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Journal

Journal of Alternative and Complementary Medicine, 27(5)

ISSN

1075-5535

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Publication Date

2021-05-01

DOI

10.1089/acm.2020.0420

Peer reviewed

THE JOURNAL OF ALTERNATIVE AND COMPLEMENTARY MEDICINE
Volume 27, Number 5, 2021, pp. 442–457

DOI: 10.1089/acm.2020.0420

JACM

Analysis of Movement-Based Mind–Body Interventions to Guide the Implementation of Osteoarthritis Exercise Programs: A Descriptive Review of Randomized Controlled Trials

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Abstract

Background: Clear and complete reporting of the components of complex interventions is required in clinical trials to ensure that research can be reliably replicated and successfully translated into clinical practice. Movement-based mind–body exercises, such as Tai Chi, *qigong*, and Yoga (TQY), are considered complex interventions and recommended for individuals with osteoarthritis in the latest guidelines of the American College of Rheumatology. This review analyzes the intervention reporting of randomized controlled trials of TQY to guide the implementation in osteoarthritis exercise programs.

Methods: We searched PubMed, Cochrane Central Register of Controlled Trials, and EMBASE for TQY exercise trials in osteoarthritis between 2000 and 2020. Pairs of researchers independently screened the records, extracted study characteristics, and assessed 19 items on the Consensus on Exercise Reporting Template (CERT) checklist. For each of these items, the numbers of studies that clearly reported the item were calculated. We then identified the items in the studies that are key to delivering home-based exercises for further analysis.

Results: We included 27 publications reporting 22 TQY interventions in the analysis. None of the studies reported sufficient details on all the 19 CERT items. The median completeness of reporting score was 11 and ranged from 6 to 15 of 19. The most frequently incompletely reported items (number reporting and percentage of studies) were ''starting level rule'' ($n=1$, 5%) and ''progression rule'' ($n=1$, 5%). Other incompletely reported items included ''fidelity or adherence (planned)'' ($n=9$, 41%), ''motivations'' ($n=9$, 41%), and ''progression description'' ($n=5$, 23%).

Conclusions: The content analysis highlights motivational strategies for long-term adherence to home-based exercises, which may help clinicians develop interventions for their patients. Details of TQY exercises interventions for osteoarthritis are incompletely reported in the included studies. The study suggests that improvements in content reporting are especially needed on items related to exercise intensity and program progression decisions, and motivational strategies in future implementation.

Keywords: osteoarthritis, Yoga, Tai Chi, *qigong*, implementation, home-based exercise

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Introduction

THE IMPORTANCE OF DOCUMENTING the contextual factors and multicomponent aspects of complex interventions is increasingly recognized.[1–3] Clinical recommendations and guidelines need to provide clinicians with sufficient details of the interventions, including specificity about dosage, frequency, intensity, and contextual factors. This requires clear and complete reporting of the components of complex interventions in clinical trials that form the basis of the clinical guidelines.[4] In 2014, the Template for Intervention Description and Replication (TIDieR) guidelines and checklist were established to guide researchers to answer the questions of ''Why, What, Who, How, Where, and When'' to improve the completeness of intervention reporting.[5] However, for exercise interventions, the general recommendations of TIDieR are not adequate to provide all the necessary details. In 2016, the Consensus on Exercise Reporting Template (CERT) was developed to provide guidance on a minimum set of key items considered essential to report replicable exercise interventions. The 19-item CERT checklist consists of 7 categories: materials, provider, delivery, location, dosage, tailoring, and compliance. The use of the CERT facilitates trial replication and increases the impact of clinical research on both theory and practice.[6–8]

Movement-based mind–body exercises, including Tai Chi, *qigong*, and Yoga (TQY), are considered complex interventions, defined as having multiple components and a number of features, unlike ''simple'' interventions such as devices or pharmaceuticals.[9] TQY exercise programs have been subjected to research evaluation and are increasingly practiced. In the United States, the use of TQY exercises increased from 6% in 2002 to 15% in 2017.[10] For patients with osteoarthritis, TQY can be effective in reducing pain, improving physical functioning, and increasing emotional well-being.[11–16] Given the numerous benefits enumerated in published clinical trials, the latest American College of Rheumatology guideline strongly recommends Tai Chi for patients with knee and/or hip osteoarthritis and conditionally recommends Yoga for people with knee osteoarthritis.[17] Successful implementation of this guideline requires detailed descriptions of the interventions in TQY trials for clinicians to apply in their clinical practice and instruct their patients in home-based exercises. Home-based exercise is considered as a key indicator of successful long-term exercise adherence in real-world settings.[18] Recent CERT analyses of exercise interventions in musculoskeletal, knee osteoarthritis, and hand osteoarthritis trials indicated that most research does not adequately report intervention details.[19–21] To date, no studies have been conducted to specifically assess the quality of the descriptions provided in intervention reporting of TQY exercises.

To fill this gap, this study applies the CERT checklist to assess the reporting of TQY exercise interventions in randomized controlled trials (RCTs) for individuals with osteoarthritis. In addition, this study focuses on analyzing CERT items related to home-based exercises to provide perspectives on future implementation in real-world setting.

Methods

Data sources and search methods

A literature search was performed in PubMed, Cochrane Central Register of Controlled Trials, and EMBASE to identify all eligible clinical studies reporting on movement-based mind–body exercises, including Yoga, Tai Chi, and *qigong*, for individuals with osteoarthritis. The search was limited to the literature published in English between January 2000 and July 2020. Search terms used were the following: ((tai chi[Title]) OR (taiji[Title]) OR (qigong[Title/Abstract]) OR (yoga[Title/Abstract])) AND (osteoarthritis[Title/Abstract]) AND (randomized[Title/Abstract]). The search strategy was adapted for each database as necessary. Supplementary Appendix SA1 provides the detailed search strategy for each of the three databases. In addition, recent review articles on TQY exercises were hand searched for relevant citations.

Selection of studies

All abstracts identified through the literature search were screened to exclude redundant and irrelevant abstracts. Full-text articles of potentially relevant abstracts were retrieved and evaluated for eligibility by one investigator and confirmed by two other investigators. Table 1 describes the study eligibility criteria. Studies that assessed TQY exercises as the main intervention were included. Studies with co-intervention (such as pharmacotherapy) were only included if all participants in all groups received the same co-interventions. We excluded external *qigong* modality because it involves *qigong* healers providing treatment and is not an exercise by participants themselves.

