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REVIEW ARTICLE

The Science of Tai Chi and Qigong as Whole Person Health-Part II: Evidence Gaps and Opportunities for Future Research and Implementation

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Abstract

Background: The emerging paradigm of whole person health shares many core principles with traditional complementary and integrative health frameworks, including Tai Chi and Qigong (TCQ).

Methods: In the fall of 2023, the Harvard Medical School Osher Center for Integrative Health hosted the inaugural international conference on *The Science of Tai Chi & Qigong for Whole Person Health*: *Advancing the Integration of Mind-Body Practices into Contemporary Healthcare* at Harvard Medical School. A two-part white paper was written to summarize key conference topics, findings, and issues.

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Results and Discussion: Part II presented here summarizes evidence gaps and future research opportunities, including: understudied clinical conditions and populations, impact of long-term TCQ training, understanding the impact of specific TCQ styles, training regimens, dosage, and contextual effects; implementation, cost-effectiveness, and medical utilization research; individual data meta-analysis, and teaching competencies, credentialing, and licensure. Part I of this white paper discusses the rationale for the conference, synthesizes the state of evidence for TCQ as rehabilitative and preventive tools for a range of clinical conditions, and summarizes the translational research informing therapeutic mechanisms associated with TCQ training.

Keywords: mind-body, integrative health, movement, whole person health

Introduction

In the past 20 years, there has been an exponential growth in research on Tai Chi and Qigong (TCQ) as rehabilitative treatment and prevention across a wide range of populations and clinical conditions. In September 2023, we convened the inaugural international conference, *The Science of Tai Chi & Qigong as Whole Person Health: Advancing the Integration of Mind-Body Practices in Contemporary Healthcare* in Boston, MA. As a result, we developed this two-part white paper to present the rationale for the event within the framework of whole person health, synthesize the state of the scientific evidence for TCQ, and propose a roadmap to address current knowledge gaps in evidence to inform a future research agenda and discuss challenges for implementation and integration in health care.

In Part I of this two-part series, we articulated the re-emerging concept of "whole person health" as an ideal framework within which to view TCQ that acknowledges and emphasizes its multicomponent and cross-physiological system effects. With that perspective, we then summarized the evidence for TCQ highlighting the state of the science in the domains of falls and balance, cognition, cardiorespiratory health, musculoskeletal pain, mental health, and cancer.

In this second part of the series (Part II), we focus on the evidence gaps and strategies to address challenges and opportunities for future TCQ research, as well as important considerations for dissemination and implementation. Below we outline the following critical topics: a) understudied clinical conditions and populations, b) understanding the impact of long-term TCQ training, c) synergistic and additive effects of TCQ as an integrated component of a combined or multimodal approach, d) the need for outcomes that more effectively capture the impact of multimodal interventions, e) a deeper understanding of the impact of specific TCQ styles, training regimens, "dosage" and contextual effects, f) implementation research, g) cost-effectiveness and medical utilization, h) virtual delivery and assessment, i) the value of individual patient data meta-analysis, and j) discussion of teaching competencies, credentialing, and licensure in the context of TCQ access and integration into health care.

Evidence Gaps and Opportunities in Future Research

Understudied clinical conditions and populations

As is summarized in the companion evidence summary to this current review (Part I), as well as in the broader published literature, there are only a handful of conditions for which the evidence base for TCQ is sufficiently rigorous and robust to inform clinical guidelines. A recent critical analysis of systematic reviews of Tai Chi reported effect estimates extracted from 37 systematic reviews.[1] Only two were scored high quality using the AMSTAR 2 (A MeaSurement Tool to Assess systematic Reviews, improved version)[2] grading system; the remaining were scored moderate ($n = 6$), low ($n = 18$), and critically low ($n = 11$) quality. Moreover, of the 114 outcomes included in the same review, based on GRADE (Grading of Recommendations, Assessment, Development and Evaluation) guidelines, which classify the certainty of effect estimates,[3] only 8 (7.0%) of the estimates were deemed high certainty; 43 (29.7%), 36 (31.6%), and 27 (23.75%) were graded moderate, low, and very low certainty, respectively. Thus, rigor and quality of reported data to date limit conclusions that can be drawn. The authors of this comprehensive review concluded that, taking into account limitations, clinically important benefits related to Tai Chi were most consistently reported for Parkinson's disease, fall risk, knee osteoarthritis, cerebrovascular, and cardiovascular diseases including hypertension.[1]

