



Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.



Clinical trial

Learning to breathe with Tai Chi online - qualitative data from a randomized controlled feasibility study of patients with cystic fibrosis

Patricia Ronan^{a,1}, Awais Mian^a, Siobhán B. Carr^{b,c}, Susan L. Madge^d, Ava Lorenc^e, Nicola Robinson^{a,f,1,*}

^a Allied Health Sciences, School of Health and Social Care, London South Bank University, 103 Borough Road, London SE1 0AA, United Kingdom

^b Department of Paediatric Respiratory Medicine, Royal Brompton and Harefield NHS Foundation Trust, Sydney Street, London, SW3 6NP, United Kingdom

^c National Heart and Lung Institute, Imperial College London, Emmanuel Kaye Building, 1B Manresa Road, London, SW3 6LR, United Kingdom

^d Adult Cystic Fibrosis Department, Royal Brompton and Harefield NHS Foundation Trust, London, Sydney Street, London, SW3 6NP, United Kingdom

^e Population Health Sciences Department, University of Bristol, Beacon House, Queens Road, Bristol, BS8 1QU, England

^f Centre for Evidence based Chinese Medicine, Beijing University of Chinese Medicine No. 11, Bei San Huan Dong Lu, Chaoyang District, Beijing 100029, China

ARTICLE INFO

Keywords:

Internet delivery
Tai chi
Cystic fibrosis
Qualitative
Breathing
Social isolation
Remote learning
Telemedicine
Feasibility study

ABSTRACT

Introduction: Tai Chi (TC), a gentle exercise, incorporates meditative movement and respiratory control. The high risk of cross infection for people with cystic fibrosis (CF) requires close management in healthcare settings, limiting group activities such as TC. A mixed-methods randomized controlled feasibility study compared teaching TC over the internet with in-person, face to face TC tuition provided to CF patients. This article explores qualitative data from patients and TC instructors on their attitudes, acceptability and engagement with the two modes of TC delivery.

Methods: Qualitative data from CF patients (>6 years) were collected using Skype interviews/focus groups and written feedback. TC instructors provided weekly written feedback, and took part in interviews/ focus groups at the end of the study. Patient and instructor interviews explored their experiences and engagement with TC online delivery and ability to practice.

Results: Irrespective of the type of TC delivery, all CF participants interviewed ($n = 28$) practiced between lessons and most wanted to continue TC. Teenagers were more likely to miss TC appointments. Internet delivery was well received by both patients and TC instructors. Two patients reported difficulties with screen size/camera and one with internet connectivity.

Conclusion: Both face-to-face and internet delivery of TC lessons were equally well received and perceived as beneficial. In the current COVID-19 pandemic, CF patients self-isolating could find this intervention provides important support, therefore the programme was made available on YouTube in April 2020 and linked to the websites of the CF charities funding the research.

The study was registered on the clinical trials.gov website (Registration number: NCT02054377)

1. Background

Exercise is an essential factor in the management of people with cystic fibrosis (CF). It helps to develop fitness, social skills, relationships and improves quality of life (QOL) [1]. However cross infection risk means CF group activities are not permitted. In addition to routine airway clearance to clear phlegm, open airways and reduce the possibility of respiratory infection, people with CF are advised to exercise on

a regular basis to help maintain optimum health [2]. Although there are few adequately powered trials to provide evidence of the benefits of exercise, there is general agreement on its importance and usefulness [3]. CF is a progressive disease, so respiratory exacerbations and deteriorating health status mean that regular exercise may not always be possible [2]. Moreover, vigorous exercise may not always be advisable, particularly as it has been shown to produce a mismatch between oxygen delivery and muscle contraction which may contribute to

* Corresponding author at: Allied Health Sciences, School of Health and Social Care, London South Bank University, 103 Borough Road, SE1 0AA London, United Kingdom, ORCID 0000-0001-5256-4527.

E-mail addresses: ronanowh@gmail.com (P. Ronan), awais@sevenheavens.co.uk (A. Mian), S.Carr@rbht.nhs.uk (S.B. Carr), S.Madge@rbht.nhs.uk (S.L. Madge), nicky.robinson@lsbu.ac.uk (N. Robinson).