TABLE 1. STUDY ELIGIBILITY CRITERIA

Study design	*Published data from randomized controlled trials*
Population	Adults diagnosed with OA of the knee, feet, and spine
Intervention	Tai Chi, *qigong*, or Yoga interventions or these mind–body therapies as a major component of the intervention, with duration of more than 4 weeks. In studies that involved more than one active intervention, we restricted our analysis to the comparisons between mind–body therapy intervention and control group
Comparator	Any control
Outcome	At least one outcome from the following: (1) pain intensity, (2) function or disability, (3) quality of life, (4) mental health, and (5) sleep quality
Minimal sample size	10 Participants

OA, osteoarthritis.

Data extraction

One investigator performed data extraction that was then confirmed by at least one other investigator. Disagreements were resolved by consensus among team members. Data on participants (e.g., age, gender), interventions (e.g., style, forms, frequency, and duration, whether there was home-based exercise, exercise tailoring), adherence, and results of the interventions were recorded using a standardized data extraction form. Data extraction of adherence rates included three measures: (1) attendance (the number of sessions attended over the follow-up period), (2) dropout (retention), and (3) percentage of lost to follow-up.[22]

CERT checklist and calculation of completeness of reporting

In the original CERT checklist, the first item is the exercise equipment used. Since TQY exercises do not use any equipment (except Chair Yoga may use certain types of chairs), we revised the first item to describe the exercise, style, and forms. Table 2 summarizes the final modified version of the CERT checklist based on Shade et al.[7] The CERT includes 7 categories and 19 separate items considered essential in the reporting of reproducible exercise interventions. A CERT assessment form (Supplementary Appendix SA2) was developed for applying the CERT to extract descriptive information of exercise interventions.[7] We reviewed each study to determine how many of the 19 items were reported using this CERT assessment form. A researcher applied the checklist to the included studies and documented the results using an Excel spreadsheet. Each CERT item was rated as ''yes'' (1 point) if the item was clearly reported or ''no'' (0 point) if the item was not reported or not clearly described. At least one other investigator double-checked the results. Disagreements were resolved by consensus among team members. The number of checklist items that were adequately reported in each study was tabulated. The completeness of reporting score was computed for each study as the number of items rated as having been reported.

Results

Figure 1 summarizes the results of the literature search and screening process. There are a total of 22 unique studies of 27 articles published between 2000 and 2020.

Characteristics of the included studies

Table 3 presents the characteristics of the 22 studies, including: country, year of publication, percentage of female participants, average age of participants, sample size,

Table 2. Final Modified Version of the Consensus on Exercise Reporting Template Checklist

Item category	*Item No.*	*Item name*	*Item description*
WHAT: style and forms	1	Brief exercise name	Provide the name or a phrase that describes the exercise, including style and forms
WHO: provider	2	Instructor qualification	Qualifications, teaching/supervising expertise, and/or training of the exercise instructor
HOW: delivery	3	Individual or group	Describe whether exercises are performed individually or in a group
	4	Supervised or not supervised	Describe whether exercises are supervised or unsupervised
	5	Adherence	Detailed description of how adherence to exercise is measured and reported
	6	Motivations	Detailed description of motivation strategies
	7a	Progression rule	Detailed description of the decision rules(s) for determining exercise progression
	7b	Progression description	Detailed description of how the exercise program was progressed
	8	Exercise description	Detailed description of each exercise to enable replication
	9	Home program	Detailed description of any home program component
	10	Nonexercise component	Describe whether there are any nonexercise components
	11	Adverse event	Describe the type and number of adverse events that occur during exercise
WHERE: location	12	Setting	Describe the types(s) of location(s) where the exercises are performed
WHEN, HOW MUCH: dosage	13	Intervention details	Detailed description of the exercise intervention
TAILORING: what, how	14a	Generic or individually tailored	Describe whether the exercises are generic (one size fits all) or tailored
	14b	Tailored (how)	Detailed description of how exercises are tailored to be individual
	15	Starting level rule	Describe the decision rule for determining the starting level
HOW WELL: planned, actual	16a	Fidelity or adherence (planned)	Describe how adherence or fidelity is assessed/measured
	16b	Adherence (actual)	Describe the extent to which the intervention was delivered as planned

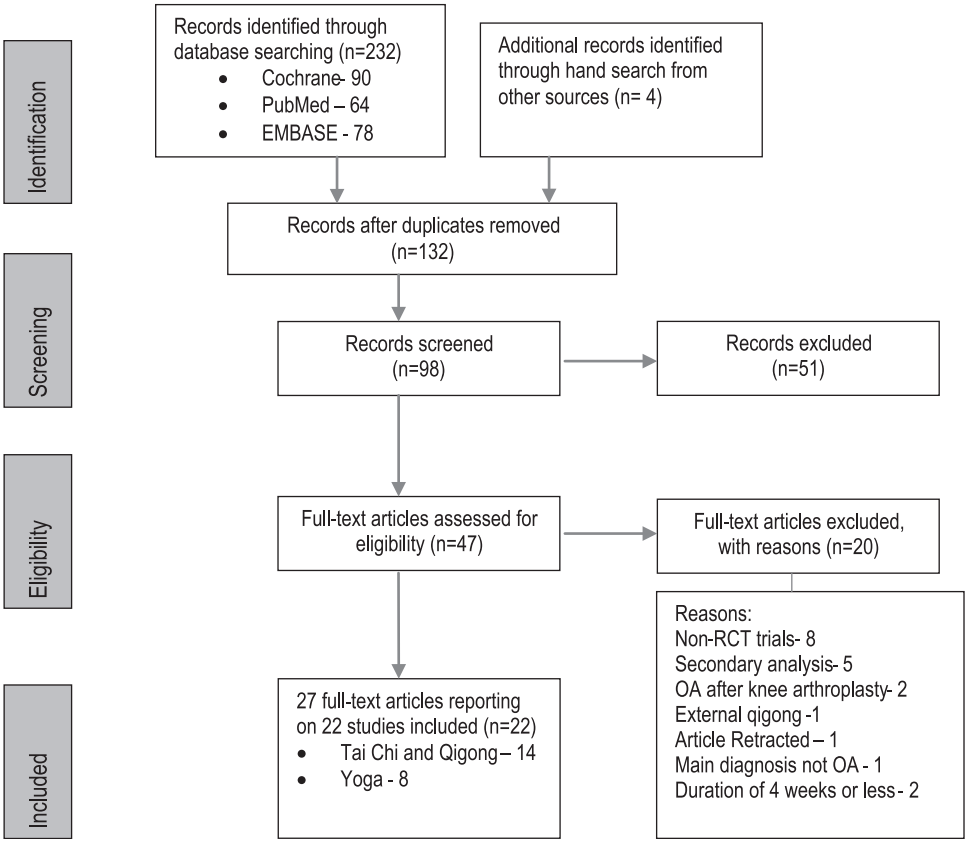

FIG. 1. The flow of the literature search and publication selection process following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guideline. OA, osteoarthritis; RCT, randomized controlled trial.

