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The benefits of yoga for people living with HIV/AIDS: A systematic review and meta-analysis

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ABSTRACT

Background: People living with HIV/AIDS (PLWHA) often experience psychological stress associated with disease management. This meta-analysis examines the benefits of yoga interventions on psychological distress among PLWHA.

Methods: Included were studies that (a) evaluated a yoga intervention in PLWHA; (b) provided between-group or within-group changes; and (c) assessed a psychological, physiological, or biomedical outcome.

Results: Seven studies sampling 396 PLWHA (M age = 42 years, SD = 5 years; 40% women) met inclusion criteria. PLWHA who received yoga interventions reported significant improvements in perceived stress (d + = 0.80, 95% Confidence Interval [CI] = 0.53, 1.07), positive affect (d + = 0.73, 95% CI = 0.49, 0.98), and anxiety (d+ = 0.71, 95% CI = 0.27, 1.14) compared to controls.

Conclusion: Yoga is a promising intervention for stress management. However, the literature is limited by the small number of studies. Randomized controlled trials with objective measures of HIV-related outcomes are needed to further evaluate the benefits of yoga.

1. Introduction

People living with HIV/AIDS (PLWHA) experience high rates of psychological stress due to the demands of living with a complex and highly stigmatized health condition. Estimates of depression range as high as 42% among PLWHA, which amounts to a two- to four-times greater prevalence compared to non-HIV samples [1]. Chronic stress and depressive symptoms have been found to negatively impact immune function, which may accelerate HIV disease progression [2,3]. Further, depression and anxiety negatively impact quality of life (QOL) and contribute to poor medication adherence among PLWHA [4]. Given the medication chronicity and stigma associated with HIV, it is not surprising that prevalence rates of stress, anxiety, and depression are elevated among PLWHA. In addition to mental health comorbidities, PLWHA are at increased risk of experiencing sleep disturbances and chronic pain. Recent meta-analyses show that sleep problems occur in approximately 58% of participants [5], while the prevalence of chronic pain ranges from 55 to 67% across studies [6]. Given the interest in non-pharmacological treatment options for mental and behavioral health concerns, it is important to understand the evidence-base for extant non-pharmacological interventions.

Several psychological and behavioral interventions have been found to be effective in improving distress and other health outcomes among PLWHA. For instance, cognitive behavioral therapy has been shown to reduce depressive symptoms and improve antiretroviral medication adherence [7]. Mindfulness-based interventions are also effective at reducing distress and improving psychological well-being [8,9]. Furthermore, meta-analytic reviews of stress-management interventions among PLWHA found improvements in several psychological domains (e.g., depression, anxiety, distress), fatigue, and overall QOL [10]. The authors of the meta-analysis reported effects from various interventions, including relaxation techniques, aerobic exercise, massage, and tai chi.

The practice of yoga is becoming increasingly popular in integrative

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healthcare and an emerging literature supports its use as a complementary therapy. Yoga is an ancient mind-body practice that involves physical movement or postures, breathing techniques, and meditation [11,12]. The most common forms of yoga practice are Hatha yoga, Iyengar yoga, and Sudarshan Kriya. Hatha yoga typically focuses on postures and physical movements, though most Hatha yoga practices in western culture also include breathing and meditation [13]. Iyengar yoga, a variant of Hatha, is largely comprised of specific postures with precise alignment, as well as breathing techniques [14,15] and usually includes the use of props to ease practice for participants with varying levels of yoga training or physical abilities. Iyengar yoga has been found to improve pain-related outcomes [16,17] and mood-related factors, including depression, anxiety, and anger [18]. Sudarshan Kriya yoga (SKY) is a form of breathing yoga, and incorporates several breathing techniques [19]. SKY has been found to reduce symptoms of distress, depression, anxiety, and insomnia, in addition to improving overall well-being [20,21]. A recent review of randomized controlled trials comparing yoga interventions to non-yoga control conditions concluded that yoga improves mental health outcomes regardless of the yoga style or form used [22], though the authors note that the meditative component of yoga appears to be particularly beneficial for psychological wellbeing.

Although yoga is increasingly used in clinical populations, there is limited information on the impact of yoga among PLWHA. Mind-body approaches (i.e., yoga) appear to be of particular interest among PLWHA [23], yet their potential benefits in this population remain understudied. Previous reviews and meta-analyses examining the benefits of yoga have largely failed to include studies of PLWHA. To address this gap in the literature, the present systematic review and meta-analysis examined the emerging body of research that assesses the efficacy of yoga as an intervention for PLWHA. Specifically, we aimed to determine whether yoga interventions would improve outcomes related to stress processes, psychological and behavioral health, overall quality of life, and biomarkers of HIV disease progression. Our aim was also to assess the potential benefits of yoga among this specific HIV population and summarize the findings to guide future scientific inquiry.

2. Methods

We followed the guidelines of the Preferred Reporting Items for systematic reviews and meta-analyses (PRISMA) [24]. The PRISMA checklist is included in the supplement (See Electronic Supplementary Materials 1 for the PRISMA Checklist).

2.1. Eligibility criteria

Studies were included if the study (a) evaluated a yoga intervention among PLWHA; (b) included a control condition; (c) assessed psychological stress, physiological markers of stress, or biomarkers of disease progression; and (d) provided statistics needed to calculate effect sizes. Studies that (a) sampled children or adolescents (*M* age < 18 years); (b) did not provide sufficient data to calculate effect sizes; or (c) sampled individuals not living with HIV (or reported results in a way that did not allow us to separate outcomes based on HIV status) were excluded.

