RESEARCH ARTICLE

Yoga for Functional Ability, Pain and Psychosocial Outcomes in Musculoskeletal Conditions: A Systematic Review and Meta-Analysis

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Abstract

Objectives. Musculoskeletal conditions (MSCs) are the leading cause of disability and chronic pain in the developed world, impacting both functional ability and psychosocial health. The current review investigates the effectiveness of yoga on primary outcomes of functional ability, pain and psychosocial outcomes across a range of MSCs.

Methods. A comprehensive search of 20 databases was conducted for full-text, randomized controlled trials of yoga in clinically diagnosed MSCs.

Result. Seventeen studies met the inclusion criteria, involving 1,626 participants with low back pain (LBP), osteoarthritis (OA), rheumatoid arthritis (RA), kyphosis or fibromyalgia. Studies were quality rated, and analysed for the effect of yoga on primary outcomes, immediately post-intervention. Twelve studies were rated as good quality. Yoga interventions resulted in a clinically significant improvement in functional outcomes in mild-to-moderate LBP and fibromyalgia, and showed a trend to improvement in kyphosis. Yoga significantly improved pain in OA, RA and mild-to-severe LBP. Psychosocial outcomes were significantly improved in mild-to-moderate LBP and OA.

Meta-analysis of good-quality studies showed a moderate treatment effect for yoga of $-0.64$ (95%CI $-0.89$ to $-0.39$) for functional outcomes and $-0.61$ (95%CI $-0.97$ to $-0.26$) for pain outcomes.

Conclusions. Evidence suggests that yoga is an acceptable and safe intervention, which may result in clinically relevant improvements in functional outcomes and pain associated with a range of MSCs. Future analysis of outcomes which take into account the amount of yoga received by participants may provide insight into any putative duration or dosage effects of yoga interventions for MSCs. Copyright © 2013 John Wiley & Sons, Ltd.

Keywords

yoga; musculoskeletal conditions; systematic review

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Introduction

Musculoskeletal conditions (MSCs) are a heterogeneous group of disorders, including inflammatory disorders such as rheumatoid arthritis (RA), degenerative disorders of osteoarthritis (OA) and soft tissue disorders such as fibromyalgia and low back pain (LBP)(Salaffi et al., 2005; Woolf and Pfleger, 2003). The leading causes of chronic pain and disability in developed countries, these conditions are united by common symptoms...
including chronic pain and functional impairment, and a negative impact on quality of life (Greendale et al., 2009; Picavet and Hoeymans, 2004; Woolf and Pfleger, 2003).

While chronic MSCs are predominantly managed using a biomedical model which involves the prescriptive use of pharmaceuticals or physical therapy (Koes et al., 2001), individuals with MSCs are the highest users of complementary and alternative medicine (CAM) therapies (Barnes et al., 2008). The main reasons cited for using CAM therapies are improvements in pain and functional limitations (Carlson and Krahn, 2006; Okoro et al., 2012), and such therapies are used either as an adjunct to biomedical treatment or as a preferred treatment option (Eisenberg et al., 2001).

An increasingly popular form of CAM among people with MSCs is yoga (Saper et al., 2004; Barnes et al., 2008). Comprising physical, breathing and relaxation techniques, yoga is seen by users as providing both musculoskeletal and psychosocial benefits which are not currently part of the prescriptive management of MSCs (Evans et al., 2009; Ward et al., 2011). Despite such popularity, past reviews of CAM research have recognized the need for empirical evidence to support the therapeutic use of yoga for the management of the functional and psychosocial impact of chronic health conditions (Raub, 2002; Wren et al., 2011).

The aim of the current systematic review was to determine the effectiveness of yoga on primary functional, pain and psychosocial outcomes in people with clinically diagnosed MSCs. A comprehensive systematic search of multiple databases was undertaken. Included studies of randomized controlled trials (RCTs) were rated for methodological quality and risk of bias (Harris et al., 2001; Maher et al., 2003), and good quality studies were included in a conservative meta-analysis of the effect of yoga on pain and functional outcomes. The present systematic review is reported in accordance with the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) statement (Liberati et al., 2009).

Methods

Literature search strategy

Twenty databases relevant to CAM and MSCs were identified through a literature review of the field (Harris et al., 2001; van Tulder et al., 2003). Databases were searched from their inception until 31 December 2011 or as stated: AMED, BioMedCentral, CINAHL, Cochrane Central Register of Controlled Trials (4th quarter 2011), EMBASE, Medline, Google Scholar, IndMED, International Journal of Yoga Therapy (IJYT; from 2009), NAHCC, NZ Theses, PEDro, Proquest, Proquest Dissertations and Theses, PsycInfo (from 1967), PubMed, Science Direct, Scopus, SPORT Discus and Web of Science.

Database-specific search strategies, developed and pilot tested in consultation with a senior faculty librarian, were based on the terms ‘yoga’, ‘musculoskeletal’ and ‘random’ (identified from MeSH and Thesaurus terms, and subject headings), combined with the keywords ‘back pain’ and ‘arthritis’. Full details of search strategies are available from the corresponding author on request.

Additional hand searches were conducted of key CAM and musculoskeletal journals (from 2000 until 31 December 2011), reference lists of articles included in the final systematic review and relevant systematic or literature reviews identified in the searches.