Despite not yet meeting high standards for quantity and quality of data, based on a combination of relevance to public health and the existence of promising preliminary findings, we propose a number of areas of research that should be prioritized. These include TCQ for the following health conditions: age-related decline and frailty in older adults[4,5]; symptoms associated with cancer and cancer treatment,[6–9,10]; diabetes, metabolic syndrome, obesity, and cardiovascular risk factors[11]; COPD[12]; cognitive function[13,14]; sleep quality[15]; depression, anxiety, Post Traumatic Stress Disorder, and mental health[9,16–18]; headache[19]; and musculoskeletal conditions, including back and neck pain and fibromyalgia.[20–23] Within these groups, we emphasize impact on symptom clusters, wellness/salutogenesis, quality of life, and exploring measures of whole person health (see below).[24,25]

In filling these evidence gaps for specific relevant conditions (e.g., metabolic syndrome, obesity, mental health, Attention Deficit Hyperactivity Disorder, sleep, and pain), particular attention should be given to studying adolescents and younger adults,[16,26–29] as the vast majority of research to date has centered around older adults. Only 0.5% and 8.4% of studies to date include children (0–9 years) and adolescents/young adults (10–24 years), respectively.[30]

As is the case across all medical research, greater emphasis should also be placed on studying more diverse and representative sociodemographic groups, including diversity with respect to race/ethnicity and socioeconomic status.[31] TCQ represents a potentially powerful tool for addressing health disparities and providing a low-cost and accessible health care tool for disadvantaged individuals. In the context of whole person health, disadvantaged individuals are more

likely to age with multiple morbidities and poorer overall health status,[32,33] conditions for which TCQ's adaptable and multimodal components appear to be particularly effective. At the societal level, disadvantaged individuals tend to use more health care services and account for a disproportionate share of Medicare spending relative to more advantaged populations. Large-scale studies evaluating effectiveness, cost-effectiveness, and implementability of long-term TCQ programs in lower-income and under-resourced populations should be a research priority.

To date, the majority of studies have been published in China (74.2%) and the United States (12.5%).[30] Studies including populations representing Europe, South and Central America, Africa, Middle East, Australia, and other Asian regions would add significantly to our understanding and the generalizability of TCQ's effectiveness and implementability across diverse health care systems. Well-designed, collaborative multi-site trials comparing outcomes across different cultures (e.g., Asian vs. Western, African vs. European) would afford opportunities to compare outcomes in populations that vary in genetic makeup and culture environment. For example, race-related genotype differences (e.g., bone metabolism in postmenopausal women[34]) could underlie the differential impact of TCQ on osteopenic and osteoporotic women.[35] Culturally, predisposing beliefs about TCQ (e.g., China vs. Korea vs. United States) could modify psychosocial effects of interventions and inform culturally appropriate adaptations needed for successful implementation.[36]

Impact of long(er)-term TCQ training

The majority of research to date has been limited to evaluating the short-term (e.g., weeks to months) impact of TCQ on health. An important but largely unaddressed question for the field of TCQ research is whether long-term practice can enhance overall life expectancy and prevent longer-term morbidity. We propose three complementary strategies for addressing these questions.

Leveraging existing cohort studies to evaluate mortality/lifespan. Findings from large cohort studies support that higher levels of exercise and physical activity are generally associated with greater longevity (i.e., lower hazard ratios [HR] for mortality).[37,38] However, few published studies have been based on populations that include large (sub)cohorts of TCQ practitioners. Two noteworthy exceptions warrant mention. The first is the Shanghai Men's Health Study, which assessed the associations of regular exercise—Tai Chi, walking, and jogging—with total and cause-specific mortality among 61,477 Chinese men (average age = 55.4 years).[39] After adjustment for potential confounders, men in this cohort who regularly practice Tai Chi had an HR for total mortality of 0.80 (over 7 years of observation), on par with the benefits of walking and jogging. For men who reported engaging in both Tai Chi and walking, cardiovascular mortality HR was further reduced (HR = 0.55). A second study based in rural China evaluated whether exercise and physical work can reduce the risk of cognitive impairment.[40] The study included 7000 older men and women with no cognitive impairment at baseline. At the 2-year follow-up, after adjustment for potential confounders, regular Tai Chi was associated with reduced cognitive impairment (HR = 0.75), a benefit that was not statistically different from brisk walking or agricultural work. There may be an opportunity to utilize other existing large cohort studies in Asia (e.g., Shanghai Women's Health Study,[41] Singapore Chinese Health Study,[42] Japan Collaborative Cohort Study[43]) that also include large numbers of TCQ practitioners, to further inform the association between TCQ practice and lifespan. Findings from such studies could generate hypotheses to be tested in large-scale prospective clinical trials.