2.2. Information sources and search strategy

Studies were identified using a comprehensive search strategy that included: (a) electronic bibliographic databases (i.e., PubMed, PsycINFO, Embase, ProQuest Dissertations and Theses Full Text, CINAHL, ERIC, Global Health, SocIndex, Cochrane Library, Web of Science: Social Sciences Citation Index and Science Citation Index), (b) reference sections of relevant manuscripts, (c) tables of contents of scientific journals (e.g., *Health Psychology, Journal of the American Medical Association)*, and (d) databases ongoing or completed research (i.e., NIH RePORTer, ClinicalTrials.gov). Broad search terms included "yoga" and "HIV." The search string used a Boolean search strategy and included: ("yoga" OR "yogasan" OR "yogic" OR "asana" OR "pranayama" OR "dhyana" OR "vinyasa" OR "viniyog") AND ("HIV" OR "AIDS" OR "PLWH" OR "PLWA" OR "people living with HIV" OR "people living with HIV/AIDS" OR "people living with AIDS" OR "HIV-positive" OR "HIV+" OR "seropositive"). The electronic bibliographic database searches were modified (as necessary) for each database (e.g., removing the medical subject headings [MeSH] designations, eliminating wildcards [*]). Electronic bibliographic database searches were conducted in July 2017. To ensure no new relevant studies were missed during the process of conducting the current meta-analysis, the overall database from the parent project was reviewed in January 2018. No new records were identified for consideration, thus the current meta-analysis is considered inclusive of all available studies (published or unpublished) through December 2017.

2.3. Study selection

First, duplicate records were removed. Titles and abstracts were reviewed by two coders to determine initial eligibility for inclusion. Records unrelated to population (PLWHA) and/or interventions of interest for this review (yoga) were removed. Review articles and meta-analyses were also excluded. The full texts of the remaining records were retrieved and reviewed for eligibility by two study authors. Full text records were removed based on current study inclusion and exclusion criteria. Remaining records were retained for inclusion in this review and meta-analysis.

2.4. Data collection and reliability

Four independent coders were involved in the extraction of study content and data. Each record was coded by two of the four independent coders, which included extraction of study design, sample, and intervention information using standardized coding forms. The methodological quality (MQ) of the studies was assessed by two independent coders using 17 items from validated measures [25–28]. Discrepancies were reviewed, discussed, and resolved by the coders or by the principal investigator if coders could not reach consensus. For categorical variables, coders agreed on 94% of the judgments (mean Cohen's $\kappa = 0.79$, range = -0.20 to 1.00). Reliability for continuous variables (e.g., mean age, proportion women) yielded an intra-class correlation (ICC) coefficient (ρ) of 0.97 across categories (median = 1.00). Data were also extracted by two independent coders to calculate effect sizes. Discrepancies were resolved by discussion prior to data entry and analyses.

2.5. Outcome domains

Primary outcome variables available for this review included stress processes, psychological health, physiological markers of stress, and biomarkers of disease progression.

2.6. Summary measures

The effect sizes (ES) assessed between- and within-group differences in psychological stress, physiological markers of stress, and biomarkers of disease progression. The first post-intervention assessment was used because most of the studies did not include follow-up assessments. ES were calculated as the mean differences between the yoga intervention and controls (between-subjects) or pre-test and post-test (within-subjects) divided by the pre-test standard deviations [29,30]. Other statistics (e.g., *F*-tests) were used to calculate ES when means and standard deviations were not available [31]. All ES were corrected for sample size bias [32]. Positive ES indicate improvements in each outcome for participants in the yoga intervention compared to the control group (between-subjects), or improvements observed over time (within-

subjects). ES were calculated by two independent coders; differences were reconciled through discussion and finalized.

2.7. Synthesis of results

Data analyses were conducted using Stata/SE 12.1 [33]. Random-effects assumptions were used to calculate weighted mean ES ($d+$). The 95% confidence interval indicates the degree of precision. The hypothesis of homogeneity was assessed by calculating the Q statistic and I [2] index [34,35]. Due to the limited number of studies examining yoga interventions among PLWHA, we were unable to assess publication bias which requires ≥10 effect sizes for a given outcome [36].

3. Results

3.1. Study selection

Our search yielded 208 unique records after removing duplicates. Reference sections of review articles or commentaries were reviewed to ensure all available studies were found. Eight studies meet initial inclusion criteria but one study was excluded because it did not include a control condition, but instead used three active conditions (i.e., three yoga interventions [37]). Seven records remained (Fig. 1), including six full text manuscripts [38–43] and one published conference abstract [44]. One supplemental manuscript provided additional details for one of the primary studies [45].

Nine clinical trials were identified through ClinicalTrials.gov, though none of these had published results as of December 2017. Four clinical trials had recently completed recruitment (NCT00627380; NCT00090506; NCT01073423; NCT02492893); two were still recruiting (NCT02936310; NCT02626949); two were not yet recruiting participants (NCT02932384; NCT03071562); and one trial was enrolling participants by invitation only (NCT02624193). One trial (NCT02492893) previously identified as meeting inclusion criteria was published August 2018 and was included in our final analyses [46].

3.2. Study characteristics

Studies (summarized in Table 1) were published between 2006 and 2018 (M = 2013, SD = 4.1), with data collection occurring an average of 3 years prior to publication. Four studies were conducted in North America and three in India. Participants were recruited from medical centers, HIV-specific service organization and outpatient clinics, and through the AIDS clinical trials network. All studies randomized participants to yoga or a treatment as usual (TAU) control group.