setting, and results. Studies from six countries were represented. The United States was the most common country ($n=12$),[23–35] followed by China[36–40] ($n=4$), Korea[41–44] ($n=3$), Australia[45] ($n=1$), India[46] ($n=1$), and Canada[47] ($n=1$). The systematic review includes a total of 1592 participants (median study size of 48, ranging from 14 to 250). More than half of the studies were performed on groups of 10–50 participants ($n=12$), followed by groups of 51–100 participants ($n=6$) and groups of more than 100 participants ($n=4$). The percentage of female participants ranged from 44% to 100% (median of 83%). One study did not include the percentage of female participants. The average age of study participants ranged from 52 to 79 years. Of 15 studies, the average age of participants was 65 years or older.

Settings. Sixteen (73%) studies reported the settings where the exercise programs took place. Clinical settings were the most common settings across the studies ($n=8$, 50%), followed by community settings ($n=6$, 38%) and academic settings ($n=2$, 12%). Of the 14 studies containing a home-based exercise component, 11 (79%) studies reported settings. Clinical settings were also the most common setting in these studies ($n=6$, 55%), followed by community settings ($n=4$, 36%) and academic settings ($n=1$, 9%). Overall, there were no setting differences between all included studies and studies having home-based exercise components.

Results. Of the 15 (68%) studies that measured pain intensity, 3 studies reported no significant pain improvement[27,43,45]; among the 12 studies that reported pain reduction, 3 studies found that pain reduction could not sustain after 12-week detraining.[24,25,32] Sixteen (73%) studies measured and found that TQY interventions could improve physical functioning. One study found the improvement in physical functioning sustained after 12-week detraining.[45] Eight (36%) trials measured and showed improvement in mental health symptoms, such as anxiety, depression, and sleep.[25,28–31,34–36]

Reporting completeness of movement-based mind–body exercise trials

The overall scores of each trial and scores for each CERT item are shown in Supplementary Appendix SA3. None of the 22 included studies adequately reported all the checklist items. The median number of items reported (i.e., completeness of reporting score) in the included studies was 11 (range 6–15) of a possible score of 19. Figure 2 shows the number of studies with complete reporting for each of the CERT checklist items. Three CERT items (''exercise names,'' ''interventional details,'' and ''individual or group'') were clearly described in all included studies. Nine CERT items were clearly described by at least 50% of the trials: ''exercise description'' ($n=21$), ''supervised or not supervised'' ($n=21$), ''instructor qualifications'' ($n=20$), ''adherence (actual)'' ($n=17$), ''setting'' ($n=16$), ''home program'' ($n=15$), ''generic or individually tailored'' ($n=13$), ''adverse events'' ($n=13$), and ''adherence'' ($n=11$). Several items were poorly reported across most trials, including: ''fidelity or adherence (planned)'' and ''motivations'' in nine trials, ''progression description'' in five studies, ''progression rule'' and ''starting level rule'' were only reported in one study.

Table 3. Characteristics of Included 22 Randomized Controlled Trials of Movement-Based Mind–Body Exercises

			Exercise intervention			*Adherence*			
Study	*Setting*	*Sample (N; age; female)*	*Supervised*	*Home*	*DR (weeks)*	*Attendance*	*Dropout*	*Lost follow-up*	*Results*
Hartman et al.[23] USA, 2000	Clinical	*N*=33 68 years 85% F	9-form Yang-style Tai Chi: 60 min, 2×/week for 12 weeks	No	12	Exp: 63% attended ≥87%, 57%, attended ≥92%	Exp: 6% Ctrl: 7%	NR	Tai Chi improved arthritis self-efficacy; satisfaction of general health status; lower extremity functional mobility
Song et al.[41,42] Korea, 2007	NR	*N*=72 64 years 100% F	12-form Sun-style Tai Chi: 60 min, 3×/week for 2 weeks	Yes	12	NR	Exp: 43% Ctrl: 39%	NR	Tai Chi perceived less pain and stiffness; fewer difficulties in physical function; improved balance and abdominal muscle strength
Brismee et al.[24] USA, 2007	NR	*N*=41 70 years 83% F	24-form Yang-style Tai Chi: 40 min, 3×/week for 6 weeks	Yes	12	Exp: 89% Ctrl: 83%	Exp: 9% Ctrl: 5%	At 18 weeks: Exp: 9% Ctrl: 27%	Tai Chi improved knee pain, physical functioning, and stiffness. All improvements disappeared after detraining
Fransen et al.[45] Australia, 2007	Clinical	*N*=152 70 years 74% F	24-form Sun-style Tai Chi: 60 min, 2×/week	No	12	Exp: 61% attended ≥50% classes Ctrl: 81% attended ≥50% classes	Exp: 7% Ctrl: 5%	At 24 weeks: Exp: 4% Ctrl: 2%	Tai Chi improved physical functioning and sustained for 12 weeks of detraining; no significant pain improvement
Lee et al.[43] Korea, 2009	Community	*N*=44 69 years 93% F	18-form Tai Chi *qigong*: 60 min, 2×/week	No	8	NR	Exp: 3% Ctrl: 13%	NR	Tai Chi improved quality of life and 6-m walking test. No significant change of WOMAC scores
Wang et al.[25] USA, 2009	Clinical	*N*=40 65 years 75% F	10-form Yang-style Tai Chi: 60 min, 2×/week for 12 weeks	Yes	48	Exp: 85% Ctrl: 89%	Exp: 0 Ctrl: 0	At 48 weeks: Exp: 45% Ctrl: 40%	Tai Chi reduced pain at 12 and 24 weeks; improved physical functioning and depression at 12 weeks. All nonsignificant at 24 and 48 weeks of home-based exercise