Inclusion criteria and screening

Articles were included in the systematic review if they met all of the following criteria: 1) yoga was the primary intervention; 2) the study population had a clinical diagnosis of a musculoskeletal condition; 3) participants were aged 18 years and over; 4) the study was designed as an RCT; 5) the article was published in a peer-reviewed journal; and 6) the article was available as full text. Articles were assessed for relevance with respect to the above inclusion criteria by two independent reviewers. Any discrepancy between reviewers was taken to a third independent reviewer, whose decision was final. Direct requests were made to the authors or journal of publication for papers when abstracts were difficult to obtain. Authors of PhD theses were contacted to determine if subsequent articles had been published.

Methodological quality and risk of bias assessment

Sixteen of the 17 articles which met the inclusion criteria were assessed for methodological quality and risk of bias by two independent reviewers, and disagreements were resolved by consensus; one article was excluded from assessments as it provided baseline data only (Jacobs et al., 2004). Methodological quality was assessed...
by scoring articles according to the ten-item PEDro and 19-item van Tulder scales (PEDro, 2012; van Tulder et al., 2003, 1997). These scales have been used previously in systematic reviews of yoga and exercise interventions (Lin et al., 2011; Slade and Keating, 2007), and show good correlation in the rating of musculoskeletal interventions (Macedo et al., 2010). A priori we determined a score of over 50% for the PEDro (≥6 out of 10) and van Tulder (≥10 out of 19) scales as representing a good quality article, and a score of less than 50% as a poor quality article (Lin et al., 2011; McVeigh et al., 2008; Woodley et al., 2007). Subsequent to rating, scores were compared with those available in the PEDro database (PEDro, 2012).

Risk of bias was assessed using the seven-domain Cochrane Collaboration tool (Higgins and Green, 2009), which has been used previously in the assessment of yoga interventions (Cramer et al., 2011; Posadzki and Ernst, 2011). For the purpose of the current review, studies were considered to have an overall low risk of bias if ≥4 of the seven domains were rated as low, and an overall high risk of bias if ≥4 of the seven domains were rated as high or unclear.

**Data extraction**

Data regarding demographics, study characteristics, outcome measures and statistics were independently extracted from the included articles onto a pre-designed form, and checked by an independent assessor. For the purpose of the current review, outcome measures were grouped into three main categories: function, pain and psychosocial outcomes. We considered the primary time point as immediately post-intervention, or as stated in the study write-up (McVeigh et al., 2008).

**Meta-analysis**

A conservative meta-analysis of pain and multi-item functional outcomes was conducted on studies rated as good quality on the van Tulder scale, using Review Manager 5 (RevMan5) software. The small number of studies incorporating primary psychosocial outcomes precluded meta-analysis of this outcome category. The continuous data source for analysis was published data only, from unadjusted analysis, with standard deviations calculated by RevMan5 where necessary. Following discussion with the Australasian Cochrane Centre, the total number of participants in the yoga group of three-arm studies was halved for comparison with the two control groups, to adjust for overestimating the sample size. An a priori level of I² > 50% indicated heterogeneity of studies (Cramer et al., 2011), resulting in a random-effects model being applied for analysis. Standard mean differences (SMDs) were used as the measure of change from pre- to post-intervention, to account for differences in outcome measures used across the studies (Helewa and Walker, 2000). An SMD less than 0 favoured the yoga intervention over the control intervention, with a priori levels of SMD < −0.50 indicating a medium effect size and potential clinical relevance, and an SMD < −0.80 indicating a large effect (Büssing et al., 2012).

**Results**

**Study selection**

Electronic searches of 20 databases returned 774 articles. After duplicate removal, screening and searching of other sources, 17 articles met the inclusion criteria and were included in the systematic review. Following methodological quality assessment, statistics from eight of these articles were included in the meta-analysis (Figure 1).

**Study characteristics**

The study characteristics are presented in Table 1. The 17 studies were conducted between 1994 and 2011 in the USA, India and the UK. Five articles were pilot studies (Carson et al., 2010; Cox et al., 2010; Galantino et al., 2004; Jacobs et al., 2004; Saper et al., 2009), with one providing baseline data only (Jacobs et al., 2004), and two not powered for statistical significance (Cox et al., 2010; Galantino et al., 2004). Studies were predominantly conducted at one site, in an outpatient setting, with the exception of two residential studies, which reported different outcome measures from the same intervention (Tekur et al., 2008, 2010), and two multi-site interventions (Sherman et al., 2011; Tilbrook et al., 2011).

Two studies used a three-arm RCT design (Sherman et al., 2005, 2011), and the remaining 15 studies used a two-arm RCT design. Control groups were of two main categories: passive interventions (usual care/wait-list controls; education/social environment controls) or active interventions (physical therapy or therapeutic exercise programmes). The control group was not reported for one study (Bhandari and Singh, 2009),
and the authors could not be contacted; therefore, for the purposes of the current review, the study group will be conservatively grouped as a passive intervention.

Fifteen of the 17 studies specified six particular styles of yoga used in the interventions (Table 2). All styles were Hatha yoga based, focusing on the practice of physical yoga postures, and commonly incorporating breathing, relaxation or meditation practices (Iyengar, 2001; McCall, 2007). The main styles of yoga reported were Iyengar, Hatha and Integrated Yoga Therapy, and were representative of the most common forms of yoga practised in the West (Williams et al., 2005; Yoga Alliance, 2012). Variation in the duration of the interventions (1–24 weeks), duration of individual yoga sessions (40–120 minutes) and frequency of yoga sessions (1–7 times per week) resulted in a range of 8–72 hours of instructor-taught yoga delivered per intervention across the 17 studies (Table 2). Ten studies reported home practice as a component of the yoga intervention, with written instructions, yoga props and audio-visual aids (CD, DVD) supplied as common resources for this purpose.