3.3. Sample characteristics

A total of 396 participants consented to participate in the studies. Due to participants being lost to follow-up in studies not reporting intent-to-treat analyses, the final analyses included 369 PLWHA (M age = 42 years, SD = 5 years; 40% women). Participants were

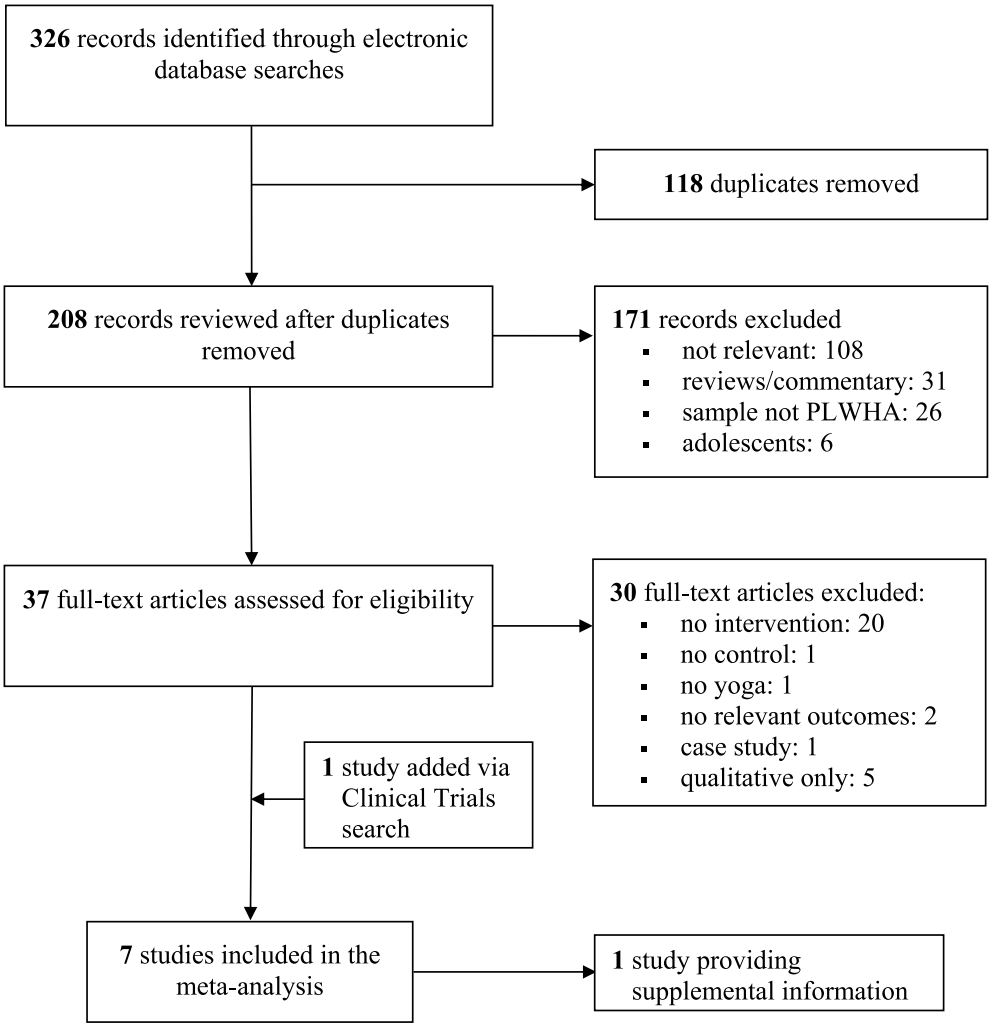


Fig. 1. Screening and selection procedure.

Table 1
Study, sample, and intervention characteristics of the 7 studies included in the meta-analysis.

Citation	Sample	Recruitment and Location	Control	Intervention Details						Outcomes
				Yoga Practice	Primary Components	OtherComponents	# of Weeks	Sessions	Dose[a]	
Agarwal et al. (2015)	N = 24 (100%); 35% F; Age Range = 24-57	Medical Wellness Center in Miami, FL, USA	TAU	Integrative	P, B, M	NR	8	16	960	Perceived stress QOL
Brazier, Mulkins, & Verhoef (2006)	N = 62 (76%); $M_{\text{years HIV+}}$ = 11	Community organizations; Vancouver, Canada	TAU	Integrative	P, B, M	Group process, home practice	14	27	NR	Affect Anxiety Depression QOL
Cade et al. (2010)	N = 60 (84%); 26% F; 42% B/AA; M_{age} = 45; 96% ART	AIDS Clinical Trials Unit in St. Louis, MO, USA	TAU	Asthanga Vinyasa	P, B, M	Participants provided feedback at start of each session	20	50	3000	$CD4^+$ QOL
Mawar et al. (2015)	N = 61 (100%); 64% F; Mdn_{age} = 32; 0% ART	HIV/AIDS Research Institute in Maharashtra, India	TAU	Sudarshan Kriya	B	Social support, spirituality ("Om" chant), and home practice	12	24	NR	$CD4^+$ QOL
Naoroibam, Metri, Bhargav, Nagaratna, & Nagendra (2016)	N = 44 (100%); 46% F; M_{age} = 36; 100% ART	HIV Rehabilitation Centers in Manipur, India	TAU	Integrative	P, B, M	NR	4	26	1560	Anxiety Depression $CD4^+$
Rao et al. (2012)	N = 70 (100%); 0% ART	HIV Referral Center in Bangalore, India	TAU/WL	Integrative	P, B, M	NR	12	91	5460	Perceived stress Affect Anxiety[b] Depression[b]
Wimberly et al. (2018)	N = 75 (85%); 29% F; 78% B/AA; M_{age} = 44; $M_{\text{years HIV+}}$ = 14	HIV/AIDS Service Organization in Philadelphia, PA, USA	TAU	Hatha	P, B, M	Home practice	12	90	1080	Perceived stress

Note. N (%), number of participants who consented to participate in the study (% retention); F, female; W, White; B/AA, Black/African American; ART, antiretroviral therapy; TAU, treatment as usual; WL, wait list; NA, not applicable; NR, none reported; P, postures; B, breathing; M, meditation.