¹ Co - first authors

<https://doi.org/10.1016/j.eujim.2020.101229>

Received 14 July 2020; Received in revised form 16 September 2020; Accepted 14 October 2020

1876-3820/ © 2020 Elsevier GmbH. All rights reserved.

exercise intolerance [2] and may trigger upper respiratory infections [4].

There is some evidence to show that teleconferencing can be successfully employed to deliver therapeutic interventions to people with chronic conditions [5] and video conferencing has proven to be equivalent to in-person care for psychological support and clinical review for people with CF awaiting a transplant [6]. A systematic review on the use of telehealth for children and adults with CF reported there was insufficient conclusive evidence on the benefits of telehealth, but it did demonstrate that participants were able to use the technology. [7]

Tai Chi (TC) is a gentle exercise that incorporates respiratory control and meditative movement, which people may feel able to perform even when unwell, or in situations where they cannot maintain a regimen of vigorous exercise. Recent evidence suggests TC benefits people with various chronic conditions [8,9], including chronic obstructive pulmonary disease (COPD) [10, 11]. It is suitable for a variety of fitness levels- making it suitable for the fluctuating health experienced by people with CF.

Our previous feasibility study suggested that Tai Chi may benefit people with CF, in particular it may help with sleep, anxiety and breathing [12]. However, the one to one classes provided in patients' homes were expensive and time-consuming to deliver. Given that the TC sequence was designed to be simple with limited movements, designed to aid breathing and could be practiced standing or sitting, it was a good candidate for internet teaching. As a result we set out to test whether it was feasible to deliver these classes over the internet and whether the outcomes were comparable with lessons delivered in person. The quantitative results from this trial have previously been published and indicated some improvements in patient self-reported outcomes: sleep, breathing, stomach ache and cough [13]. This current paper reports on the qualitative data obtained from the CF participants and their TC instructors who took part in the trial. In particular, we explored their comments on the feasibility of an internet based delivery, recruitment, retention, acceptability and practicalities of delivering online TC teaching compared with in-person, one to one, face to face TC tuition delivered in patients' homes. Since the completion of this study, the importance of self -help approaches have become even more important for these vulnerable individuals who have been shielding during the current COVID-19 pandemic, and this article and the dissemination of the resource is most timely.

2. The study

2.1. Design

Full details on the quantitative data obtained in the study have already been published [13]. In brief, participants were randomized to learning TC with a private TC instructor, either in person, face-to-face (in their own home or in hospital during an admission – Group A); or over the internet with online or telephone instructor support (Group B) (See Fig 1 for details of the study design). Group B had a delayed start of

3 months while group A completed their taught sessions so a non-intervention control group was provided for comparison. For each group, eight lessons were delivered over a period of three months, timetabled depending on the patient's current health status. Details of the data collection points are shown in Fig 1.

Qualitative data were collected from participants by the TC instructors prior to each individual session regarding any issues experienced while learning and practicing TC and any specific changes they had noticed in their health and wellbeing. The instructors also kept their own diary over the study period.

At the end of the study, once all lessons had been completed, CF participants were invited to participate in either an online Skype focus group or a telephone interview. Once all teaching sessions had been completed, TC instructors participated in telephone interviews and a focus group as well as providing their written notes on a participant feedback form completed before each teaching session.

2.2. Participants

Full details on inclusion and exclusion criteria, recruitment and participants included in this study have previously been published [13, 14], but the study flow chart is provided in Fig. 2.

Participant inclusion criteria were: patients attending the Royal Brompton Hospital (London, UK), a diagnosis of cystic fibrosis, aged ≥6 years, able to commit to the time needed to be involved in the study, within reasonable distance of central London so that the instructors were able to travel to deliver lessons, and access to the internet. Individuals were excluded if they were taking part in any other intervention study or if they had participated in the previous pilot study [12].

Briefly, 40 participants with a diagnosis of CF, aged > 6 years were recruited from the Royal Brompton and Harefield NHS Foundation Trust, London, during June 2014 - September 2015. For those who agreed to participate, the project co-ordinators (AL, PR), used randomized block allocation based on age (6–11, 12–16 > 16 years). Of those who went on to receive the interventions, 22 were allocated to the in person, face-to-face group (Group A) and 18 to the internet group (Group B) with individual online tutor support group.