**Participant characteristics**

The total number of participants randomized in the studies was 1,626 (range 12–313). Participants ranged from 23–90 years old, and were predominantly female (72%). Principal differences between participant demographics were found in Greendale et al. (2009), with an older population (average age 76 years); Carson et al. (2010), who selected for a female population because of gender differences in fibromyalgia prevalence; and Saper et al. (2009), who selected for ethnicity (83% racial/ethnic minority).

Five MSCs were investigated: LBP (Attanayake et al., 2010; Cox et al., 2010; Galantino et al., 2004; Jacobs et al., 2004; Saper et al., 2009; Sherman et al., 2005, 2011; Tekur et al., 2008, 2010; Tilbrook et al., 2011; Williams et al., 2005, 2009), kyphosis (Greendale et al., 2009), OA (Ebnezar et al., 2011; Garfinkel et al., 1994), RA (Bhandari and Singh, 2009) and fibromyalgia (Carson et al., 2010). The average duration of MSCs, where reported, ranged from ten (Tilbrook et al., 2011) to 15 (Williams et al., 2009) years for LBP, and 12 years for fibromyalgia (Carson et al., 2010). Clinical diagnoses...
<table>
<thead>
<tr>
<th>First author, year</th>
<th>MSC</th>
<th>Initial N</th>
<th>Age (years)</th>
<th>Control group</th>
<th>Primary time point</th>
<th>Quality rating (/19)</th>
<th>Risk of bias</th>
<th>Primary outcome</th>
<th>Results</th>
<th>Attrition and compliance in yoga condition</th>
<th>Adverse events in yoga condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attanayake, 2010</td>
<td>LBP</td>
<td>12</td>
<td>30–49</td>
<td>Education</td>
<td>3 weeks</td>
<td>Poor (7)</td>
<td>High</td>
<td>FRI</td>
<td>NA</td>
<td>Attrib: 0% yoga; Compliance: NR</td>
<td>None</td>
</tr>
<tr>
<td>Bhandari, 2009</td>
<td>RA</td>
<td>80</td>
<td>23–48</td>
<td>Not reported</td>
<td>40 days</td>
<td>Poor (2)</td>
<td>High</td>
<td>ROM – spinal</td>
<td>NA</td>
<td>p &lt; 0.005 NR</td>
<td>None</td>
</tr>
<tr>
<td>Carson, 2010</td>
<td>FM</td>
<td>53</td>
<td>54 ± 12 (SD)</td>
<td>Wait list/usual care</td>
<td>8 weeks</td>
<td>Good (13)</td>
<td>High</td>
<td>FIQR</td>
<td>p = 0.0003 NR</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Cox, 2010</td>
<td>LBP</td>
<td>20</td>
<td>45</td>
<td>Usual care</td>
<td>12 weeks</td>
<td>Good (10)</td>
<td>High</td>
<td>RDQ</td>
<td>p = 0.72 NR</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Ebnezar, 2011</td>
<td>OA</td>
<td>250</td>
<td>59 ± 9 (SD)</td>
<td>Therapeutic exercise</td>
<td>15 days</td>
<td>Good (11)</td>
<td>High</td>
<td>SF-36</td>
<td>p &lt; 0.001 NR</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Galantino, 2004</td>
<td>LBP</td>
<td>22</td>
<td>30–65</td>
<td>Usual care</td>
<td>6 weeks</td>
<td>Poor (9)</td>
<td>High</td>
<td>ODI</td>
<td>NA</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Garfinkel, 1994</td>
<td>OA</td>
<td>26</td>
<td>52–79</td>
<td>Usual care</td>
<td>6 weeks</td>
<td>Poor (5)</td>
<td>High</td>
<td>BDH</td>
<td>NA</td>
<td>Attrib: 0%; Compliance: NR</td>
<td>None</td>
</tr>
<tr>
<td>Greendale, 2009</td>
<td>Kyphosis</td>
<td>118</td>
<td>76 ± 7 (SD)</td>
<td>Social environment</td>
<td>8 weeks</td>
<td>Good (15)</td>
<td>Low</td>
<td>Timed chair stand</td>
<td>p = 0.14</td>
<td>Attrib: 5%; Compliance: 50%</td>
<td>None</td>
</tr>
<tr>
<td>Jacobs, 2004</td>
<td>LBP</td>
<td>52</td>
<td>25–65</td>
<td>Wait list/usual care</td>
<td>12 weeks</td>
<td>-</td>
<td>-</td>
<td>FR</td>
<td>p = 0.47</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Saper, 2009</td>
<td>LBP</td>
<td>30</td>
<td>44 ± 12 (SD)</td>
<td>Wait list/usual care</td>
<td>12 weeks</td>
<td>Good (15)</td>
<td>High</td>
<td>RDQ</td>
<td>NA</td>
<td>Attrib: 0%; Compliance: 66%</td>
<td>None</td>
</tr>
<tr>
<td>Sherman, 2005</td>
<td>LBP</td>
<td>101</td>
<td>44 ± 13 (SD)</td>
<td>Therapeutic exercise</td>
<td>12 weeks</td>
<td>Good (14)</td>
<td>High</td>
<td>Pain (numeric)</td>
<td>p = 0.02</td>
<td>Increased LBP in 1 Ppt</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Self-care book</td>
<td>12 weeks</td>
<td>-</td>
<td>-</td>
<td>Bothensomeness (Pain – numeric)</td>
<td>p = 0.0003</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