[a] Total number of minutes of intervention.

[b] Only within-group data available for effect size calculations.

diagnosed with HIV and/or AIDS, with an average length of time since initial diagnosis of 13 years (range = 11–14 years). In the four studies reporting the use of antiretroviral therapy (ARTs), nearly 47% of participants were currently prescribed ART. A single study described patients' mental health status in which 32% of participants reported symptoms of depression and 46% reported symptoms of anxiety [43].

3.4. Intervention characteristics

Intervention details are provided in Table 1. Yoga styles included Hatha, Sudarshan Kriya, Iyengar, Asthanga Vinyasa, and integrative practices. The most common intervention components were Pranayama (breathing exercises), Asanas (postures), and Dhyana (meditation) practices. Three interventions included additional components (e.g., social support, spiritual chant) to supplement the yoga program. Three interventions encouraged home practice of yoga. On average, the number of yoga session offered was 35 (SD = 27), with a duration ranging from 60 to 90 min per session (M = 66, SD = 13). Based on the studies providing data to estimate intervention dose (k = 5), participant engagement in yoga practice ranged from 16 to 91 h (M = 40, SD = 31).

3.5. Methodological quality

Methodological quality (MQ) was reviewed using a comprehensive 17-item assessment (Table 2). MQ scores ranged from 13 to 18 (M = 16, SD = 2), with the highest possible score of 25. All seven studies described objectives and hypotheses. Only one study described their sample as representative of the population from which they were recruited. All participants were randomized to yoga or a control condition. Blinding was not used due to the nature of the intervention.

3.6. Synthesis of results

Table 3 displays between-group effect sizes and forest plots for each outcome.

3.6.1. Stress processes

Three interventions examined perceived stress using the Perceived Stress Scale (PSS) [47] to examine the effect of yoga on perceived stress. This 14-item measure uses a five-point Likert-type scale (*never* to *very often*) to assess the frequency of stressful situations. Compared to control conditions, PLWHA who received a yoga intervention reported a significantly greater reduction in perceived stress, $d+$ = 0.57, 95% CI = 0.10, 1.04. The null hypothesis of homogeneity was supported, though the uncertainly limits were wide, Q [1] = 4.57, p = .10; I [2] = 56, 95% uncertainty limits = 0, 88.

Positive affect was assessed in two studies using the Positive and Negative Affect Scale (PANAS) [48] and a subscale of the Mental Health Inventory (MHI) [49]. Positive affect refers to the subjective feeling of elevated mood states, such as enthusiasm and happiness; conversely, negative affect indicates a dimension of subjective distress, which would include mood states related to sadness and anger [48]. The PANAS includes two 10-item scales and a six-point response scale to assess past month feelings; it is among the most commonly used measures of affect. Compared to controls, PLWHA who received a yoga intervention showed improvements in positive affect, $d+$ = 0.73, 95% CI = 0.49, 0.98. The null hypothesis of homogeneity was supported, though the uncertainly limits were wide, Q [1] = 0.03, p = .85; I [2] = 0.00, 95% uncertainty limits = 0, 99.

3.6.2. Psychological outcomes

Anxiety or depression were most frequently assessed using one of three measures: (a) the Hospital Anxiety and Depression Scale (HADS) [50], a commonly used and valid measure to assess symptom severity in clinical populations, (b) the anxiety and depression subscales of the MHI [49], and (c) self-reported rating scale from 0 (not experiencing anxiety) to 10 (highest level of anxiety) [39]. The World Health Organization Quality of Life Scale for HIV populations (WHOQOL-HIV BREF), which assess various domains including physical health, independence, psychological health, social support, environmental, and spiritual, were used to assess QOL [51,52]. The short form QOL measure from the Medical Outcome Study was also used by studies in this meta-analysis to assess QOL (MOS-HIV SF-36) and has been tailored for HIV populations [53].

Compared to control conditions, PLWHA who received a yoga intervention (k = 2) reported greater reductions in symptoms of anxiety, $d+$ = 0.71, 95% CI = 0.27, 1.14. The hypothesis of homogeneity was

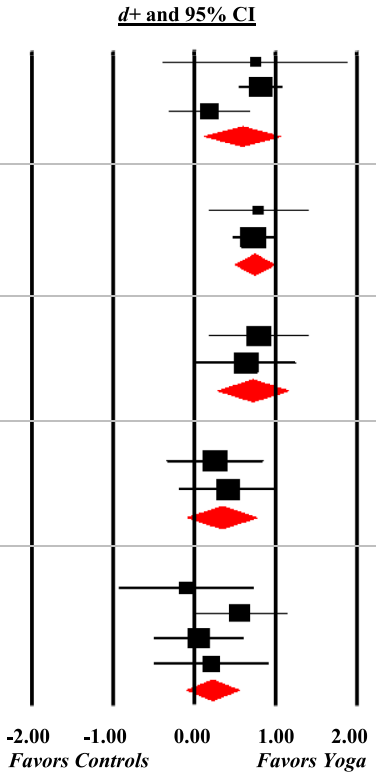
Table 2
Methodological quality (MQ) of the 7 studies included in the meta-analysis.