(*continued*)

TABLE 3. (CONTINUED)

Study	Setting	Sample (N; age; female)	Exercise intervention			Adherence			Results
			Supervised	Home	DR (weeks)	Attendance	Dropout	Lost follow-up	
Song et al.[44] Korea, 2010	NR	$N=82$ 64 years 100% F	31-form Sun-style Tai Chi: 60 min, 3×/week for 3 weeks	Yes	26	Exp: 93% Ctrl: 96%	Exp: 16%	At 6 months: Exp: 27% Ctrl: 15%	Tai Chi improved bone mineral density and reduced fear of falling. Increased knee extensor muscle endurance insignificantly
Wortley et al.[27] USA, 2013	NR	$N=31$ 69 years 71% F	12-form Yang-style Tai Chi: 60 min, 2×/week	No	10	Exp: 82% Ctrl: 88%	Exp: 20% Ctrl: 33%	NR	Tai Chi improved mobility but not knee OA symptoms
Tsai et al.[26] USA, 2013	NR	$N=55$ 79 years 73% F	12-form Sun-style Tai Chi: 20–40 min, 3×/week	No	20	NR	Exp: 14% Ctrl: 22%	NR	Tai Chi reduced pain and stiffness
Wang et al.[28] USA, 2016	Clinical	$N=204$ 60 years 70% F	10-form Yang-style Tai Chi: 60 min, 2×/week for 12 weeks	Yes	52	Exp: 74% Ctrl: 81%	Exp: 18% Ctrl: 18%	At 53 weeks: Exp: 16% Ctrl: 9%	Tai Chi reduced pain and improved physical functioning similar to physical therapy. Tai Chi improved depression
Zhu et al.[36]; Lu et al.[37] China, 2017, 2017	Community	$N=46$ 65 years 100% F	8-form Yang-style Tai Chi: 3×/week	No	24	Exp: 87% Ctrl: 78%	Exp: 9% Ctrl: 17%	NR	Tai Chi reduced pain, improved sleep quality and HRQOL, physical functioning, and gait performance
Ye et al.[38] China, 2019	Clinical	$N=50$ 64 years 60% F	8-form Baduanjin *qigong*: 40 min, 3×/week for 4 weeks, 1×/month for following 8 weeks	Yes	12	NR	NR	NR	Baduanjin *qigong* reduced pain, stiffness, and functional impairment; improve knee joint proprioception and postural stability
Ye et al.[39] China, 2020	Clinical	$N=56$ 64 years 66% F	8-form Baduanjin *qigong*: 40 min, 3×/week for first 4 weeks and followed by 1×/month for 8 weeks	Yes	12	NR	NR	NR	Baduanjin improved WOMAC functions, postural control
Zhang et al.[40] China, 2020	NR	$N=46$ 65 years 100% F	5-form Tai Chi: 60 min, 2×/week	No	26	NR	NR	Exp: 9% Ctrl: 17%	Tai Chi changed the pattern of plantar load during walking for potential reduction in pain

(*continued*)

Table 3. (Continued)

Study	Setting	Sample (N; age; female)	Exercise intervention			Adherence			Results
			Supervised	Home	DR (weeks)	Attendance	Dropout	Lost follow-up	
Ebnezar et al.[46,54] INdia, 2011, 2012	Clinical	$N=250$ 60 years 70% F	Integrated Yoga therapy: 40 min, 7/week for 2 weeks	Yes	12	NR	Exp: 6% Ctrl: 7%	NR	Yoga as adjunct of TENS reduced knee pain, tenderness, swelling, crepitus, knee disability, and walking time
Taibi et al.[29] USA, 2011	Academic	$N=14$ 65 years 100% F	Hatha Yoga: 75 min, 1×/week for 8 weeks	Yes	8	Exp: 90%	Exp: 7% Ctrl: 7%	NR	Yoga improved sleep quality. Study was feasible and acceptable
Cheung et al.[30] USA, 2014	Community	$N=36$ 72 years 100% F	Hatha Yoga: 60 min, 1×/week for 8 weeks	Yes	8	Exp: 69% attended ≥75% of classes	Exp: 5% Ctrl: 5%	NR	Yoga reduced pain, stiffness, and improved physical functioning and sleep disturbance. Study was feasible and acceptable
Moonaz et al.[31] USA, 2015	Clinical	$N=75$ 52 years 96% F	Integral-based Hatha Yoga: 60 min, 2×/week for 8 weeks	Yes	8	Exp: 79% attended ≥75% of classes	Exp: 24% Ctrl: 20%	At 9 months: Exp: 12% Ctrl: 60%	Yoga increased physical activity, improved physical and psychological health, and HRQOL
Park et al.[32,33] USA, 2017, 2017	Community	$N=131$ 75 years 76% F	Chair Yoga: 45 min, 2×/week for 8 weeks	Yes	20	NR	Exp: 5%	NR	Chair Yoga reduced pain and sustained through 3 months. WOMAC pain, gait, and fatigue were improved but not sustained at 3 months
Buchanan et al.[34] USA, 2017	Community	$N=18$ 55 years 44%	Viniyoga: 75 min, 1×/week for 12 weeks	Yes	12	Exp: median of 9 classes among 12 (range 7–10)	Exp: 10% Ctrl: 29%	NR	Yoga improved sleep. Study is feasible
Cheung et al.[35] USA, 2017	Community	$N=83$ 72 years 84% F	Hatha Yoga: 45 min, 1×/week for 8 weeks	Yes	8	Exp: 63% attended ≥50% of classes	Exp: 13% Ctrl: 18%	NR	Yoga reduced pain and improved physical functioning, lower extremity strength, anxiety, and fear of falling
Kuntz et al.[47] USA, 2018	Academic	$N=31$ 66 years NR	Biomechanically based Yoga: 60 min, 3×/week	No	12	Exp: average attendance of 3.0 ± 0.75/week	Exp: 0% Ctrl: 9%	Exp: 10% Ctrl: 0	Yoga reduced pain and improved self-reported physical functioning and mobility

DR, duration; F, female; HRQOL, health-related quality of life; NR, not reported; TENS, transcutaneous electrical nerve stimulation; WOMAC, Western Ontario and McMaster Universities Arthritis Index.