Leveraging existing cohort studies to evaluate biomarkers of longevity and morbidity. A second opportunity afforded by existing cohorts is studying the association between long-term TCQ training and biomarkers of health and disease. In recent years, there has been remarkable progress in identifying genomic, epigenetic, and metabolomic markers, which have been used to study the association between physical activity and markers of lifespan, and physical, cognitive, and metabolic function.[44–48] Although relatively short-term Randomized Controlled Trial (RCTs) or smaller cross-sectional and case-controlled studies suggest that being a long-term TCQ practitioner is associated with unique longevity- and morbidity-related biomarker profiles (e.g., inflammatory markers, telomere length, and indices of autonomic tone),[49–57] we are not aware of studies leveraging existing large cohorts to inform the association of long-term TCQ training and longevity biomarkers.

Longer-term prospective trials to evaluate mortality and morbidity. Although cohort studies can inform associations between exposures and outcomes, RCTs remain the most rigorous tool for testing the impact of long-term TCQ exposure on health outcomes, including mortality. However, long-term exposure and follow-up in both conventional exercise and TCQ trials are challenging and costly, and rarely extend more than 24 months.[58] For mortality, one recent exception is worth noting. Takamura and colleagues conducted a three-arm RCT comparing 16 weeks of Tai Chi, aerobic exercise, and a self-care control for patients with advanced lung cancer.[6] In addition to findings supporting that Tai Chi was superior for sleep quality (primary outcome), they also reported that at 1-year follow-up, compared with the control, the Tai Chi group exhibited higher median survival times (49.2 vs. 44.2 weeks; $p < 0.05$). Although studying survival rates in relatively healthy populations would require very large sizes and long exposure periods, this study suggests that in older and health-comprised populations, assessing survival time estimates may be feasible. In the above case of lung cancer survivors, demonstrating that Tai Chi training can add more than a month of life, at relatively low cost and with few side effects, is a clinically meaningful finding that is worth exploring in other populations with advanced illness.

TCQ as part of multimodal care—synergies and additive effects

Surveys of integrative health users for most health conditions, including pain,[59] sleep,[60,61] and mood[62] suggest that many use more than one therapy concomitantly. Clinically, for example, it is not uncommon for chiropractors, acupuncturists, massage therapists, and meditation instructors to refer clients to TCQ classes to complement and reinforce respective therapeutic strategies; and conversely,

TCQ instructors commonly refer to other complementary and integrative (CIH) providers to address pre-existing chronic or more acute medical issues (e.g., chronic knee pain) that may limit a trainee's ability to sustain a practice. Although some studies support that multimodal approaches integrating exercise and manual therapies might be better than unimodal approaches,[63–66] surprisingly, very few published studies have evaluated the benefits of TCQ as an integrated component of a combined or multimodal approach.

One recent small uncontrolled study targeting hospital nurses with neck pain found that combined Tai Chi and chiropractic care was feasible to administer, and showed promise for reducing pain and disability, and enhancing physical function.[67] A systematic review limited to a handful of studies in China suggests that adding TCQ to routine therapy (i.e., physical therapy, acupuncture, tuina) leads to better outcomes in chronic low back pain compared with routine care alone.[68] Another trial underway is evaluating the combined effect of Tai Chi and acupressure for insomnia in college students.[69] Of course, these potential synergies are not limited to complementary therapies. In fact, many studies have explored Tai Chi as an adjunct to conventional pharmacologic and behavioral, lifestyle interventions (e.g., Tai Chi plus cognitive behavioral therapy, Tai Chi plus conventional exercise, Tai Chi plus dietary education, Tai Chi plus Fitbit step tracker).[70,71] Newer cutting-edge research is also investigating neuromodulation (e.g., transcranial direct current stimulation or vagal nerve stimulation),[72] virtual reality,[73,74] and accelerometry-based feedback[75] to enhance Tai Chi training effects. Given the widespread use of TCQ in combination with other integrative and conventional therapies, and the promise of additive and synergistic effects for many conditions, future studies are warranted. These studies might especially benefit from experimental designs, such as Multiphase Optimization Strategy and the Sequential Multiple Assignment Randomized Trial,[76,77] and the use of community-based pragmatic interventions that enhance compliance, reduce participant burden,[78,79] or provide valuable information on component effects.