MQ Item	Agarwal (2015)	Brazier (2006)	Cade (2010)	Mawar (2015)	Naoroibam (2016)	Rao (2012)	Wimberly (2018)
1. Aim/Hypothesis clearly defined	1	1	1	1	1	1	1
2. Participant characteristics clearly described	1	0	1	1	1	0	1
3. Sample representative of recruitment population	1	0	0	0	0	0	0
4. Type of random assignment[a]	4	4	3	4	4	4	4
5. Adequacy of control group[b]	2	2	3	2	2	1	2
6. Attempt to blind participants	0	0	0	0	0	0	0
7. Quality control of treatment	1	1	1	1	1	0	1
8. Compliance with intervention	1	0	1	1	0	0	1
9. Outcomes clearly described	1	1	1	1	1	1	1
10. Validity and reliability of outcome measures	1	1	1	1	1	1	1
11. Use of objective outcomes	1	0	1	1	1	1	0
12. Attempt to blind researchers	0	0	0	0	0	0	0
13. Follow-up length[c]	0	1	0	0	0	0	0
14. Described participants lost to follow-up	0	0	1	1	1	0	1
15. Retention rate[d]	0	2	1	1	2	1	2
16. Appropriate statistical analyses[e]	2	2	2	2	2	2	2
17. Missing data reported and considered	0	0	0	1	1	1	1
Total MQ Score	16	15	17	18	18	13	18

Note: Except where denoted and described below, scores are binary (0 = No/not reported, 1 = Yes).
[a] 0 = None, 1 = Quasi-experimental, 2 = Randomized groups, 3 = Matched, then randomized, 4 = True randomization.
[b] 0 = No control group, 1 = Did not determine group equivalency, 2 = Compared for equivalence, 3 = Matched for equivalency.
[c] 0 = ≤3 months, 1 = 3–5 months, 2 = ≥6 months.
[d] 0 = < 70% retention, 1 = 70–84% retention, 2 = 85–100% retention.
[e] 0 = Inadequate, 1 = Appropriate, did not control for relevant variables, 2 = Appropriate, controlled for relevant variables.

Table 3
Between-group effect sizes and forest plots for effects of yoga interventions at first assessment.

Domain Study (Year)	*d*+	Lower limit	Upper limit	Z-value	*p*-value
Perceived Stress					
Agarwal (2015)	0.74	-0.40	1.88	1.27	0.20
Rao (2012)	0.80	0.53	1.08	5.75	<0.01
Wimberly (2018)	0.18	-0.33	0.68	0.68	0.50
Overall	0.57	0.10	1.04	2.39	0.02
Positive Affect					
Brazier (2006)	0.78	0.17	1.40	2.50	0.01
Rao (2012)	0.72	0.45	0.99	5.28	<0.01
Overall	0.73	0.49	0.98	5.84	<0.01
Anxiety					
Brazier (2006)	0.78	0.17	1.40	2.50	0.01
Naoroibam (2016)	0.63	0.01	1.25	1.98	0.04
Overall	0.71	0.27	1.14	3.17	<0.01
Depression					
Brazier (2006)	0.25	-0.34	0.85	0.83	0.41
Naoroibam (2016)	0.41	-0.20	1.03	1.33	0.19
Overall	0.33	-0.10	0.76	1.52	0.13
Quality of Life					
Agarwal (2015)	-0.08	-0.92	0.76	-0.20	0.84
Brazier (2006)	0.57	-0.02	1.16	1.88	0.06
Cade (2010)	0.06	-0.50	0.62	0.21	0.83
Mawar (2015)	0.22	-0.50	0.94	0.60	0.55
Overall	0.23	-0.10	0.55	1.36	0.17



supported, though the uncertainly limits were wide, Q [1] = 0.12, p = .73; I [2] = 0.00, 95% uncertainty limits = 0, 99. Yoga interventions (k = 2) did not reduce depressive symptoms for PLWHA, d + = 0.33, 95% CI = −0.10, 0.76, nor improve QOL, d+ = 0.23, 95% CI = −0.10, 0.55, when compared to control conditions.

3.6.3. Biological outcomes

$CD4^+$ count (k = 3) and plasma viral load (k = 1) were assessed through blood collection. $CD4^+$ cell levels are biological measures of the severity of HIV disease, such that lower $CD4^+$ values indicate greater disease progression. Yoga interventions did not improve $CD4^+$ counts among PLWHA when compared to control conditions, d + = 0.05, 95% CI = −0.31, 0.42. Unfortunately, only a single study measured plasma viral load, prohibiting inclusion in the meta-analyses [41].

3.6.4. Physiological markers

The current meta-analysis also sought to assess effects of yoga on physiological markers of stress, such as blood pressure, heart rate, and cortisol for PLWHA. Among included studies, one study (k = 1) assessed blood pressure [41], while one additional study measured salivary cortisol (k = 1) [38]. As no physiological marker of stress was assessed by two or more studies, effect sizes were not able to be calculated in this meta-analysis.

3.6.5. Within-group comparisons

Anxiety was the most commonly reported outcome for within-group comparison, with three yoga interventions assessing this domain. Participants in the yoga interventions were found to have reduced anxiety immediately post-intervention when compared to baseline assessment, d+ = 0.48, 95% CI = 0.11, 0.85, k = 3. Depressive symptoms were also significantly reduced from baseline scores following yoga interventions, d+ = 0.48, 95% CI = 0.23, 0.73; k = 3. Participants in yoga intervention conditions also reported improved QOL at follow-up compared to baseline assessments, d+ = 0.27, 95% CI = 0.02, 0.53; k = 4. No significant changes were observed following yoga interventions for $CD4^+$ counts, positive or negative affect, or perceived stress. No within-group changes were observed among control conditions, as controls did not experience significant changes from baseline on assessed outcomes.