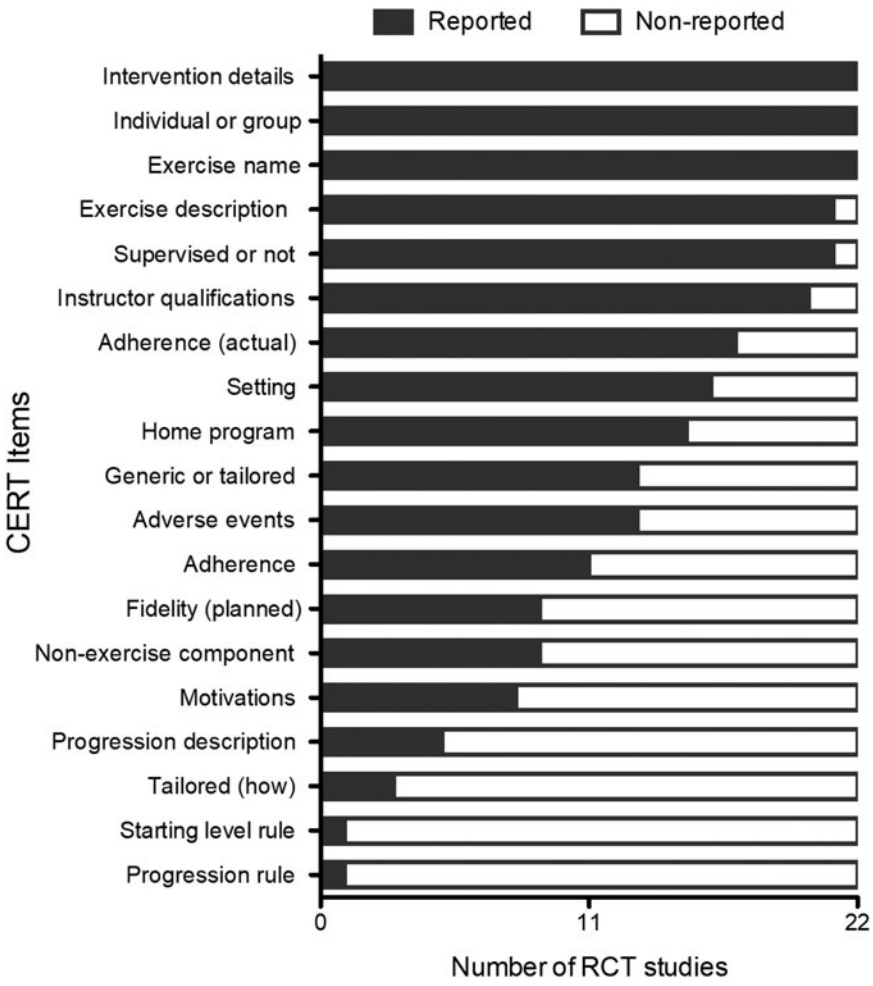

FIG. 2. Number of items reporting completeness in 22 included studies.

In summary, none of studies adequately included and described all the items on the CERT checklist. A few items, such as decision rules regarding intensity and program progression, motivational strategies, and fidelity, were rarely reported.

Description of intervention details

Table 3 provides detailed information about intervention and exercise adherence for all included studies. Table 4 presents the description of key CERT items that closely relate to the delivery of home-based exercises, including exercise names (Item 1), individual or group (Item 3), supervised or not supervised (Item 4), motivation (Item 6), home program (Item 9), nonexercise component (Item 10), intervention details (Item 13), generic or individually tailored (Item 14a), tailored (how) (Item 14b), and adherence (actual) (Item 16b). Items 3, 4, and 13 are merged for the convenience of presentation in Table 4.

Exercise names (Item 1). Among the 22 RCTs in Table 3, 14 used Tai Chi and Baduanjin *qigong* exercises as interventions and 8 used Yoga. Baduanjin is a standard 8-form *qigong* exercise widely adopted in China.[38,39] Tai Chi and Yoga interventions are represented by various styles with different numbers of movements. Among the Tai Chi studies, six interventions included Yang-style Tai Chi exercises with 8-form,[37] 9-form,[23] 10-form,[25,28] 12-form,[27] and 24-form[24] movements, respectively. Four interventions included Sun-style Tai Chi exercises with 12-form,[26,41] 24-form,[45] and 31-form[44] movements, respectively. Two studies did not specify the Tai Chi style but listed 5-form[36] and 18-form[43] movements as their interventions. For the Yoga studies, five studies[29–31,35,46] had Hatha Yoga as the experimental intervention. Viniyoga,[34] Chair Yoga,[32,33] and Biomechanically based Yoga[47] were also used in the included studies. By analyzing the authors and affiliated organizations, we discovered that the 22 RCTs were conducted by 17 research groups. Two research groups adopted different styles and/or forms in their different studies. Song et al.[41] used 12-form Sun-style Tai Chi as the modality in 2003, whereas in their 2010 study,[44] they used 31-form Sun-style Tai Chi. Taibi and Vitiello[29] used Hatha Yoga as their intervention in 2011, whereas in 2017,[34] they used Viniyoga as the modality. Overall, the different styles and number of movements deployed in TQY studies may influence future implementation.

Supervised group exercise (Items 3 and 4) and home program (Item 9). Study designs varied. As shown in Table 3, among the eight Yoga trials, only one study[47] had no home exercise component. A total of 14 studies had home exercise components, and as shown in Table 4, 5 of

Table 4. Characteristics of 14 Studies That Contain Home-Based Exercise Components