2.3. Intervention

Six experienced TC instructors worked together with a senior TC instructor (AM) to plan lessons and ensure consistency of the delivery for this specific TC intervention. None had previous experience of teaching over the internet.

The exercise itself involved a short sequence of movements selected for their specific effect on the respiratory system and overall benefit on quality of life for people with CF. These movements were adapted from the “Eternal Spring” therapeutic Tai Chi and Qigong method, which uses animal movements and can be practiced standing or seated. The instructors met regularly over one year to agree and refine the teaching

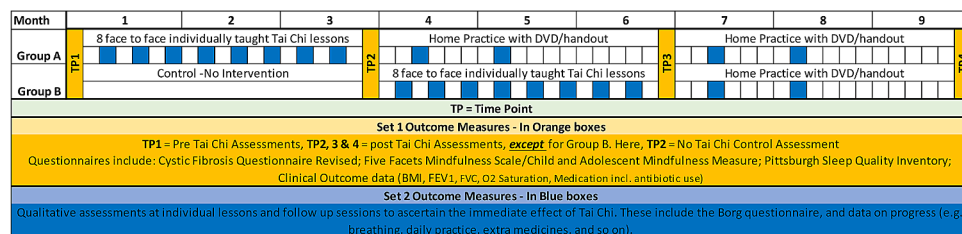


Fig. 1. Design of the randomized controlled feasibility trial. Timing of data collection. Group A: Before lessons began, after lessons finished, and at 3 and 6 months after lessons finished. Group B: At 3 and 0 months before lessons began, after lessons finished, and at 3 months after lessons finished. Participants were also asked a series of questions by their teachers before and after each individual lesson (Set 2 Outcome Measures), and were invited to participate in a focus group or telephone interview once all lessons had been completed.

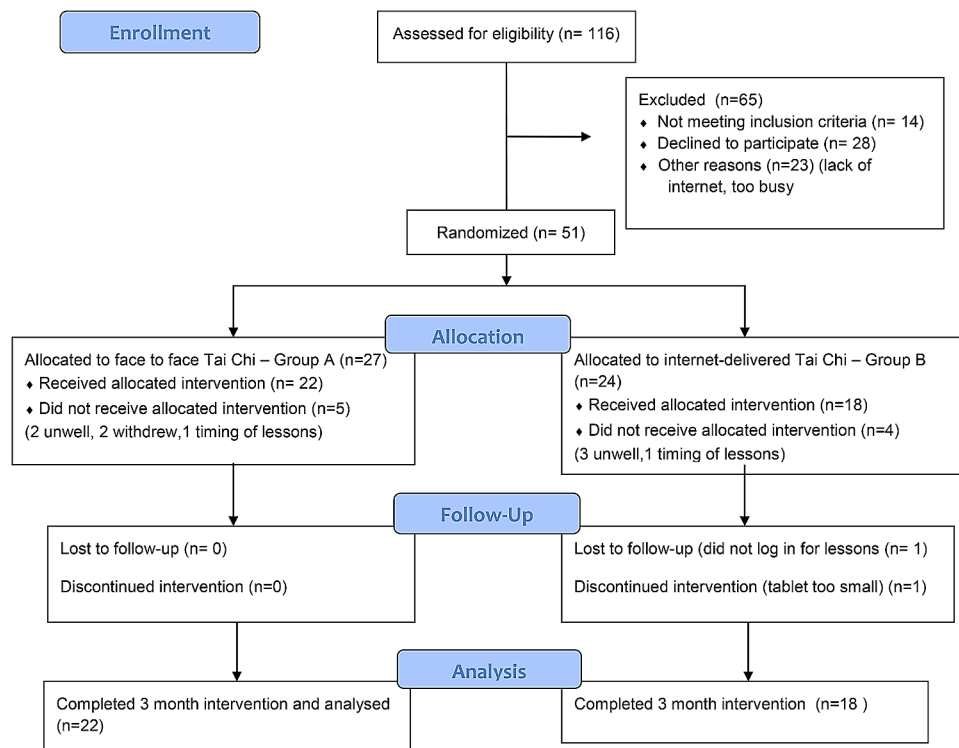


Fig 2. Study flow diagram.

protocol for the movements and how they should be taught. These were adapted to the needs of this particular patient group. Also during the intervention period the TC instructors met and held regular meetings to reinforce the consistency of approach and gain support for any difficulties encountered. In order to support practice between lessons, a bespoke DVD and printed instruction booklet (including photographs) was produced and given to each participant irrespective of group allocation. The DVD included versions for children, adults and those who needed to sit rather than stand whilst exercising. Participants were encouraged to practice the exercises daily where possible for 5 to 10mins, at least up to 5 times a week. A study diary for children was also provided; family friends or carers were encouraged to take part in the sessions.