4. Discussion

The present review and meta-analysis examined the evidence for the use of yoga as an intervention for individuals living with HIV. Yoga has been previously studied as a complimentary treatment method with benefits for several health conditions, including psychological stress [20], chronic pain [16], and cardiovascular risk reduction [54]. However, fewer studies have examined the use of yoga intervention in the context of HIV. In fact, our search yielded only seven empirical studies that delivered a yoga intervention program and compared outcomes to a control group to determine efficacy.

The results of this meta-analysis provide initial support use of yoga intervention for PLWHA, particularly with regards to stress and psychological outcomes. PLWHA who participated in a yoga program showed improved positive affect, reduced perceived stress, and fewer anxiety symptoms. Improvements in positive affect are particularly important because such improvements have been found to be protective against stress and depression [48,55]. Further, positive affect is linked to physical health, as it increases engagement in healthy behaviors, including physical activity and social behaviors, and results in improved sleep [55]. Stress is also associated with physical health, including poorer immune function and accelerated disease progression for individuals living with HIV [56].

Yoga may be particularly useful for persons living with HIV given the findings related to reduced anxiety. Prior studies have found that anxiety is associated with poor antiretroviral medication adherence [57]. The current study found within-group effects which suggest that yoga participants were found to have reduced depression and improved QOL immediately following yoga programs when compared to baseline. In contrast, within-group effects for controls did not reveal improvements on any outcome post-intervention. The unique within-subject improvements for yoga groups in depression and QOL provide initial evidence that yoga may improve these additional outcomes, though future between-group designs are needed. It may be possible that longer follow-up may have resulted in detectable between group effects for depressive symptoms and QOL. This explanation is particularly relevant for QOL, which may require sustained changes in mood and affect prior to changes in more global factors.

The meta-analysis did not find a significant effect of yoga on markers of disease progression (i.e., $CD4^+$), which may be explained, at least in part, by the short duration of follow-up. If yoga improves stress and psychological symptoms, PLWHA may become more apt to engage in health promoting behaviors, including medication adherence, nutritious diet, and physical activity. Furthermore, only a few studies assessed effects of yoga on physiological markers of stress (e.g., salivary cortisol), which did not permit inclusion in the current meta-analysis. Additional studies with longer-term follow-ups (e.g., 12-month) of biological and physiological markers are needed.

This meta-analysis has several limitations, of which the most important is the limited number of studies evaluating a yoga program among PLWHA. This limitation is further compounded by the lack of homogeneity in the outcomes reported across studies. As a result, several between-group effect size calculations were limited to two studies. We are also limited by the lack of objective measurement of HIV-related outcomes. Our ability to detect more consistent changes in stress processes and biological factors may have been hampered by the lack of studies reporting these outcomes. Further, the included studies were largely pilot trials with small sample sizes, thus may have been underpowered to detect significant between-group changes. This meta-analysis is also limited by focusing on a single post-intervention assessment. Due to the small number of studies using multiple follow-up time points, we were unable to assess the longitudinal impact of yoga. Lastly, control conditions were assessment only or treatment as usual, which limits the ability to control for the time and attention provided to participants in the active treatment groups. Nonetheless, these studies provide promising initial evidence to suggest the feasibility of yoga programs for PLWHA.

5. Conclusion

Based on the current review and meta-analysis, we tentatively conclude that yoga can have beneficial effects on stress and psychological outcomes for PLWHA. However, additional research is needed using rigorous methodology. Future studies should utilize a randomized controlled design with an attention control. To the extent possible, participants (and assessors) should be blinded to the research hypotheses and outcomes of interest. Assessors should also be blinded to the assigned condition of participants. One option would be to use technology-assisted assessment methods, such as computer- or tablet-administered assessments, to reduce potential bias associated with assessors knowing the intervention condition of participants. Future studies should use validated measures of perceived stress, affective states, depression, anxiety, and QOL, and should continue to collect objective data (e.g., $CD4^+$), when resources permit, to detect changes in immune function and viral load. Longitudinal designs assessing 12- or 18-month post-intervention may be required to detect changes in immune function and to provide evidence of sustained coping and psychological benefits. Consistent with other intervention research, “booster” or “refresher” sessions may be necessary to promote enduring treatment benefit.

In sum, the available evidence from the literature suggests that yoga

is feasible and efficacious for improving psychological outcomes among PLWHA and is a promising complementary medicine approach for PLWHA. This review and meta-analysis highlights these findings and recommendations for future research on yoga for PLWHA.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ctcp.2018.11.009.

