Effect	95% CI	I†
Overall	4,8,9,10,12,14,17,19,21,22,23,24	−.79	−1.02; −.56	54%
Duration of treatment				
Short	4,8,12	−1.14	−1.50; −.79	0%
Intermediate	14,17,21,23,24	−.78	−1.07; −.49	37%
Long	9,10,19,22	−.64	−1.11; −.18	65%
Jadad score				
High	4,9,17,22	−.75	−1.18; −.32	80%
Intermediate	8,9,14,19,23	−.56	−.83; −.30	0%
Low	12,21,24	−.72	−1.19; −.26	15%
Control group				
Waiting list	8,14,17,19,22,24	−.75	−1.04; −.47	44%
Other controls	4,9,10,12,21,23	−.84	−1.25; −.43	66%
Pain condition				
Chronic pain*	4,9,10,14,19,21,22,24	−.76	−1.08; −.43	59%
Other†	8	−.73	−1.47; −.01	/
Healthy‡	12,17,23	−.88	−1.28; −.47	57%

*Chronic back pain and rheumatoid arthritis.
†Irritable bowel syndrome.
‡Labor pain, PC user, muscle soreness.

Study or Subgroup	Std. Mean Difference	SE	Weight	Std. Mean Difference IV, Random, 95% CI
[04] Tekur, 2008	-1.25	0.23	10.4%	-1.25 [-1.70, -0.80]
[08] Kuttner, 2006	-0.73	0.38	6.2%	-0.73 [-1.47, 0.01]
[09] Sherman, 2005	-0.33	0.24	10.1%	-0.33 [-0.80, 0.14]
[10] Williams, 2005	-1.4	0.33	7.3%	-1.40 [-2.05, -0.75]
[12] Boyle, 2004	-1.31	0.46	4.7%	-1.31 [-2.21, -0.41]
[14] Galantino, 2004	-1.18	0.45	4.9%	-1.18 [-2.06, -0.30]
[17] Telles, 2009	-1.01	0.12	14.8%	-1.01 [-1.25, -0.77]
[19] Saper, 2009	-0.7	0.37	6.4%	-0.70 [-1.43, 0.03]
[21] Bosch, 2009	-0.38	0.43	5.2%	-0.38 [-1.22, 0.46]
[22] Williams, 2009	-0.34	0.21	11.2%	-0.34 [-0.75, 0.07]
[23] Chuntharapat , 2008	-0.5	0.23	10.4%	-0.50 [-0.95, -0.05]
[24] Badsha, 2009	-0.63	0.29	8.4%	-0.63 [-1.20, -0.06]
Total (95% CI)			**100.0%**	**-0.79 [-1.02, -0.56]**

Heterogeneity: Tau² = 0.08; Chi² = 23.83, df = 11 (P = 0.01); I² = 54%
Test for overall effect: Z = 6.72 (P < 0.00001)

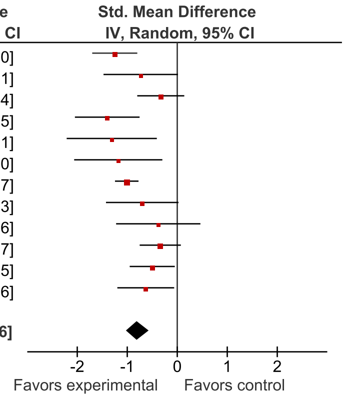

Figure 3. Standardized treatment effects (SMD and confidence intervals) on pain-related disability. The size of circles represents the weight of the study in meta-regression.

which did not occur with respect to disability. Also remarkable is the finding that short-term interventions yielded stronger effects on pain-related disability than longer treatments. One could argue that patients' enthusiasm may decrease over long treatment periods; however, this effect cannot be verified with respect to pain intensity/frequency. On the other hand, Williams et al[41] reported significant improvement of pain intensity and disability within 12 weeks, which further improved after 24-week intervention. This could indicate that longer interventions would improve skills and abilities (training) of the completer, while the dropouts might be due to a loss of enthusiasm. The problem of adherence, which may contribute to the effect that studies with longer duration of yoga interventions were less effective than shorter studies, should be addressed in future studies.

It is an important issue whether some yoga styles might be more effective than others, particularly because some styles were designed for individuals with physical limitations. Due to the heterogeneity of the studies with their different yoga traditions, we cannot draw any valid conclusions on this topic. This and also the impact of the qualification of yoga trainers has to be addressed in future studies.