Routine care and treatment were as normal during the study period.

3. Data collection

3.1. Outcome measures

The feasibility of delivering TC and comparing the two different modes of delivery was assessed and included recruitment, reasons for declining participation in the study, withdrawals, advantages and disadvantages of online experience in lessons, feedback on the TC practice aids provided, level of perceived engagement (online versus in-person), frequency and duration of practice, open ended questions on participants' experience of the study and any potential for improvements [14].

Clinical and quantitative outcome measures including the validated Cystic Fibrosis Questionnaire- Revised (CFQ-R) (measuring health related quality of life) were collected but are reported elsewhere [13,14].

The qualitative data reported in this article were collected from the open-ended comments entered into the online questionnaire completed by participants at three monthly feedback sessions with the teachers before each session, and recorded on specifically designed instructor questionnaires. Finally, online Skype/telephone interviews were conducted post-intervention by NR and scribed by PR using a semi structured interview schedule. If children were under 16 years a parent was

present at the interviews. Instructors were also individually interviewed on the phone and also in a focus group once the study was finished.

3.2. Data analysis

Qualitative data were analysed using Framework analysis which is a thematic framework [15]. Frequency of reports on emerging themes were identified by the number per participant and number of participants reporting. Reports were read by two people, themes extracted and consensus arrived at for resulting themes. Themes were challenged and verified through comparison between outcome measures used for individual cases and groups [16–18]. Quantitative data were generated from thematic reporting and compared with quantitative data from validated outcome measures in order to challenge and comment on findings [19,20]. The synthesis of these themes is reported in this paper.

3.3. Ethical approval

The study received ethical approval from Harrow Research Ethics Committee (REC reference no.:14/LO/0327), was registered on the clinical trials.gov website (Registration number: NCT02054377) and the study protocol published[14].

3.4. Results

3.4.1. Recruitment

Of 116 people approached to participate, 65 declined, but only one of these did so because they said that they did not like the idea of online tuition [13]. Most people declined either because they reported that TC did not appeal to them (43%) or they could not fit the study into their other commitments (36%) or because of their current health problems. Many people were not eligible because of their commitment to other ongoing studies at the hospital and/or distance from the geographical area of the CF teaching team. A total of 51 people consented to participate, some of these reported being nervous about which group they would be allocated to and expressing relief if they were allocated to the

Table 1
Reasons for withdrawal from the study.

Reasons for Withdrawal	Face to Face Group (Group A)	Internet Group (Group B)	Total
Ambivalent	1	0	1
Did not attend lessons	0	1	1
Ill health	1	3	3
Internet teaching problems	0	2	2
Online questionnaire problems	0	2	1
Too busy	0	1	1
Total	2	7	11

group they thought they would prefer – usually the in-person, face to face group. However, no individual withdrew because of disliking their group allocation and 40 individuals completed all eight lessons.

3.4.2. *Reasons for withdrawal and loss to follow up*

Telephone follow up identified that two participants aged between 6 and 11 years withdrew from the study, both in the internet group (Group B), because of reported difficulties with technology (Table 1). One participant decided that they did not like the idea of learning over the internet, whilst the other only had a tablet for lessons and after logging on to a lesson could not satisfactorily view the instructor to understand the exercises. One participant consistently failed to log in for lessons. Ill health (n = 3) and life pressures (n = 1) accounted for four of the internet withdrawals (Group B), compared with only 1 person in the Face to Face group (Groups A). In Group B, one individual stated that they did not like the questions being asked in the questionnaires, and another had technical difficulties with the questionnaires (which were completed online). In addition there was a gradual fall off in quantitative questionnaire completion over the study period. Overall, withdrawal was higher in the internet group (Group B).