(Continues)
<table>
<thead>
<tr>
<th>First author, year</th>
<th>MSC</th>
<th>Initial N</th>
<th>Age (years)</th>
<th>Control group</th>
<th>Primary time point</th>
<th>Quality rating (/19)</th>
<th>Risk of bias</th>
<th>Primary outcome</th>
<th>Results</th>
<th>Attrition and compliance in yoga condition</th>
<th>Adverse events in yoga condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sherman, 2011</td>
<td>LBP</td>
<td>228</td>
<td>48 ± 10 (SD)</td>
<td>Conventional stretching</td>
<td>12 weeks</td>
<td>Good (16)</td>
<td>Low</td>
<td>Bothersomeness</td>
<td>RDQ</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Tekur, 2008</td>
<td>LBP</td>
<td>91</td>
<td>49 ± 4 (SD)</td>
<td>Physical therapy exercise</td>
<td>1 week</td>
<td>Good (14)</td>
<td>High</td>
<td>Bothersomeness</td>
<td>RDQ</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Tekur, 2010</td>
<td>LBP</td>
<td>80</td>
<td>49 ± 4 (SD)</td>
<td>Physical therapy exercise</td>
<td>1 week</td>
<td>Good (15)</td>
<td>High</td>
<td>ROM - spinal</td>
<td>WHOQOL-Bref</td>
<td>p &lt; 0.008</td>
<td>None</td>
</tr>
<tr>
<td>Tilbrook, 2011</td>
<td>LBP</td>
<td>313</td>
<td>46 ± 11 (SD)</td>
<td>Usual care</td>
<td>12 weeks</td>
<td>Good (13)</td>
<td>Low</td>
<td>SLR</td>
<td>RDQ</td>
<td>NS</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td>Williams, 2005</td>
<td>LBP</td>
<td>60</td>
<td>48 ± 1.5 (SE)</td>
<td>Education</td>
<td>16 weeks</td>
<td>Good (13)</td>
<td>High</td>
<td>PDI</td>
<td></td>
<td>p = 0.005</td>
<td>None</td>
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<tr>
<td>Williams, 2009</td>
<td>LBP</td>
<td>90</td>
<td>48 ± 1.3 (SE)</td>
<td>Standard medical care</td>
<td>24 weeks</td>
<td>Good (14)</td>
<td>High</td>
<td>ODI</td>
<td></td>
<td>p = 0.011</td>
<td>None</td>
</tr>
</tbody>
</table>

*Completers only.*

1van Tulder scale.

2Not powered for statistical significance.

3Minimal clinically important difference.