		Intervention details								*Adherence (actual)*		
		Supervised group exercise		*Home program*								
Study	*Exercise name*	Session length; frequency	DR (weeks)	Session length; frequency	DR (weeks)	*Non-exercise component*	*Motivation*	*Generic or individual tailored*	*Tailored (how)*	*Minutes*	*Times/ week*	*Overall*
Song et al.[41,42]	12-form Sun-style TC	60 min, 3×/ week 60 min, 1×/ week	2 10	20 min, 3×/ week for the same 10 weeks	10	Home audiotape, handout	Phone reminders	Tailored	Adapt movements based on pain and discomfort of individuals	NR	NR	NR
Brismee et al.[24]	24-form Yang-style TC	40 min, 3×/ week	6	Followed by: 40 min, 3×/week	6	Tai Chi video	Self-reported exercise log	Generic	N/A	NR	2.5	90% home exercise attendance
Wang et al.[25]	10-form Yang-style TC	60 min, 2×/ week	12	Followed by: >20 min daily	36	Tai Chi video, handout	Readings of theory and techniques; phone reminders, monetary incentive	Tailored	Minor modification of movement to suit for individuals with pain	NR	NR	NR
Song et al.[44]	31-form Sun-style TC	60 min, 3×/ week 60 min, 1×/ week	3 23	>20 min, daily for the same 23 weeks	23	Handout	Handout; phone reminders weekly; exercise log	NR	NR	NR	NR	NR
Wang et al.[28]	10-form Yang-style TC	60 min, 2×/ week	12	Followed by: >20 min daily	40	Handout	Monthly phone calls; maintain daily exercise log	Generic	N/A	NR	NR	NR
Ye et al.[38]	8-form Baduanjin *qigong*	40 min, 3×/ week Followed by: 1×/ month	4 8	40 min, 3×/week for the same 8 weeks	8	NR	Reminder phone call biweekly, monthly group practice, and meeting	Generic	N/A	NR	NR	NR
Ye et al.[39]	8-form Baduanjin *qigong*	40 min, 3×/ week Followed by 1×/ month	4 8	40 min, 3×/ week for the same 8weeks	8	NR	Reminder phone call; monthly group practice and meeting	Generic	N/A	NR	NR	NR
Ebnezar et al.[46,54]	Integrated Yoga therapy	40 min, 7/ week	2	Followed by: 40 min, 7×/week for 10 weeks	10	Handout	NR	Generic	N/A	NR	NR	NR
Taibi et al.[29]	Hatha Yoga	75 min, 1×/ week	8	20 min nightly for the same 8 weeks	8	Handout, audio CD	Self-reported exercise log	NR	NR	23	5.8	NR

(*continued*)

Table 4. (Continued)

		Intervention details								*Adherence (actual)*		
		Supervised group exercise		*Home program*								
Study	*Exercise name*	Session length; frequency	DR (weeks)	Session length; frequency	DR (weeks)	*Non-exercise component*	*Motivation*	*Generic or individual tailored*	*Tailored (how)*	*Minutes*	*Times/ week*	*Overall*
Cheung et al.[30]	Hatha Yoga	60 min, 1×/ week	8	30 min, 4×/ week for the same 8 weeks	8	Handout	$10 incentive for each data collection; self-reported exercise log	Tailored	Modified poses based on physical limitation	112 min/ week	70% ≥ 4 days/ week	33% completed it as prescribed
Moonaz et al.[31]	Integral-based Hatha Yoga	60 min, 2×/ week	8	60 min, 1×/ week for the same 8 weeks	8	Handout with illustration	Weekly readings for Yoga benefits	Tailored	Modified poses for individuals	NR	NR	NR
Park et al.[32,33]	Chair Yoga	45 min, 2×/ week	8	Followed by: 45 min, 2×/ week	12	Handout with instruction and pictures	Observation using a standardized checklist; self-reported exercise log	NR	NR	10–20 min	NR	13/37 practice daily
Buchanan et al.[34]	Viniyoga	75 min, 1×/ week for	12	30 min daily for the same 12 weeks	12	Audio CD, handout with diagrams	Participants paid $250 for completing assessment; self-reported exercise log	Tailored	Modified poses to address individual needs	NR	6.2	NR
Cheung et al.[35]	Hatha Yoga	45 min, 1×/ week	8	30 min, 4×/ week for the same 8 weeks	8	Handout with picture and instruction	Video recordings of home exercise, self-recorded exercise log	Tailored	Modified poses based on physical limitation	Average 79 min/ week	3	NR

CD, compact disc; N/A, not applied; TC, Tai Chi.

these studies provided supervised group exercise, followed by a home exercise period[24,25,28,33,46]; 4 studies provided supervised group exercises and occasional group sessions (booster sessions) during the home exercise period[38,39,41,44]; the remaining 5 studies provided supervised group exercise and a home exercise component of the same duration.[29–31,34,35] The median duration of home-based exercises was 9 weeks with a range of 6–40 weeks. The median duration of supervised group exercises was 8 weeks, ranging from 2 to 12 weeks. In three studies, group exercise was provided for 3 weeks or less. The intent of these exercise sessions was to teach the exercise movements and then focus on home-based exercise.[41,44,46] In summary, the home-based exercises in the Tai Chi and *qigong* studies were primarily designed with supervised group exercise, with or without booster sessions. In the Yoga studies, the home-based exercise was usually mixed with supervised group sessions of the same duration. Of note, all three designs of home-based exercise have potential clinical implications in future implementations.

Motivation (Item 6) and nonexercise component (Item 10). Table 4 presents the motivation and nonexercise component of the 14 studies that contained a home-based exercise component. Nonexercise components include items such as written instructions, education materials, or training manuals. Twelve studies used home audiotape, video, handouts with pictures, and written instruction. There were five motivational strategies for home-based exercise adherence found, including: (1) regularly scheduled phone reminders from research staff or exercise leaders in six Tai Chi and *qigong* studies[25,28,38,39,41,44]; (2) monetary incentives for completing the exercise programs.[25,30,34] Interestingly, one study asked participants to donate $35 to be included in the study[45]; (3) occasional group exercise sessions (booster sessions) and meetings during the home-based exercise period[38,39,41,44]; (4) detailed instructions on movements and the health benefits of exercises.[25,31,33,34] Participants were given handouts and video materials in all 14 home-based exercise studies; and (5) using self-reported exercise logs in eight studies. Overall, these five motivational strategies for home-based exercise provide clinical implications for implementation.

Generic or individually tailored (Item 14a) and tailored (how) (Item 14b). Table 4 shows that 6 of the 14 studies reported that the Tai Chi interventions were tailored and movements and poses were modified based on participants' physical limitations or pain levels.[25,30,31,34,35,41] Four studies adopted generic sets of exercises (24-form simplified Yang style,[24] 18-form Tai Chi *qigong* routine,[43] and 8-form Baduanjin *qigong* routine[38,39]) and repeated them during group sessions. Four studies used standardized sets of exercise specially prepared for osteoarthritis.[28,36,45,46] This study defines either generic sets or standardized set of Tai Chi exercises as generic. In summary, two thirds of the included studies modified their interventions based on either a general understanding of disease status in osteoarthritis or individual needs.