References

[1] M.G. Nanni, R. Caruso, A.J. Mitchell, E. Meggiolaro, L. Grassi, Depression in HIV infected patients: a review, Curr. Psychiatr. Rep. 17 (1) (2015) 530.
[2] S. Arseniou, A. Arvaniti, M. Samakouri, HIV infection and depression, Psychiatr. Clin. Neurosci. 68 (2) (2014) 96–109.
[3] J. Hellmuth, D. Colby, V. Valcour, et al., Depression and anxiety are common in acute HIV infection and associate with plasma immune activation, AIDS Behav. (2017) 1–9.
[4] A. Nel, A. Kagee, The relationship between depression, anxiety and medication adherence among patients receiving antiretroviral treatment in South Africa, AIDS Care 25 (8) (2013) 948–955.
[5] J. Wu, H. Wu, C. Lu, L. Guo, P. Li, Self-reported sleep disturbances in HIV-infected people: a meta-analysis of prevalence and moderators, Sleep Med. 16 (8) (2015) 901–907.
[6] R. Parker, D.J. Stein, J. Jelsma, Pain in people living with HIV/AIDS: a systematic review, J. Int. AIDS Soc. 17 (1) (2014).
[7] S.A. Safren, C.A. Bedoya, C. O'Cleirigh, et al., Treating depression and adherence (CBT-AD) in patients with HIV in care: a three-arm randomized controlled trial, The Lancet HIV 3 (11) (2016) e529.
[8] P. Grossman, L. Niemann, S. Schmidt, H. Walach, Mindfulness-based stress reduction and health benefits: a meta-analysis, J. Psychosom. Res. 57 (1) (2004) 35–43.
[9] L.A. Scott-Sheldon, B.L. Balletto, M.L. Donahue, M.M. Feulner, D.G. Cruess, E. Salmoirago-Blotcher, et al., Mindfulness-based Interventions for Adults Living with HIV/AIDS: a Systematic Review and Meta-analysis, AIDS Behav. (2018) 1–16.
[10] L.A.J. Scott-Sheldon, S.C. Kalichman, M.P. Carey, R.L. Fielder, Stress management interventions for HIV+ adults: a meta-analysis of randomized controlled trials, 1989 to 2006, Health Psychol. 27 (2008) 129–139.
[11] D.S. Shannahoff-Khalsa, An introduction to Kundalini yoga meditation techniques that are specific for the treatment of psychiatric disorders, J. Alternative Compl. Med. 10 (1) (2004) 91–101.
[12] N.N. Nayak, K. Shankar, Yoga: a therapeutic approach, Physical Medicine and Rehabilitation Clinics 15 (4) (2004) 783–798.
[13] L.A. Uebelacker, G. Epstein-Lubow, B.A. Gaudiano, G. Tremont, C.L. Battle, I.W. Miller, Hatha yoga for depression: critical review of the evidence for efficacy, plausible mechanisms of action, and directions for future research, J. Psychiatr. Pract. 16 (1) (2010) 22–33.
[14] B.K.S. Iyengar, Light on Yoga, revised ed., (1979).
[15] B.K.S. Iyengar, The Tree of Yoga: Yoga Vṛkṣa, Shambhala Publications, 1989.
[16] K.A. Williams, J. Petronis, D. Smith, et al., Effect of Iyengar yoga therapy for chronic low back pain, Pain 115 (1) (2005) 107–117.
[17] A. Büssing, T. Ostermann, R. Lüdtke, A. Michalsen, Effects of yoga interventions on pain and pain-associated disability: a meta-analysis, J. Pain 13 (1) (2012) 1–9.
[18] R. Lavey, T. Sherman, K.T. Mueser, D.D. Osborne, M. Currier, R. Wolfe, The effects of yoga on mood in psychiatric inpatients, Psychiatr. Rehabil. J. 28 (4) (2005) 399.
[19] S.A. Zope, R.A. Zope, Sudarshan kriya yoga: breathing for health, Int. J. Yoga 6 (1) (2013) 4.
[20] R.P. Brown, P.L. Gerbarg, Sudarshan Kriya Yogic breathing in the treatment of stress, anxiety, and depression: part II—clinical applications and guidelines, J. Alternative Compl. Med. 11 (4) (2005) 711–717.
[21] V.V. Agte, S.A. Chiplonkar, Sudarshan kriya yoga for improving antioxidant status and reducing anxiety in adults, Altern. Compl. Ther. 14 (2) (2008) 96–100.
[22] H. Cramer, R. Lauche, J. Langhorst, G. Dobos, Is one yoga style better than another? A systematic review of associations of yoga style and conclusions in randomized yoga trials, Compl. Ther. Med. 25 (2016) 178–187.
[23] R.A. Littlewood, P.A. Vanable, Complementary and alternative medicine use among HIV-positive people: research synthesis and implications for HIV care, AIDS Care 20 (8) (2008) 1002–1018.
[24] D. Moher, A. Liberati, J. Tetzlaff, D.G. Altman, Prisma Group, Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement, Ann. Intern. Med. 151 (2009) 264–269.
[25] W.R. Miller, J.M. Brown, T.L. Simpson, N.S. Handmaker, T.H. Bien, L.F. Luckie, What Works? a Methodological Analysis of the Alcohol Treatment Outcome Literature, Allyn and Bacon, Boston, MA, 2003(Hester RK, Miller WR, eds. Handbook of Alcohilsm Treatment Approaches: Effective Alternatives).
[26] S.H. Downs, N. Black, The feasibility of creating a checklist for the assessment of the methodological quality both of randomised and non-randomised studies of health care interventions, J. Epidemiol. Community Health 52 (1998) 377–384.
[27] F.G. Fowkes, P.M. Fulton, Critical appraisal of published research: introductory guidelines, Br. Med. J. 302 (6785) (1991) 1136–1140.
[28] A.R. Jadad, R.A. Moore, D. Carroll, et al., Assessing the quality of reports of randomized clinical trials: is blinding necessary? Contr. Clin. Trials 17 (1) (1996) 1–12.
[29] B.J. Becker, Synthesizing standardized mean-change measures, Br. J. Math. Stat. Psychol. 41 (2) (1988) 257–278.