BDI-II, Beck Depression Inventory-II; FIQR, Fibromyalgia Impact Questionnaire Revised; FM, fibromyalgia; FR, functional reach; FRI, Functional Rating Index; LBP, low back pain; MSC, musculoskeletal condition; NA, not available; NR, not reported; OA, osteoarthritis; ODI, Oswestry Disability Index; PD1, Pain Disability Index; Ppt/s, participant/s; QOL, quality of life; RA, rheumatoid arthritis; RDQ, Roland–Morris Disability Questionnaire; ROM, range of motion; SD, Standard Deviation; SDPIS, Simple Descriptive Pain Intensity Scale; SE, standard error of the mean; SF-36, Short Form 36 Health Survey Questionnaire; SLR, straight leg raise; VAS, Visual Analogue Scale; WHOQOL-Bref, World Health Organization Quality of Life.
<table>
<thead>
<tr>
<th>First author, year</th>
<th>MSC</th>
<th>Style of yoga</th>
<th>Session</th>
<th>Intervention duration (weeks)</th>
<th>Dosage of yoga (hour)</th>
<th>Home practice</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Per week</td>
<td>Per intervention</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attanayake, 2010</td>
<td>LBP</td>
<td>Not reported</td>
<td>78–94</td>
<td>3</td>
<td>Unable to determine</td>
<td>Unable to determine</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Not reported</td>
<td>40 days</td>
<td>2</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Not reported</td>
<td></td>
</tr>
<tr>
<td>Bhandari, 2009</td>
<td>RA</td>
<td>Not reported</td>
<td>90</td>
<td>40 days</td>
<td>4</td>
<td>8</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>None</td>
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<tr>
<td>Carson, 2010</td>
<td>FM</td>
<td>Yoga of Awareness</td>
<td>120</td>
<td>8</td>
<td>2</td>
<td>16</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Encouraged for 20–40 min/day, 5–7 days/week; supplied props, DVD, audio, handbooks. Average adherence: 40 min/day</td>
<td></td>
</tr>
<tr>
<td>Cox, 2010</td>
<td>LBP</td>
<td>Iyengar/Hatha</td>
<td>75</td>
<td>12</td>
<td>1.25</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Encouraged; supplied manual, yoga mat, weekly practice sheets. Adherence not reported</td>
<td></td>
</tr>
<tr>
<td>Ebnezar, 2011</td>
<td>OA</td>
<td>IYT</td>
<td>40</td>
<td>2</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Encouraged for 1-hour session throughout week</td>
<td></td>
</tr>
<tr>
<td>Galantino, 2004</td>
<td>LBP</td>
<td>Hatha</td>
<td>60</td>
<td>6</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Adherence not monitored</td>
<td></td>
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<tr>
<td>Garfinkel, 1994</td>
<td>OA</td>
<td>Iyengar-based</td>
<td>60</td>
<td>8</td>
<td>1</td>
<td>8</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Not reported</td>
<td></td>
</tr>
<tr>
<td>Greendale, 2009</td>
<td>Kyphosis</td>
<td>Hatha</td>
<td>60</td>
<td>24</td>
<td>3</td>
<td>72</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Encouraged for 30 min/day, 5 days/week; supplied handout, yoga mat, props. Unclear if adherence monitored</td>
<td></td>
</tr>
<tr>
<td>Jacobs, 2004</td>
<td>LBP</td>
<td>Iyengar</td>
<td>90</td>
<td>12</td>
<td>3</td>
<td>34.5 (23 sessions)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Encouraged for 30 min daily; supplied CD, manual, yoga mat, props. Average adherence: 24 min, 4 days/week Requested daily; supplied handouts, CD. Average adherence: 30 min, 4 days/week Requested for 20 min/day on non-class days; supplied handouts, CD. Average adherence: 60 min/week</td>
<td></td>
</tr>
<tr>
<td>Saper, 2009</td>
<td>LBP</td>
<td>Hatha</td>
<td>75</td>
<td>12</td>
<td>1.25</td>
<td>15</td>
</tr>
<tr>
<td>Sherman, 2005</td>
<td>LBP</td>
<td>Viniyoga</td>
<td>75</td>
<td>12</td>
<td>1.25</td>
<td>15</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td>Requested daily; supplied handouts, CD. Average adherence: 30 min, 4 days/week</td>
<td></td>
</tr>
<tr>
<td>Sherman, 2011</td>
<td>LBP</td>
<td>Viniyoga</td>
<td>75</td>
<td>12</td>
<td>1.25</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Requested for 20 min/day on non-class days; supplied handouts, CD. Average adherence: 60 min/week</td>
<td></td>
</tr>
<tr>
<td>Tekur, 2008</td>
<td>LBP</td>
<td>IAYT</td>
<td>480 min/day</td>
<td>7</td>
<td>1</td>
<td>56</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Residential retreat, home practice not applicable</td>
<td></td>
</tr>
<tr>
<td>Tekur, 2010</td>
<td>LBP</td>
<td>IAYT</td>
<td>480 min/day</td>
<td>7</td>
<td>1</td>
<td>56</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Residential retreat, home practice not applicable</td>
<td></td>
</tr>
<tr>
<td>Tilbrook, 2011</td>
<td>LBP</td>
<td>Iyengar/Hatha</td>
<td>75</td>
<td>12</td>
<td>1.25</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Encouraged for 30 min/day or twice/week; supplied manual, yoga mat, home practice sheets, CD. Average adherence: 82%, from daily (9%) to &lt;1/week (8%) Encouraged for 30 min/day, 5 days/week. Average adherence: 32 min/week (protocol completers) Requested for 30 min/day on non-class days; supplied props, DVD, manual. Average adherence: 34 min/day on 87% non-class days (protocol completers)</td>
<td></td>
</tr>
<tr>
<td>Williams, 2005</td>
<td>LBP</td>
<td>Iyengar</td>
<td>90</td>
<td>16</td>
<td>1.5</td>
<td>24</td>
</tr>
<tr>
<td>Williams, 2009</td>
<td>LBP</td>
<td>Iyengar</td>
<td>90</td>
<td>24</td>
<td>3</td>
<td>72</td>
</tr>
</tbody>
</table>

FM, fibromyalgia; IAYT, integrated approach to yoga therapy; IYT, integrated yoga therapy; LBP, low back pain; MSC, musculoskeletal condition; OA, osteoarthritis; RA, rheumatoid arthritis.
Methodological quality and risk-of-bias assessment

There was a good correlation between the PEDro and van Tulder scales for rating methodological quality \([0.81 \ [95\% \text{ confidence interval (CI)} \ 0.52–0.93]]\). PEDro scores ranged from 1–9 out of a possible 10, and van Tulder scores ranged from 2–16 out of a possible 19. Our scores disagreed with the PEDro database for five articles, mainly regarding the item of outcome assessors, which we considered to be unblinded if the outcome measure was self-assessed. Subsequent correspondence with PEDro confirmed that self-assessed outcome measures should be rated as unblinded.

Twelve of the 16 rated studies were of good methodological quality (Table 1). Common areas of low methodological quality across studies were unclear use of co-interventions, lack (or misreporting) of intent-to-treat analysis and lack of long-term follow-up. Only nine studies referred to adverse events (Table 1). The percentage of study participants reporting adverse effects ranged from 0–17%, with increased LBP as the most commonly reported event. One serious adverse event, a herniated disc, was reported (Sherman et al., 2011).

Adherence (referred to as compliance in the methodological rating scales) and attrition rates varied widely across studies, and adherence was often not reported or was unclearly stated (Table 1). We considered 80% adherence to intervention sessions as acceptable, based on the most conservative level set within the included studies (Greendale et al., 2009). Adherence ranged from 14% (Cox et al., 2010) to 91% (Williams et al., 2005), and only four studies reported acceptable adherence (Carson et al., 2010; Sherman et al., 2011; Williams et al., 2005, 2009). Reported attrition ranged from 0–50% in the yoga groups and 0–55% in control groups. Self-reported adherence to home practice ranged from 52 minutes per week (Williams et al., 2005) to 30 minutes, four days per week (Sherman et al., 2005; Table 2).