We do not have much information about those who were lost to follow up after learning TC for 8 lessons (Table 2). These participants either did not respond to requests to complete their questionnaires, or became unwell and made it known to the researchers, and one did not answer the questions.

3.5. *Feasibility of teaching Tai Chi over the internet*

A total of 17 Skype interviews with 28 participants were held, 3 of which were focus groups. These interviews were conducted within 2 weeks of completing the TC course. In addition, one online instructor feedback session with 3 of the instructors was conducted and at the end of the study a focus group was held with all instructors. The interviews together with the qualitative data provided by participants to their instructors on their weekly feedback forms were transcribed and analysed using Framework analysis [16]. The themes that emerged were; expectations, IT constraints (screen size, connectivity), convenience, aids to practice, friends and family, engagement and TC practice frequency and duration.

Expectations: Many participants expressed enthusiasm about this new way of delivering lessons, even if they were not allocated to the internet group. Some did express a concern, especially parents who

Table 2
Reasons for loss to follow-up during home practice phase of the study.

Reasons for Loss to Follow Up	Face to Face Group (Group A)	Internet Group (Group B)	Total
Did not like questionnaires	1	0	1
Ill health	2	0	2
Unresponsive	13	5	18
Total	16	5	21

worried whether small children would be able to concentrate. Instructors also had this worry.

Patient 5's father: "We would have taken part even if in the Skype group. We would be well equipped to do this. We were excited to be in the study."

Patient 89: "Yes. I was actually [disappointed with being allocated to the internet group]. I think it was just... I don't know...I think I just thought it wouldn't be as effective as learning one to one and I kind of liked the idea of someone coming over and showing me in person, so it just felt like it was going to be a bit disconnected. Actually, since it's started, it hasn't been an issue at all."

Instructor M: "Generally it was actually better than I thought it was going to be in terms of the technical aspect."

IT constraints: The instructors and several participants commented on their worries about the quality of teaching over the internet. The main problem was being able to see each other well enough, but most participants managed by using a big computer screen or by plugging their tablet into the television. However, some participants had limited technological choices and this clearly impacted on their ability to learn and enjoy the classes. Many remarks were made about instructors' difficulties being able to physically check participants' posture and movements.

Instructor S: Yes. Space was sometimes an issue with some of the students. With the Skype, if they don't have a big enough room, you can't get the whole body on the screen.

Patient 89: The only other issue with Skype is that sometimes it's quite difficult to get the distance between the laptop and where I'm standing so I can get a full vision of what he is doing and he can see what I'm doing. So it depends on the size of the screen you've got, I've got a mid-sized screen. It's not particularly small, but there are times when it's quite hard to learn movements 'cause his legs are cut off, so.. otherwise, it's too far away for me to see properly. So that's the only negative I can see in terms of doing it over the internet.

Internet speed and connection: Most of the participants lived in urban areas, or areas with fibre-optic broadband, so all participants had internet connections. One or two participants struggled with reception and this impacted on their classes, with one class having to be deferred. Future studies need to consider connectivity.

Convenience: Several participants appreciated the convenience of having their lesson at home. This was also the case for those having the internet delivery. Home delivery of the intervention was more convenient, especially when there were others in the house that needed looking after. Individuals accessing the internet as a mode of delivery also appreciated that this reduced risk of infection that comes with this mode of delivery.

However, for the instructors, the inconvenience of having to travel to a participant's home was weighed up against the tendency for internet participants to miss appointments, teenagers in particular.

Patient 1's mother: It suited us [The Skype group]. It was good for us timings wise because we could fit it around our working day. PT1 has three siblings, so it would have been quite difficult to keep them entertained if we had to take her somewhere for a lesson. I think the practicalities of doing the questionnaire were sometimes difficult..... I personally think the whole Skype lesson worked really well. I don't know what the tutor thinks, but from our point of view, it worked really being able to do it in our front room.

Instructor J: " With Skype, there were quite a lot of no shows, with a couple of different people, usually 16 to 21 age group forgetting, whereas the younger generation, were a bit more 'parently' lead and they would ensure they were ready. But, yeah so that 16 to 21 year age group had definitely a higher percentage of forgets. Obviously, I had to reschedule

which was quite frustrating.”