Multimodal outcomes and measurement of whole person health

The National Center for Complementary and Integrative Health (NCCIH) has been trailblazing the discussion around research methodologies for whole person health, and in particular, the psychometrics of measuring whole person multisystem outcomes that are inherently impacted by multimodal interventions such as TCQ. This discussion has recognized 1) existing methodologies within health science that can be applied in creative ways, 2) methodologies that lean into newer analytic frameworks that originated in other disciplines such as complexity theory and network analyses, as well as 3) the need for innovative methodologies yet to be developed.[80]

For example, one approach is to take complex systems methodologies (e.g., multilevel computational modeling, discrete multivariable modeling, network analyses) to synthesize individual components of data. In this realm, the burgeoning of artificial intelligence and machine learning methods to extract and curate large amounts of data is promising. To date, most of the work utilizing AI in mind-body research has focused on synthesizing complex neurobiological and imaging data,[81–83] but these methods might conceivably be applied across systems to probe biomarkers. Another approach might be to identify and focus on the impacts of TCQ on exemplar systems such as the microbiome that may already represent complex cross-system interactions.[84,85] Another frontier in understanding the multidimensional impacts of mind-body movement such as TCQ calls for new instruments/tools that may target constellations or clusters of symptoms/outcomes, rather than focus on single outcomes. In fact, one of NCCIH's top priorities in their most recent strategic plan is to support research to develop and validate measures and composite indices of multisystem outcomes for whole person health.[86]

One recently developed psychometric tool for mindful movement is the Multidimensional Impacts of Movement Scale (MIMS).[87] Similar to how many quality-of-life measures, or overall well-being measures (e.g., PROMIS) incorporate multiple aspects into a composite index, the MIMS was designed to measure multiple dimensions of how movement affects an individual. The instrument was validated with a sample who participated in yoga, weightlifting, or running and includes questions on the physical body, energy, mind (thoughts, emotions, senses), intuition (trust, compassion), and contentment, which map to a traditional medicine paradigm. Although this instrument may not seem too different from many other instruments that include subscales and domains, there are clear opportunities to expand this type of thinking to composite indices that provide much more cross-system thinking. For example, there are limited tools/experimental paradigms available to quantify how clinical targets of TCQ such as gait, posture, and pain are impacted by mood, emotions, and sleep, and what underlying psychophysiological processes might link these outcomes. Utilizing existing and developing methodologies above, we might work to identify new cross-system symptom clusters that would not typically be considered and measured together, and create new composite indices that more fully measure whole person impacts of TCQ. In addition, within NCCIH and increasingly across NIH, measures of resilience[88,89] and flourishing[90] have been suggested, as well as other measures of whole health pioneered within the Veterans Affairs system of health care transformation.[91,92]

Getting more granular: Understanding the impact of specific TCQ styles, training regimens, dosage, and contextual effects

Different styles and training regimens. The scientific study of TCQ and generalizations about its therapeutic effects and safety are complicated by its pluralism. Although there are a handful of recent studies evaluating the comparative efficacy of different TCQ styles or protocols,[93–97] and some recent meta-analyses that have compared effect sizes of different styles protocols with respect to specific outcomes,[98,99] much of the current evidence is based on clinical trials evaluating specific TCQ protocols or styles. Importantly, the vast majority of these studies do not explicitly include any specific justification for choosing one TCQ protocol over any other.[100]

TCQ are evolving arts, and new styles have been developed based on the unique insights and interpretations of generations of practitioners, and in recent years, from the medical research community. Focusing on Tai Chi, a number of major styles are now widely recognized, including Yang, Chen, Wu, Sun, and Hao styles. Each of these styles is characterized by slightly different emphases in training content

as well as core Tai Chi principles. In addition, within each style, there are many substyles, which further contribute to the pluralism of Tai Chi. For example, within the Yang style lineage, distinct forms have been developed that vary with respect to the number of choreographed movements (e.g., 24-, 37-, 72-, 108-, and 150-movement forms), as well as overall emphasis (e.g., health maintenance, martial skills, meditation, self-realization, and competitive performing arts). Many styles may also include a variety of Tai Chi weapons training and two-person interactive practices. In addition to variation across styles, how Tai Chi is taught and transmitted adds further heterogeneity. For example, some schools that adopt more "traditional" methods or where language barriers exist may emphasize nonverbal instruction (mimicry, shadowing, physical posture adjustments), whereas others utilize more verbal instruction, including imagery, philosophy, and contemporary science findings. There is also variability in the format of training programs, some centered on group-based curricula where students progress as a cohort, whereas others are more individually based and students' progress at their own rate. Recent use of virtual platforms adds significant heterogeneity.[101–103] In addition, there is variability even within a school or lineage, depending on individual teachers.[104,105] Drilling deeper into the relevance of each of these exposure factors is an important next step for the TCQ research community. This more granular research agenda will necessitate well-designed comparative effectiveness studies comparing styles, specific protocols, and methods of teaching and delivery. Of note, these trials should be carefully designed to minimize bias of certain styles/protocols (i.e., attention to potential conflict of interests and bias from investigators or funders). Findings of this more granular research will both inform more effective prescription and integration of TCQ practices for populations with different needs/interests, and lead to valuable insights into the specific and nonspecific mechanisms underlying TCQ effectiveness.