Only three studies met the pre-set criteria for low risk of bias (Table 1). All studies followed a similar pattern of bias across the seven domains, tending to score as low risk regarding adequate random sequence generation and allocation concealment, high risk regarding the blinding of participants and outcomes, and unclear risk regarding reporting of outcomes and other sources of bias. Studies classified as having an overall low risk of bias were characterized as having a low attrition bias and a low outcome reporting bias, and were often associated with a published study protocol.

Effect of yoga on primary outcomes of MSCs

Fourteen studies provided sufficient statistics to enable comparison of yoga with a control intervention for primary outcome measures; the following results are limited to these studies. Statistical significance was determined as a \(p\)-value less than 0.05, and individual study results are reported in Table 1. We note that one of these studies did not provide data (Bhandari and Singh, 2009), and one was not powered for statistical significance (Cox et al., 2010). The functional, pain and psychosocial outcome measures used across studies were predominantly valid and reliable questionnaires, commonly recommended for use in musculoskeletal research (Bombardier 2000; Felson et al., 1993; Hawker et al., 2011; Mease et al., 2009; Pham et al., 2003; Smeets et al., 2011; Williams and Arnold, 2011).

Functional outcomes

Eleven studies assessed primary functional outcome measures in LBP, OA, fibromyalgia and kyphosis. Function was not assessed as a primary outcome for RA. Outcomes for LBP and fibromyalgia were predominantly condition-specific, multi-item subjective questionnaires (Smeets et al., 2011; Williams and Arnold, 2011). The most common measure of LBP was the 24-item Roland–Morris Disability Questionnaire, with baseline scores ranging from 7.8 (Tilbrook et al., 2011) to 15.3 (Saper et al., 2009). Functional changes...
in kyphosis and OA were assessed using single-item objective measures (Table 1). Only one study used objective measures alone to assess function (Greendale et al., 2009). One outcome measure (the Stanford Hand Assessment Questionnaire) could not be determined, and no references were available for it (Garfinkel et al., 1994).

When compared with passive control interventions, yoga significantly improved functional outcomes in mild-to-moderate LBP (Sherman et al., 2005, 2011; Tilbrook et al., 2011; Williams et al., 2005, 2009), OA (Garfinkel et al., 1994) and fibromyalgia (Carson et al., 2010). These functional improvements were significant at a level of minimal clinically important difference in a fibromyalgia population at eight weeks (Carson et al., 2010), and in mild-to-moderate LBP participants at 12 weeks (Sherman et al., 2005, 2011; Tilbrook et al., 2011). In one of the earliest studies of yoga for OA, an eight-week iyengar yoga-based intervention improved finger range of motion in a yoga group compared with a usual care group (Garfinkel et al., 1994); however, grip strength was unaffected. A non-significant trend to improvement for yoga was found in participants with kyphosis at 24 weeks compared with a social attention control (Greendale et al., 2009). There was no significant difference in functional outcomes between yoga and usual care at 12 weeks in a population with moderate-to-severe LBP (Saper et al., 2009).

The effects of yoga on functional outcomes compared with active interventions were varied in mild-to-moderate LBP participants. Significant functional improvements were found in a yoga group compared with an exercise group in an intensive 56-hour one-week residential intervention (Tekur et al., 2008), and also in a 12-week intervention comparing yoga to therapeutic exercise (Sherman et al., 2005). However, in a subsequent study comparing yoga with conventional stretching there was no difference in functional outcomes between the groups at 12 weeks (Sherman et al., 2011).

**Pain outcomes**

Pain was a primary outcome in studies of LBP (Saper et al., 2009; Sherman et al., 2005, 2011; Williams et al., 2009), OA (Garfinkel et al., 1994) and RA (Bhandari and Singh, 2009), but was not assessed as a primary outcome for kyphosis or fibromyalgia. Assessment was mainly conducted using generic visual analogue scales or numerical rating scales (Table 1). Baseline levels of pain (on a scale of 1–10) ranged from 4.2 (Williams et al., 2009) to 7.1 (Saper et al., 2009), with no baseline data available for two studies (Bhandari and Singh, 2009; Garfinkel et al., 1994).

Yoga interventions resulted in statistically significant decreases in pain compared with passive control interventions in participants with mild-to-moderate LBP at 12 and 24 weeks (Sherman et al., 2011; Williams et al., 2009), moderate-to-severe LBP at 12 weeks (Saper et al., 2009), OA-associated hand pain at eight weeks (Garfinkel et al., 1994) and RA at 40 days (Bhandari and Singh, 2009). This reduction in pain was clinically significant in moderate-to-severe LBP, averaging a 2.3-point decrease (on a ten-point scale) in the yoga group, compared with a 0.4 point decrease in the wait-list control group (Saper et al., 2009). Only one study found no difference in pain between yoga and a passive control intervention (Sherman et al., 2005). Compared with an active exercise intervention, yoga did not significantly improve pain in participants with mild-to-moderate LBP at 12 weeks (Sherman et al., 2005, 2011).

**Psychosocial outcomes**

Depression and quality of life (QOL) were assessed as primary outcomes in three study populations of LBP and OA. Psychosocial outcomes were not assessed as primary outcomes in kyphosis, fibromyalgia or RA populations. All outcomes were assessed using generic multi-item questionnaires.