Adherence (actual) (Item 16b). As shown in Table 3, we collected information on three measures of adherence, including attendance rate (the percentage of actual number of sessions attended of all sessions), dropout rate (the percentage of participants who dropped out during the intervention), and lost to follow-up rate (the percentage of participants who did not participate in data collection after the duration of the intervention). Twenty (91%) studies provided at least one measure of adherence. Among these 20 studies, 7 (35%) studies reported all three measures of adherence, 7 (35%) studies reported two of the three measures, and 6 (30%) studies reported only one measure. The 14 studies providing attendance information reported attendance rate from 63% to 93%. Among the 19 studies providing dropout information, the median dropout rate was 9%, ranging from 0 to 43%. Among the eight studies providing lost to follow-up information, the median lost to follow-up rate was 11%, ranging from 4% to 45%. As shown in Table 4, only 5 of the 14 studies provided information on home exercise adherence. Of note, the reported data were inconsistent and incomparable among the different studies. The home exercises were usually prescribed as session length (20–60 min each session), frequency (1–7 days/week), and duration (6–40 weeks). In one study, although 70% of the participants exercised with the prescribed frequency, only 33% of participants exercised for the prescribed session length, frequency, and duration.[30] Overall, the studies provided the adherence information mainly on the supervised group sessions. Better reporting on adherence rates of home-based exercise programs is required in future research.

Discussion

To the best of our knowledge, this is the first comprehensive review documenting the quality of the intervention descriptions in movement-based mind–body exercise trials. Of note, none of the RCTs provides sufficient details to allow for a full replication or appropriate implementation in a real-world setting based on the CERT criteria. Future research and clinical practice can be improved by better reporting of five CERT items: (1) ''starting level rule'' (the rule for determining the level of exercise at which the participant should begin); (2) ''progression rule'' (the rule for determining how the participant should progress through the exercise program); (3) ''fidelity or adherence (planned)'' (description of who delivered the intervention, how it was delivered, and any strategies employed to guarantee fidelity); (4) ''motivations'' (motivational strategies to enhance adherence); and (5) ''progress description'' (how progressive overload is managed in the exercise program). The detailed analysis of items related to home-based exercise provides clinical implications for long-term adherence to achieve optimal health outcomes.

Completeness of intervention reporting

Our findings related to how well intervention details were adequately reported are in keeping with previous studies using the CERT to evaluate exercise descriptions in musculoskeletal exercise trials,[19] knee osteoarthritis,[20] and hand osteoarthritis trials.[21] The mean completeness of reporting score for RCTs in our study (score = 11) is very similar to those found in other knee osteoarthritis exercise studies (score = 11) and hand osteoarthritis exercise studies

(score = 11). All three studies had higher mean completeness of reporting scores than the musculoskeletal exercise trials (score = 9.9). This may be due to the more heterogeneous population of the musculoskeletal exercise trial.

In the three studies noted above, the most rarely reported items were consistent with our study, including motivation strategies, adherence to the intervention, decision rule for starting level, and the progress decision rule. The optimal frequency and intensity of exercise components for knee osteoarthritis are still unclear.[48] This could explain why they all have similar problems in reporting decision rules for intensity and program progression. There are also unique reasons that decision rules for intensity and adherence for TQY exercises are difficult to report. Even though different styles and forms are deployed in different studies, all TQY exercises have a set of movements with cultural origins that require smooth transitions from one movement to another.[49] For TQY exercises, investigators could focus on the completion of a set of movements and the coordination of breathing with each movement, rather than exercise intensity and program progression. Applying decision rules of intensity and program progression would be a daunting task but is urgently needed in TQY trials. This makes process evaluation even more important in TQY trials since it can document the implementation process and provides valuable insight into clinical practice.[50]

Adaptation and tailoring

Our findings indicated that RCT participants were on average 65 years or older in 15 of the 22 studies and were predominately female. Participants with these characteristics may find some weight-bearing positions and proposed intensity and duration of exercises in TQY trials difficult and unacceptable. The intervention may have to be adapted and arranged progressively to achieve optimal effectiveness. Tailor-made exercise programs have been proven to improve exercise adherence and health outcomes in older adults with osteoarthritis.[51]

In this review, the modification and adaptation of the exercise programs are represented in two different approaches. One approach used a standardized set of movements based on a general understanding of the musculoskeletal restrictions caused by osteoarthritis. Due to its high stance compared with other Tai Chi style, Sun-style Tai Chi was developed as a special Tai Chi program for osteoarthritis. Our findings show that four studies used Sun-style Tai Chi as the exercise, but researchers in each of these studies used a different set of movements, even though two studies were conducted by same research group.[26,41,44,45] This shows that the exercises were further adapted to the study population, settings, and the understanding of osteoarthritis in three different countries. This approach is categorized as generic on the CERT checklist because the exercise is not tailored to individual needs. The other approach tailored the exercise to the individual for reasons such as comorbidities, preferences, and abilities or as part of the progression of exercise intensity or both. This approach is considered tailoring on the CERT checklist. Studies can also use both approaches, such as Song et al.,[41] and Wang et al,[25] in which a standard set of Tai Chi movements was customized for osteoarthritis and to individual needs.

In addition to exercise modifications, there are other adaptations reported in the TQY literature. In a study of Spanish-speaking individuals with osteoarthritis, adaptations of the Chair Yoga program included assigning Spanish-speaking instructors and providing language-appropriate versions of the materials. The results of this study indicate that linguistically tailored Chair Yoga can be successfully implemented in an aging community for persons with limited English proficiency.[32] For people with osteoarthritis and cognitive impairment, program progression can be adapted to suit their learning speed.[52] These adaptations can be applied into research designs for targeted individuals and for clinical practice in community settings.

Home-based exercise and exercise prescription

Immediate and short-term clinical benefits, such as pain reduction, improvement in physical functioning, and emotional well-being can be obtained through supervised group TQY exercises. However, after detraining or no exercise for a period of time, the positive effects of TQY exercise are not sustained.[24,33] Daily or almost daily home-based exercise for a longer time period can provide sustained pain reduction, increased physical functioning, and improved emotional well-being.[46,53,54] This suggests that TQY exercises should be practiced as a regular exercise routine to maintain the positive effective of the exercise.