Dose. Evaluation of the results of any clinical intervention requires knowledge of the dose of the therapy employed. TCQ's complexity and pluralism poses challenges for developing a concept of dose that is equivalent to that commonly used in pharmacology (i.e., the quantity of an active agent taken in or absorbed at any one time). There are two aspects of dosage that should be considered in developing this concept for TCQ; a broader and more easily measured aspect, and a more subtle and functional one.[104–106] At the broader, coarse level, dosage essentially involves practice time. Longer-term interventions, more frequent classes, and longer individual practice sessions correspond with higher doses. Recent meta-analyses including TCQ have begun to include preliminary statements on minimal or optimal duration of training required to attain a clinical outcome.[14,17,18,107,108] However, what may be more challenging is quantifying the finer, more subtle distinction between "clock time" doing TCQ versus "effective practice time" doing TCQ. Using a pharmaceutical as an analogy, there is a distinction between the administered dose and the effective bioavailable dose across a population of patients, due to differences among patients in drug absorption rates and other pharmacokinetic processes. Similarly, there will be variations across TCQ practitioners in the benefits they experience after 100 h of training given their commitment and proficiencies. One might expect that those whose Tai Chi performance proficiency (e.g., choreographical accuracy, quality of biomechanics, breathing patterns, mind-body regulation, etc.) improved over the course of training would also be most likely to exhibit therapeutic benefits. Although metrics for assessing proficiency have been developed and widely employed in TCQ competitions, surprisingly few studies have evaluated changes in proficiency within the context of clinical trials.[109] Recent development of wearable technology, video analysis, and machine learning show great potential for adding objectivity and implementability to integrating measures of proficiency, along with accrued practice time, to understand dose-response relationships in TCQ.[110] Better understanding of dose–response relationships will aid in optimizing clinical benefits and informing mechanisms underlying TCQ effectiveness.[111]

Contextual effects. As TCQ are complex, multicomponent interventions that integrate physical, cognitive-emotional, and cross-systems effects, the context (including environment and ritual) within which the interventions are delivered are extremely important.[104,105] For example, it is unclear whether TCQ training in natural environments impact therapeutic effects, or whether the time of day or season is relevant. Similarly, practicing with and without music might confer differential effects, or perhaps particular types of music might be most conducive to benefit. Although these effects are likely guided by individual preferences, perhaps there is certain music (rhythms, sound frequencies) that support receptivity to change. A robust and growing body of research suggests that exposure to nature, music, art, being parts of groups all can have deep therapeutic effects.[112–114] Other relevant questions might probe how the social context (e.g., self-guided practice vs. instructor-led; 1-on-1 vs. groups; collaborative learning vs. follow the lead) or how the language of the TCQ instruction might impact outcomes. Specific instructor-student effects (e.g., experience, personalization, depth of teaching/learning) may also play a role. In some research studies, there may be ancillary information such as TCQ history, philosophy, or a review of the science provided alongside the TCQ training that may impact expectations, motivation, or adherence. These and other exposures are often implicitly interwoven within some, but not all TCQ interventions, yet their independent and interactive effects are largely unexplored.

In prior decades, this richness and complexity was seen as a challenge for research methodology–related to the desire to distinguish between specific and nonspecific effects, the development and interpretation of valid sham controls, and the reductionist approach of attributing outcomes to single, independent factors.[104,105] Now with an emerging framework of whole person health, and the push to embrace the study of multicomponent interventions, we see this complexity as an opportunity to move the field forward. At the very least, we would advocate for the development of reporting guidelines for TCQ studies, similar to STRICTA for the reporting of acupuncture interventions in controlled trials,[115] that would mandate a clear reporting and description of ancillary components.

Implementation research

Implementation research is that which facilitates the uptake of evidence-based practices, programs, interventions in real-world settings.[116] It broadly considers a wide range of factors and contexts affecting implementation of practice in the real-world (e.g., sociocultural, economic, or political context; health system structures and processes; stakeholder engagement; outcomes such as cost, fidelity, sustainability). Most commonly, implementation research is concerned with how to introduce an intervention into a health system and/or how to promote and sustain large-scale use. For TCQ, there is limited formal implementation research to date, beyond typical clinical outcomes assessment in community-based settings.[117]