[30] S.B. Morris, R.P. DeShon, Combining effect size estimates in meta-analysis with repeated measures and independent-groups designs, Psychol. Methods 7 (1) (2002) 105.
[31] M.W. Lipsey, D.B. Wilson, Practical Meta-analysis vol. 49, Sage Publications, Thousand Oaks, CA, 2001.
[32] L.V. Hedges, Distribution theory for Glass's estimator of effect size and related estimators, J. Educ. Stat. 6 (2) (1981) 107–128.
[33] StataCorp. Stata Statistical Software: Release 12, StataCorp LP, College Station, TX, 2011.
[34] J. Higgins, S.G. Thompson, Quantifying heterogeneity in a meta-analysis, Stat. Med. 21 (11) (2002) 1539–1558.
[35] T.B. Huedo-Medina, J. Sánchez-Meca, F. Marín-Martínez, J. Botella, Assessing heterogeneity in meta-analysis: Q statistic or I^2 index? Psychol. Methods 11 (2) (2006) 193.
[36] J. Lau, J.P. Ioannidis, N. Terrin, C.H. Schmid, I. Olkin, Evidence based medicine: the case of the misleading funnel plot, BMJ Br. Med. J. (Clin. Res. Ed.) 333 (7568) (2006) 597.
[37] P.-E. David, S.-G. Luis-Benjamín, I.-A. Luis-Antonio, E.-Á.E.A. Delia, Yoga practice improves sleep quality of people living with HIV on ART, Indian Journal of Traditional Knowledge 16 (2017) 105–108.
[38] R.P. Agarwal, A. Kumar, J.E. Lewis, A pilot feasibility and acceptability study of yoga/meditation on the quality of life and markers of stress in persons living with HIV who also use crack cocaine, J. Alternative Compl. Med. 21 (3) (2015) 152–158.
[39] V. Bonadies, A yoga therapy program for AIDS-related pain and anxiety: implications for therapeutic recreation, Ther. Recreat. J. 38 (2) (2004) 148–166.
[40] A. Brazier, A. Mulkins, M. Verhoef, Evaluating a yogic breathing and meditation intervention for individuals living with HIV/AIDS, Am. J. Health Promot. 20 (3) (2006) 192–195.
[41] W.T. Cade, D.N. Reeds, K.E. Mondy, et al., Yoga lifestyle intervention reduces blood pressure in HIV-infected adults with cardiovascular disease risk factors, HIV Med. 11 (6) (2010) 379–388.
[42] N. Mawar, T. Katendra, R. Bagul, et al., Sudarshan Kriya yoga improves quality of life in healthy people living with HIV (PLHIV): results from an open label randomized clinical trial, Indian J. Med. Res. 141 (1) (2015) 90–99.
[43] R. Naoroibam, K.G. Metri, H. Bhargav, R. Nagaratna, H. Nagendra, Effect of Integrated Yoga (IY) on psychological states and CD4 counts of HIV-1 infected Patients: a Randomized controlled pilot study, Int. J. Yoga 9 (1) (2016) 57.
[44] R. Rao, U. Deb, N. Raghuram, N. Hongasandra Rama Rao, A. Burke, F. Hecht, Effects of an integrated yoga program on mood, perceived stress, quality of life and immune measures in HIV patients: a pilot study, BMC Complement Altern. Med. 12 (2012) 235.
[45] K. Mondy, W.T. Cade, D.N. Reeds, et al., Hatha/Ashtanga yoga intervention modestly improves cardiovascular disease (CVD) risk parameters in dyslipidaemic HIV+ subjects with central adiposity, Antivir. Ther. 12 (6) (2007) L47–L48.
[46] A.S. Wimberly, M. Engstrom, M. Layde, J.R. McKay, A randomized trial of yoga for stress and substance use among people living with HIV in reentry, J. Subst. Abuse Treat. 94 (2018) 97–104.
[47] S. Cohen, T. Kamarck, R. Mermelstein, A global measure of perceived stress, JHSB (J. Health Soc. Behav.) (1983) 385–396.
[48] D. Watson, L.A. Clark, G. Carey, Positive and negative affectivity and their relation to anxiety and depressive disorders, J. Abnorm. Psychol. 97 (3) (1988) 346.
[49] C.T. Veit, J.E. Ware, The structure of psychological distress and well-being in general populations, J. Consult. Clin. Psychol. 51 (5) (1983) 730.
[50] I. Bjelland, A.A. Dahl, T.T. Haug, D. Neckelmann, The validity of the Hospital Anxiety and Depression Scale: an updated literature review, J. Psychosom. Res. 52 (2) (2002) 69–77.
[51] K.A. O'Connell, S.M. Skevington, An international quality of life instrument to assess wellbeing in adults who are HIV-positive: a short form of the WHOQOL-HIV (31 items), AIDS Behav. 16 (2) (2012) 452–460.
[52] S.M. Skevington, M. Lotfy, K.A. O'Connell, The World Health Organization's WHOQOL-BREF quality of life assessment: psychometric properties and results of the international field trial. A report from the WHOQOL group, Qual. Life Res. 13 (2) (2004) 299–310.
[53] F.P. Robinson, Measurement of quality of life in HIV disease, J. Assoc. Nurses AIDS Care 15 (5) (2004) 14S–19S.
[54] A. Damodaran, A. Malathi, N. Patil, N. Shah, S. Marathe, Therapeutic potential of yoga practices in modifying cardiovascular risk profile in middle aged men and women, J. Assoc. Phys. India 50 (5) (2002) 633–640.
[55] S.D. Pressman, S. Cohen, Does positive affect influence health? Psychol. Bull. 131 (6) (2005) 925.
[56] G. Ironson, C. O'Cleirigh, M. Kumar, et al., Psychosocial and neurohormonal predictors of HIV disease progression (CD4 cells and viral load): a 4 year prospective study, AIDS Behav. 19 (8) (2015) 1388–1397.
[57] L.N. Campos, M.D.C. Guimarães, R.H. Remien, Anxiety and depression symptoms as risk factors for non-adherence to antiretroviral therapy in Brazil, AIDS Behav. 14 (2) (2010) 289–299.