Our study found three designs of home-based components in the 14 studies. Home-based exercises in the Tai Chi and *qigong* studies were usually designed to be conducted after a period of supervised group exercise, with or without booster sessions. Home-based exercise in the Yoga studies was often designed to be practiced daily for the same time period as the supervised group exercise. One explanation for the different designs is that Yoga poses are much easier to learn than Tai Chi or *qigong* movements. Thus, home exercise can begin earlier in Yoga studies.

Home-based exercise after a period of supervised group exercises is more similar to real-world situations and has the potential to be more cost-effective. To mimic the real-world settings, a Tai Chi study had 40 weeks of daily home-based individual exercise lasting 20 min.[28] Another Tai Chi study designed a 3-week supervised group exercise components, followed by 23 weeks of home-based exercise and monthly booster sessions to enhance participants' learning of Tai Chi and to promote engagement.[44] These two designs, when used in Tai Chi and *qigong* studies, provide insights into designing home-based exercise program in real-world settings.

Motivation strategies for better adherence

Greater adherence to exercise is correlated with improved symptoms, physical functioning, and sleep quality.[55,56] However, previous clinical trials on exercise and osteoarthritis indicated that the adherence to exercise is estimated to be as low as 50%, declining even during the group exercise period.[57] In real-world settings, the exercise adherence rate (attendance) is believed to be much lower than this estimate and could be as low as 17%.[58,59] Our findings confirm that adherence to TQY exercises is higher than that found for general exercise groups in previous studies.[60,61] However, adherence to home-based exercise is still very low. For example, a Yoga study conducted in a community

setting showed that only 33% of participants completed the home-based exercise as prescribed.[30] This poor adherence rate is problematic, as it could be a predictor of the declining impact of the long-term effectiveness of exercise therapy. Consequently, motivation strategies especially for home-based exercise to improve and maintain adherence are required.[62]

All five motivational strategies found in this study have been discussed in previous exercise studies.[63–66] However, there are many other strategies that could be used to promote exercise adherence. The first set of strategies includes cognitive-motivational factors such as outcome expectancies, self-efficacy, goal settings, and health beliefs. Educational programs are usually conducted to facilitate these strategies, but available evidence indicates that knowledge alone is not enough to create and maintain good exercise adherence habits. An individualized educational program or person-centered coping strategy is required.[67] The second set of strategies that could promote exercise adherence includes tailoring the exercise programs to patients' characteristics, including physical limitations, comorbidity, weight, gender, age, and cultural background. Previous TQY trials indicate that the ability to participate in exercise declines with age, level of physical ability, depression, and fatigue.[60,68] As previously mentioned, translating an exercise manual into Spanish and using Spanish-speaking instructors increased exercise participation by a Spanish-speaking group.[32] The third set of strategies involves creating social cohesion for better access and enjoyment of TQY exercises. Previous TQY studies also indicate that a group format for home-based exercise might be a motivating factor for some participants to continue exercising.[69,70] Regular supervision and monitoring of the exercise by an appropriately qualified exercise instructor who can provide regular movement modifications to suit the changing needs of the individual can also enhance adherence.[71] Given that the barriers and facilitators to exercise adherence in osteoarthritis are usually multifactorial, strategies aiming at increasing exercise adherence often need to be complex and combined with other sets of strategies to achieve optimal outcomes.

Strengths and limitations

A strength of our study is the use of the CERT, an internationally endorsed reporting guideline, to assess the quality of the descriptions of exercise interventions in RCTs over the past 20 years. Our analysis of the detailed description of items on the CERT checklist related to home-based exercise provides a structural understanding of delivery effectiveness. However, this study is limited. First, the main data source is primary publications, unlike other articles that combined additional resources and input from corresponding authors. Second, since most of the included studies were published before the introduction of the CERT, this study reflects the practice of content reporting of exercise interventions without any influence of the new intervention reporting recommendations. Third, all the studies we included are RCTs and might not generalize to real-world settings.

Implications for future practice

TQY exercises have been recommended for individuals with osteoarthritis by the American College of Rheumatology. Long-term patient adherence to the exercise programs, especially to home-based exercise components, is critical to achieving optimal clinical outcome. We suggest that the exercise prescription should come with motivation strategies, considering cognitive-behavior techniques, patient preferences, and access. An algorithm of adaptation should be developed to meet the individuals' needs and functional limits for safety and motivation. It would also be more beneficial to create more social cohesion through group exercise with the help of qualified instructors.

Implication for research

We recommend that researchers use the CERT checklist and adequately describe the CERT items to enable study replication and knowledge translation into practice. We also suggest that person-centered motivational strategies for home-based TQY exercise be included in future research.

Conclusions

Our findings indicate that the CERT items reported most frequently are: (1) exercise name, (2) instructor qualifications, (3) whether the exercise was preformed individually or as a group, (4) supervised or not supervised, (5) interventional details, (6) exercise description, and (7) settings. To improve TQY research, future studies should report all items required by the CERT checklist. The following CERT items were reported in less than 50% of the studies: (1) the rule for determining the beginning level of exercise; (2) the rule for determining how the participant should progress through the exercise program; (3) description of who delivered the intervention, how it was delivered, and any strategies employed to guarantee fidelity; (4) motivational strategies to enhance adherence; and (5) how progressive overload was managed. To achieve optimal clinical outcomes with TQY exercise, it is critical that participants complete the exercise program as prescribed and maintain a long-term commitment to practicing TQY. The findings of this study are helpful for clinicians in highlighting motivational strategies that are successful in enhancing long-term adherence to home-based exercise.

Authors' Contributions

W.Z. and C.W. conceptualized the study. W.Z., K.R., and C.W. searched and evaluated citations and prepared tables and figures. W.Z. wrote the original draft. W.Z., R.D.H., K.R., and C.W. discussed and revised the article. All the coauthors have reviewed and approved the article before submission.

Author Disclosure Statement

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: W.Z. received support from the National Institutes of Health (NIH) Training Institute on Dissemination and Implementation Research in Health (TIDIRH). C.W. is supported by the NIH (R01AT006367, R01AT005521, and K24AT007323) and in part supported by the Rheumatology Research Foundation Innovative Research Award. None of the sponsors had any involvement in

our decision to submit this manuscript or in the determination of its contents. None of the authors have any conflicts of interest to declare of relevance to this work.

Funding Information

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Supplementary Material

Supplementary Appendix SA1
Supplementary Appendix SA2
Supplementary Appendix SA3

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