The one area where core implementation outcomes have been explicitly assessed is for Tai Chi fall prevention programs.[118–120] A single-arm prospective clinical study assessed the implementation of a program called Tai Ji Quan: Moving for Better Balance (TJQMBB) within four Oregon counties following the RE-AIM model. Investigators reported on program adoption, reach of the intended population, delivery of TJQMBB with good fidelity, and sustainability through continued use of the program by participating centers and participants at 6 months postintervention.[121] Another recent study was a mixed-methods survey of instructors to describe implementation of FaME (Falls Management Exercise Program), a multimodal exercise program in the United Kingdom that includes a component of Tai Chi designed for frail elders and is adopted within the National Health Service. Questions probed the components of successful implementation, including setup (e.g., funding, referral), intervention delivery and fidelity (e.g., progression, tailoring, dose), instructor and individual factors (e.g., experience, attitudes), and motivational strategies for adherence.[122] An area where implementation research is just developing with respect to TCQ is chronic pain programs.[123,124] In these priority areas, where the level of scientific evidence is the strongest and most rigorous, there is opportunity to advance implementation research to systematically move towards wider adoption in varied health care settings in the real world.

Cost-effectiveness and medical utilization research

Despite the large body of data supporting the health benefits of TCQ, little research has evaluated the cost-effectiveness of TCQ, or its broader impacts on medical utilization.[125] A handful of studies have estimated the cost-effectiveness of Tai Chi for fall and fracture reduction. Using published data from a clinical trial reporting a 49% reduction in falls with Tai Chi, one study estimated an average $1,240 benefit per person per year due to reduced fall-related fractures.[126] Another study using an integrated health care modeling approach showed that Tai Chi was one of the least expensive and most effective intervention for reducing health care costs associated with hip fractures, with $\sim$0.035 per person quality adjusted life years (QALYs) to be gained over standard care at $\sim$$1,000 per person lifetime cost, ahead of other interventions such as vitamin D, home modifications, and muscle and balance exercises.[127] A third study using meta-analytic methods combined with decision analysis modeling concluded that Tai Chi was the most cost-effective falls prevention strategy in community-dwelling older adults at an incremental cost of $239 per fall avoided, $5,172 per hospitalization avoided, and $44,879 per QALY gained.[128,129] Finally, two clinical trials showed that Tai Chi was a cost-effective method for reducing falls and fall-related injury in older adults with high risk of falling and in Parkinson's patients.[130,131]

Data on broader patterns of medical utilization as a result of TCQ intervention remain limited. Large-scale health services studies suggest that the use of CIH therapies for pain conditions can reduce use of both pharmacological and surgical interventions and costly procedures,[132,133] however, few studies have specifically evaluated TCQ. One cluster RCT of year-long Tai Chi versus Health Education in older adults living in low-income housing reported that Emergency Department utilization tended to be lower following Tai Chi training, however, estimated cost savings were small and statistically nonsignificant.[134]

Based on the broad impacts on clinical outcomes, it may be reasonable to expect that TCQ training positively impacts medical utilization (including costly hospitalizations and medical procedures) and, thus, cost-effectiveness, but much research is needed. This gap in evidence will be critical to fill in order to inform policies related to access and health care coverage. In addition to well-designed prospective clinical trials, leveraging large databases that include information on both TCQ exposure and medical utilization (e.g., large Asian cohort studies) could provide valuable information.

Virtual delivery and assessment

Prior to the COVID pandemic, virtual delivery of TCQ was already gaining traction given advantages around ease of access and potential cost-effectiveness. Particularly for populations such as older adults with limited mobility, remote home-based programs of TCQ addressed common barriers related to transportation and travel time, and provided broader reach to those living far from available classes/instructors. Interestingly, an analysis of the 2012 National Health Interview Survey data indicated that a significant proportion of the U.S. population using TCQ for health preferred self-directed learning from videos and internet resources.[135] At that time, only a handful of studies had assessed the full potential for either real-time synchronous or asynchronous video-assisted remote learning of TCQ.

With the pandemic, mirroring the overnight accelerated delivery of telehealth, virtual delivery of mind-body movement practices has grown exponentially in a relatively short time. Many studies across delivery formats now support the feasibility/acceptability of mind-body movement delivered remotely. For example, many have used widely available platforms such as Zoom to conduct classes, allowing one-on-one or group interactions and screen sharing, or have implemented hybrid approaches that supplement synchronous delivery with prerecorded video programs. With movement interventions such as TCQ, additional considerations of synchronous delivery might include optimal device choice and video placement, with the need for instructors/students to engage and view the full body in movement, unlike other more static mind-body interventions such as seated meditation. Many studies have now reported study outcomes with virtual/remote delivery similar to in-person delivery.[136–140] Recent reviews have focused on feasibility, acceptability, and

engagement factors relevant to virtual mind-body interventions. One scoping review of virtual mind-body exercise in studies with older adults reported potential barriers to consider, (e.g., lack of space or privacy, connectivity issues, lack of bidirectional feedback with trainers and students). Another systematic review specifically of virtual TCQ in studies with varied populations (including those early neurogenerative disease, mild cognitive impairment, and balance-impaired older adults) reported no significant issues with internet access or connectivity, participant safety, or program costs, while highlighting online social involvement, digital literacy, and provision of technical support as important facilitators for engagement and adherence.[136,139]