In mild-to-moderate LBP populations, QOL was significantly improved in a yoga group compared with a physical exercise group in a one-week residential retreat in India (Tekur et al., 2010), and depression was significantly improved in participants practising yoga compared with usual care in a 24-week yoga intervention (Williams et al., 2009). However, in these two studies the baseline levels of depression were sub-clinical (Dozois et al., 1998), and the baseline levels of QOL were reflective of cultural population means (Skevington et al., 2004), suggesting that participants had high levels of psychosocial health at the outset of the studies.

By contrast, a study of people with moderate-to-severe knee OA (Ebnezar et al., 2011) showed baseline levels of QOL which were well below clinical norms (Picavet and Hoeymans, 2004), indicating a population with reduced QOL. Following a 15-day intervention, participants practising yoga had significantly improved QOL compared with a therapeutic exercise control (Ebnezar et al., 2011).
Meta-analysis

Good-quality studies involving primary functional and pain outcomes for LBP and fibromyalgia were available for meta-analysis. Studies of OA, RA and kyphosis did not meet the criteria for further analysis.

Four studies were included in a meta-analysis of pain outcomes using a random effects model (Figure 2). Two of these were two-arm studies (Saper et al., 2009; Williams et al., 2009) and two were three-arm studies (Sherman et al., 2005, 2011). This allowed the analysis of yoga with six control interventions: four passive and two active. The SMD of individual studies ranged from $-0.16$ to $-1.34$, with three study arms having confidence intervals including 0 (Sherman et al., 2005, 2011). There was an overall moderate effect size of $-0.61$ (95% CI $-0.97$ to $-0.26; p = 0.0007$) in favour of the yoga interventions. Sub-analysis of passive control interventions only increased the treatment effect to $-0.84$ (95% CI $-1.24$ to $-0.44; p < 0.0001$).

Eight studies of LBP and fibromyalgia, involving ten yoga–control group comparisons (seven passive and three active controls) were included in a meta-analysis of functional outcomes (Figure 3). Individual SMDs ranged from 0.04 to $-1.25$, with four comparisons having a confidence interval including 0. An overall moderate treatment effect of $-0.64$ (95% CI $-0.89$ to $-0.39; p < 0.0001$) favoured the yoga interventions. The effect size was unchanged when a sub-analysis was limited to LBP studies [SMD $-0.64$ (95% CI $-0.91$ to $-0.37; p < 0.0001$)]. Sub-analysis according to control condition showed differential results. The effect size remained unchanged when yoga was compared with passive control interventions [SMD $-0.60$ (95% CI $-0.76$ to $-0.43; p < 0.0001$)]. When yoga was compared with active control interventions, the effect size decreased slightly and became non-significant (SMD $-0.56$ (95% CI $-1.37$ to $0.24; p = 0.17$)).

Discussion

The aim of the current systematic review was to determine the effects of yoga on primary functional, pain and psychosocial outcomes for participants with...
MSCs, immediately post-intervention. A comprehensive systematic search of 20 databases identified 17 RCTs for inclusion in the review, representing LBP, OA, RA, kyphosis and fibromyalgia. All studies used similar posture-based styles of Hatha yoga, often incorporating breathing and relaxation techniques. These styles were representative of the predominant styles of Hatha yoga practised in the West (McCall, 2007; Williams et al., 2005; Yoga Alliance, 2012).

Function was assessed as a primary outcome in LBP, OA, kyphosis and fibromyalgia; pain was a primary outcome in LBP, OA and RA; and psychosocial measures were primary outcomes in LBP and OA. Yoga interventions resulted in clinically significant improvements in functional outcomes compared with passive interventions for mild-to-moderate LBP and fibromyalgia; significantly improved functional outcomes in mild-to-moderate LBP compared with active interventions; and showed a trend to improvement in functional outcomes in an older kyphosis population. A significant improvement in pain for yoga compared with passive interventions was found in all three reported conditions of OA, RA and LBP, with the improvements reaching levels of clinical significance in a moderate-to-severe LBP population. A conservative meta-analysis indicated a moderate treatment effect of yoga for both pain (SMD −0.61) and functional outcomes (SMD −0.64), with these results supporting previous findings of yoga for pain and pain-related disability (Büssing et al., 2012).

Yoga significantly improved psychosocial outcomes of QOL and depression in the OA and LBP populations in which it was assessed. However, participant populations in two of the three studies had low baseline levels of these psychosocial outcomes, questioning their use as a primary outcome measure. Given the increasing use of minimum levels of pain (Ebnezar et al., 2011; Saper et al., 2009; Sherman et al., 2011; Williams et al., 2009), and functional ability (Cox et al., 2010; Tilbrook et al., 2011) as inclusion criteria in studies where they are used as primary outcome measures, we suggest that this application of inclusion criteria may be equally relevant to primary psychosocial outcomes. This would ensure that the population being studied has the ability to show levels of clinical improvement in response to the interventions being researched, as opposed to being limited by potential ceiling effects.

A number of studies in the current review showed no significant difference in functional or pain outcomes between yoga and a control condition at 12 weeks (Note: in Sherman et al., 2011, outcome differences were significant for yoga at 12 weeks compared with the passive, but not the active, control group). In a 24-week study of yoga for LBP, preliminary data indicated no significant difference in functional and pain outcomes at 12 weeks; however, at 24 weeks both outcomes were significantly improved in favour of the yoga group (Williams et al., 2009). This suggests that intervention duration or dosage of yoga may be an important factor in the effect of yoga on functional and pain symptoms of MSCs.