Our analysis has several potential limitations. For example, the pooled estimates were based on heterogeneous data, with respect to indications, control groups, and methodological quality of these studies, although the methodological quality overall was moderate. The analysis was limited by small sample sizes (in average 63 ± 66) and evaluation of younger populations, and thus it is unclear whether yoga is effective also in the elderly. Most studies had adequate control interventions, ie, physical activity or at least a wait-list design, while 1 study compared a 3-month yoga intervention with education sessions (briefing about medication overuse and migraine modifications, and handouts emphasizing self-care strategies and lifestyle modification)[23] and thus is less appropriate. In a pilot study with weak quality, the putative activities of the control group were unclear; the authors by themselves stated that the "lack of randomization may have led to a self-selection bias."[4] There was just 1 study which compared the effects of yoga with a control group using conventional anti-inflammatory drugs; this study described strong effects in favor of a short yoga intervention, but had the lowest methodological quality.[2]

Although formal inspections of the funnel plots did not reveal any significant asymmetry which might indicate a publication bias (Fig 5), we cannot exclude the possibility that our analysis could lack studies with negative results which were never published at all.

Having in mind these limitations, we found good evidence that yoga interventions might be useful for several pain-associated disorders. There are hints that even short-term interventions might be effective. Nevertheless, further studies have to identify which patients may benefit from the interventions,[6] and which aspects of the yoga interventions (ie, physical activity and/or

Study or Subgroup	Std. Mean Difference	SE	Weight	Std. Mean Difference IV, Random, 95% CI
[06] Yurtkuran, 2007	-0.45	0.31	15.4%	-0.45 [-1.06, 0.16]
[07] John, 2007	-0.9	0.24	25.7%	-0.90 [-1.37, -0.43]
[08] Kuttner, 2006	-0.42	0.37	10.8%	-0.42 [-1.15, 0.31]
[14] Galantino, 2004	-1.16	0.45	7.3%	-1.16 [-2.04, -0.28]
[21] Bosch, 2009	-0.9	0.45	7.3%	-0.90 [-1.78, -0.02]
[22] Williams, 2009	-0.47	0.21	33.5%	-0.47 [-0.88, -0.06]
Total (95% CI)			**100.0%**	**-0.65 [-0.89, -0.42]**

Heterogeneity: Tau² = 0.00; Chi² = 4.21, df = 5 (P = 0.52); I² = 0%
Test for overall effect: Z = 5.38 (P < 0.00001)

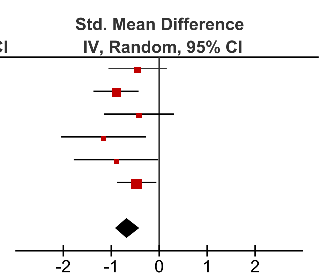

Figure 4. Standardized treatment effects (SMD and confidence intervals) on mood. The size of circles represents the weight of the study in meta-regression.

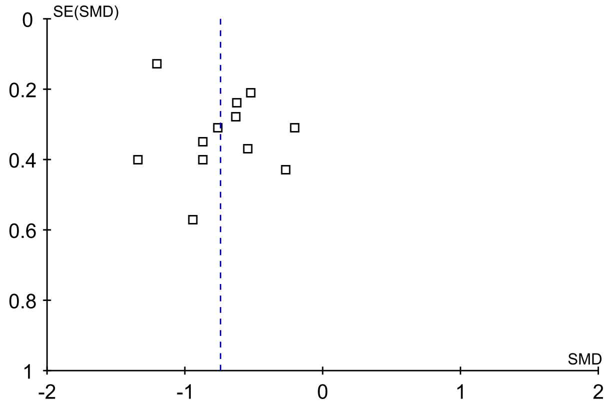

Figure 5. Funnel plot asymmetry of studies addressing pain.

meditation and subsequent life-style modification) or which specific yoga styles were more effective than others.

The beneficial effects of yoga can be explained, in part, by an increased physical flexibility, coordination, and strength,[35] by calming and focusing the mind to develop greater awareness and diminish anxiety,[25] reduction of distress,[9] improvement of mood (Fig 4), etc. Because patients may recognize that they are able to be physically active, even despite persisting pain symptoms, they experience higher self-competence and self-awareness, which contributes to higher quality of life.

Apart from the above-mentioned training effects, it is difficult to judge the relevance of contributing unspecific effects (ie, due to positive expectation, attention, conditioning, etc.). Looking at the studies with passive (waiting list) controls, the treatment effects with respect to pain were higher than those with an active control (ie, physical activity), while with respect to disability, there were no relevant differences between the control groups. Because positive expectations are a relevant variable in all interventional studies, further studies on the effects of yoga should address this, too.

In conclusion, large-scale and sound research is highly encouraged because yoga may have potential to be implemented as a safe and beneficial supportive treatment which is relatively cheap and requires just the motivation of patients.

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