In addition to virtual intervention delivery, newer technology and wearables have made remote intervention assessment equally possible. Wearable technology (e.g., for remote physiological signal collection such as heart rate, breathing, Electroencephalography, skin conductance, blood oxygen level, accelerometry/step counts, sleep indices) has greatly expanded possibilities to assess TCQ across physiological systems in the home setting. As an intervention that impacts whole person health, these technologies may allow a more pragmatic, ecological assessment versus in-laboratory assessment in more artificial or controlled settings.[141] An interesting new frontier in virtual TCQ is remote monitoring of adherence and performance proficiency assessment. Recent work has begun to develop a framework using wearable sensor data and machine learning to monitor both adherence and proficiency among Tai Chi practitioners.[110] This lays the groundwork for future application of these new tools that may enhance the evaluation of safety in Tai Chi, inform training parameters, and monitor adherence and proficiency that are key to achieving optimal clinical outcomes.

Individual patient data meta-analysis

Despite remarkable growth in the number of published clinical trials, systematic reviews, and meta-analyses on TCQ, we are not aware of any individual patient data meta-analyses (IPDMA) applied to TCQ research. Unlike traditional meta-analyses that rely on already aggregated summary statistics across multiple studies, IPDMA combines raw data from individual participants across multiple studies. This granular approach offers several distinct advantages. These include increased statistical power; enhanced opportunities to explore more nuanced subgroup analyses and potential effect modifiers; and more comprehensive adjustment for covariates at the individual level, reducing the risk of confounding and providing more accurate estimates of associations.[142,143] One very successful example of IPDMA in the CIH community is the Acupuncture Trialists' Collaboration comprising a database of 39 high-quality RCTs with more than 20,000 individual patients. Publications from this database have provided precise estimates of the effects of verum versus sham acupuncture for pain conditions not apparent from individual studies[144] and allowed the evaluation of more nuanced questions such as the relevance of training and/or sociodemographic characteristics of treating acupuncturists to clinical outcomes.[145] Based on already published trials, examples of promising applications of IPDMA for TCQ research could be studying the impact of Tai Chi on fall risk and measures of balance and mobility, the impact of Tai Chi on blood pressure and other CV risk factors, and the impact of TCQ on symptoms in cancer patients, and overall quality of life in older adults. Implementation of IPDMAs pose many challenges including: establishing a network of trusting research collaborators; compliance with data-sharing policies and other privacy and ethical consideration; and data harmonization and quality control.[142,143] Of course, coordinated endeavors of this scale would require significant funding. More broadly, the establishment of a funded TCQ Trialist Collaborative, analogous to the Acupuncture Trialists' Collaboration,[144] would represent a significant advance for the TCQ research community, not only leading to synthetic data but also catalyzing novel collaborations and improved guidelines and standards for future research.

Barriers and Opportunities to Expanding TCQ Access and Integration into Health care

Teaching competencies, credentialing, and licensure

Most health care professions in North America, including some of those that fall within CIH (e.g., acupuncture, naturopathy, chiropractic), license or otherwise regulate practitioners based on a credentialing process established by law.[146] Other CIH health care fields (e.g., yoga therapy, homeopathy, Ayurvedic medicine) that are not currently regulated by a governmental agency have established their own, independent training, accreditation and/or certification. The purpose of these "regulating/oversight" processes is to verify that professional training and competency standards have been met, thus better ensuring safe, effective, and competent services and implementation fidelity. Although many TCQ programs and organizations have developed their own training and/or certification/credentialing criteria, there are, to date, no nationally or internationally agreed upon guidelines for the credentialing and/or licensing of TCQ practitioners, teachers, or providers. If TCQ are to be more formally integrated into clinical practice and health care systems, the topics of teacher qualifications, program competencies, content, credentialing, and licensure need to be formally addressed.