Three factors make it difficult to determine if the studies in the current review included a minimum duration or dosage of yoga necessary for significant changes in musculoskeletal symptoms: 1) variation in yoga intervention parameters, resulting in a range of 8–72 hours of instructor-taught yoga per intervention; 2) frequency of home practice (0–7 days per week) affecting the weekly amount of self-taught yoga; and 3) variable adherence rates to yoga practice. Future consideration of analysis of outcome measures in relation to the above three factors may give insight into potential duration or dosage effects of yoga for MSCs.

Yoga appears to be acceptable as a safe and self-manageable intervention for participants with MSCs. Only one serious adverse event was potentially associated with yoga; otherwise, only mild increases in LBP were reported with any frequency. The lack of rigour in reporting adverse events precludes the assessment of any potential associations between certain yoga practices and worsening symptoms, or identification of possible at-risk participant demographics. Improved reporting of instructor and participant experiences of these issues is essential in future studies to investigate these issues and further inform the therapeutic use of yoga for MSCs.

There were good levels of adherence to home practice; however, low adherence to the instructor-taught sessions was highlighted and requires addressing in future studies. Qualitative research exploring the attitudes and experiences of people with MSCs participating in yoga interventions may be useful in identifying perceived barriers to intervention adherence, with processes to alleviate these barriers integrated into future study design (Atkinson and Permuth-Levine, 2009; Ward et al., 2011; Wilcox et al., 2006).

Several studies were rated as being of poor methodological quality because of their lack of statistical analyses and unclear reporting of several aspects of the study. However, these studies often had the most comprehensive
intervention descriptions, allowing reproducibility, and therefore comparability, of the intervention results. By contrast, some of the higher-rating studies included insufficient detail for replication of the yoga intervention. Therefore, current quality-rating scales may be weighted heavily towards the quality of reporting, at the expense of the quality of the actual content of complex CAM interventions. The Cochrane Risk of Bias tool may also suffer from a disparity in weighting. Developed with pharmaceutical interventions in mind, the tool has an inherent bias against non-blinded participants and assessors, and requires a published trial protocol to adequately determine the risks of reporting and other sources of bias.

Recognized guidelines have been updated to address the complex issues of reporting of non-pharmaceutical interventions (Boutron et al., 2008; Zwarenstein et al., 2008). Given the increasing research emphasis on patient-centred outcomes (Selby et al., 2012), and recognized discrepancies between participant and clinician views of outcome priorities and improvement in MSCs (Hewlett, 2003), adaptions of quality-rating scales may also be necessary to comprehensively assess the methodological quality, reproducibility and bias of future yoga interventions.

There are two caveats regarding the interpretation and generalization of the results of the current review. Firstly, there is a noted bias towards LBP conditions. However, this skewed distribution towards musculoskeletal populations is reflective of the use of CAM therapies among MSCs, with over four times more people with back pain than with fibromyalgia or arthritis conditions using CAM treatments (Barnes et al., 2008). Additionally, the current review was limited to RCTs, and a number of single-arm studies excluded in the selection process would have reduced the LBP bias. Secondly, the majority of studies have low participant numbers, are of short duration and compare yoga with mainly passive controls. This is reflective of the emerging nature of this field of research, with a number of the small studies in the current review being pilot studies, and three of the included studies (Cox et al., 2010; Sherman et al., 2005; Williams et al., 2005) giving rise to larger studies (Sherman et al., 2011; Tilbrook et al., 2011; Williams et al., 2009).

A limitation of the current review is the possibility of incomplete retrieval of relevant articles for inclusion. This risk was anticipated, and minimized, as a result of the breadth of CAM-pertinent databases accessed in the search, and the stringent pilot testing of search strategies with a medical librarian to ensure that database-specific search terms encompassed the range of medical conditions classified as musculoskeletal. Additionally, the quality ratings of the included studies are noted as subjective based on the authors’ interpretation of items, and, as such, ratings given here may differ from those in previous reviews. However, the subjectivity of quality ratings has previously been noted by developers of the rating scales (van Tulder et al., 1997), and the discrepancies in rating scores was raised directly with PEDro.

**Conclusion**

A comprehensive search of 20 databases relevant to CAM research resulted in the analysis of 17 RCTs covering LBP, RA, OA, kyphosis and fibromyalgia. A conservative analysis of high-quality studies suggests that yoga interventions produce clinically meaningful improvements in pain and functional outcomes across a range of MSCs. This effect of yoga is stronger when yoga is compared with passive rather than active control interventions. Current studies are using recommended validated outcomes measures, and are of suitable duration for a positive change in outcomes to be measured. Yoga appears to be a safe intervention, accepted by participants to the extent of being practised independently at home. Further investigation of putative dose–response relationships between yoga and outcomes is warranted to determine optimum intervention parameters, requiring clear reporting of intervention parameters, home practice rates and adherence. While some studies were of lower methodological quality, their yoga protocols were clearly reported and replicable, in contrast to some higher-rating studies with less transparent protocols. This suggests that in addition to using accepted guidelines such as the Consolidated Standards of Reporting Trials (CONSORT; Boutron et al., 2008), when reporting studies, additional guidelines may need to be developed to increase the transparency and replication of yoga interventions for MSCs.

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