It is important to note that the concept of credentialing and/or licensure is in sharp contrast to traditional lineage-based training. In many traditional TCQ lineages, some still active today, being granted permission to teach was only granted after many years of intensive training and significant levels of "mastery," often granted only to inner-circle disciples. In many traditional training systems, knowledge passed on also included martial, spiritual, and medical (e.g., bone setting, herbal training) dimensions, in addition to basic self-care practices. Many traditional masters felt they were successful if a small handful of students, or even a single one, achieved or exceeded their skill level and could represent their lineage. Although admirably steeped in tradition, this orthodox approach is not likely to generate the numbers of teachers/instructors needed to meet the secular growing demand for TCQ as a CIH health modality. In response to this need, traditional and contemporary lineages, and individual teachers, have developed local, national and international training and credentialing programs that vary greatly in content and competency requirements. Some, for example, provide teaching certification following participation in

a single weekend training. Others involve multiyear training with competency exams including performance of training regimen, demonstration of teaching competency, and written exams related to TCQ knowledge (e.g., health benefits, history). Most recently, paralleling programs in Asia,[147] a few academic and vocational programs in the West offer bachelors or master's level degrees centered around TCQ.[148]

Appreciating the heterogeneity within and between TCQ training systems, some national and international organizations have begun to develop credentialing criteria that is nonspecific to a particular TCQ system. For example, in the United States, the National Qigong Association and the American Tai Chi and Qigong Association provide credentialing guidelines, rankings, and listings for instructors.[149,150] Similar credentialing programs exist in Europe, South America, and Australia. One international organization, the International Medical Tai Chi and Qigong Association, developed a set of accreditation standard guidelines for TCQ instructors and training institutions.[151,152] The guidelines were developed in collaboration with health professionals, integrative medicine academics, TCQ master instructors and consumers including public safety officers from several countries, such as Australia, Canada, China, Germany, Italy, Korea, Sweden, and United States. Guidelines include a tiered, four-level certification scheme ranging from basic entry-level skills to advanced TCQ skills in combination with complementary skills related to clinical application, education, research, and/or service.[151]

Although a comprehensive review and evaluation of this topic is beyond the scope of this white paper, it is a critical issue that requires thoughtful attention and future research. Institutions such as the Veteran's Health Administration that wish to integrate TCQ into whole health care have been tasked to developing guidelines regarding qualifications of TCQ instructors hired as staff or consultants.[153] To guide consumers, who generally are unfamiliar with TCQ lineages, other institutions, such as the Center for Disease Control[154] now include endorsements for some specific Tai Chi programs, presumably based on clinical evidence. However, in these cases, programs, but not the qualifications of the individual instructors, are being endorsed. To address the complexities of this topic, we proposed that interdisciplinary and multistakeholder teams, including seasoned practitioners, researchers, clinicians, policy makers, lawyers, and students alike, including representatives of multiple cultures and systems be assembled to explore ethical, effective, and practical solutions.

Conclusions

Following the growth of research in mind-body and behavioral medicine, our understanding of TCQ has significantly increased over the past two decades. Fortuitously, the emerging paradigm of whole person health articulated by national organizations such as the NIH National Center for Complementary and Integrative Health and the U.S. Veteran's Affairs Health Administration, has even more recently provided a highly relevant framework through which TCQ and related mind-body movement practices can be viewed and studied. With this maturing of the TCQ field, we have begun to move beyond simple questions of safety and efficacy, toward much more sophisticated inquiry across multiple conditions and populations, recognizing the heterogeneity and multidimensionality of TCQ's practice, and the implications on health outcomes. Despite these successes and continued progress, we also recognize the gaps and future opportunities for further translational research across the research spectrum, strategically and creatively leveraging available datasets, resources, and exploring both existing and newer research methodologies to effectively elevate the next generation of TCQ research and add to the needed rigor of the evidence base. At the same time, we also need more attention to implementation and dissemination, and to meet the pragmatic challenges and considerations around credentialing and licensure of clinicians should TCQ practices be systematically integrated into our health care system. Critical in all these endeavors will be *collaboration*. We will need collaboration on multiple levels—across research fields, professional disciplines, geographic and cultural divides. The inaugural international conference on *The Science of Tai Chi and Qigong for Whole Person Health* in 2023, which convened multiple stakeholders around this central theme and produced this two-part white paper served as one important catalyst for this goal. Building upon these initiatives, we hope this roadmap for the integration of TCQ into contemporary health care will help support the advancement of whole person and mind-body health.

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Authors' Contributions

P.W., G.Y., and W.M. were responsible for this project's conceptualization. P.W. and G.Y.Y. wrote the first draft of the overall article and were responsible for funding acquisition. All authors contributed written content in their areas of expertise and reviewed and edited subsequent drafts.

Author Disclosure Statement

P.W. has a financial interest in the Tree of Life Tai Chi Center, a Tai Chi teaching center. P.W.'s interests were reviewed and are managed by Brigham and Women's Hospital and Mass General Brigham in accordance with their conflict-of-interest policies. J.K. has holding equity in two start-up companies (MNT, BTT) and a patent on applying neuromodulation, but declares no conflict of interest. No other authors report any competing interests.

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