Aids to practice: Most participants used either the handbook or the DVD to aid practice, with 9 reporting they preferred the handbook but the same number opting for the DVD. Often the handbook was chosen due to lack of access to DVD players. Participants commented that they might have used the video if it was available on the internet. However, for many, a book was much easier to access and they just wanted a prompt for the exercise they were practicing.

Patient 73: At first I used the book mainly to help practice. Then tried the DVD. I preferred it and use the DVD now. I practice in sequence. And the DVD does it in sequence.

Patient 6: Used handbook, not DVD as we have no DVD player. Downloaded some other lessons from the internet as a guide instead. We helped each other remember, so having two people in the lessons was very helpful. Two brains are better than one!

Patient 5's father: Children on the DVD is better than adults. There is a good mix and it is more real. A child can associate with other children. He would like the instructor to go to his school.

Friends and family: Participants who had the support of family members or partners seemed to enjoy having their company in practice and lessons, but their practice appeared to tail off if their practice partner lost interest. Partners in the internet group may have been more likely to lose interest because of the problems with seeing two people (technological limitations) which the instructors were more aware of.

Engagement: Smaller children and some teenagers appeared to have struggled most to engage with the lessons over the internet.

Instructor S: “Yes. I did quite a few internet sessions and I found that the 16 and above, it generally worked OK, although it was very two dimensional, so it was very difficult to see any faults or bad habits that the person was picking up. Because a lot of Qi gong is being able to correct people standing and doing it constantly. So, that was quite difficult. And the second thing was that kids found it extremely boring, and the two children I had both basically stopped doing it. They just didn't find it exciting enough, over the internet.”

3.6. Tai Chi practice frequency and duration

Both groups reported comparable frequency and duration of their practice. All participants practiced between lessons on average three times weekly for 13 min. At follow up 84% of those interviewed in the focus groups (n = 20) still reported practicing an average of two to three times per week (average practice frequency: face to face (Group A) - Child = 1 (n = 3), Teen = 1.5 (n = 2), Adult = 3.5 (n = 5) Internet group (Group B) Child = 2 (n = 2), Teen = 2 (n = 2), Adult = 2.5 (n = 3). 79% of individuals (both groups combined) said they intended to continue TC, (face to face=8, internet=7). Some participants asked about local classes. 32% included a family member or friend in their lessons. Two participants reported using TC whilst hospitalized. In focus groups, both participants and instructors reported issues around motivation to practice, particularly as lessons came to a close.

Instructors also reported that some participants really benefited from their partner doing the lessons with them and this motivated practice. However, instructors reported that they found it difficult to pay as much attention to the partners of participants in the online group with the result that the partners tended to drop out of lessons. This in turn reduced the motivation of participants to continue lessons or practice. Time and finding the best time of day to practice also impeded practice.

The instructors were unable to report whether there was a difference in the levels of practice between the groups, apart from one, who felt that the ‘in person’ group practiced more.

Instructor M: “Most of the people I taught, I'd probably say 80% of them, did practice between the sessions. The 16 year old girl I mentioned, did not practice at all. She was off doing things with her teenage friends, because that's what she wanted to do. But, apart from her, most people did practice. Some people practiced quite a bit at the start and just tailed off a little bit as we went on, and some people practiced more and more and got into it.”

Instructor M: “—there were a couple of participants who practiced with a partner, which was actually really important for their own motivation. So, something that I had my attention drawn to was, if I was teaching two people, (and in the context of Skype, not so much for the face to face), was when I was teaching two people, obviously I would be putting my attention on the person who was in the trial. But, I got some feedback that said that because I haven't also put a similar amount of attention or more attention on that second person who was doing it with them, the person lost interest and didn't continue with practice. And about halfway through the sessions they actually dropped out, and that affected the motivation of the person in the trial, because when their partner wasn't practicing with them in between, they were less inclined to practice, and when their partner wasn't with them in the session. So in that situation actually, even though we were told to focus our attention on the participants in the trial, if we neglected the second person too much it actually had a knock on effect on the person who was actually in the trial.”

Patient 1's mother: She does quite like doing it. She does it about once a week. I don't know how long she will continue doing it. Now that the weekly prompts are gone (teaching sessions). Having a weekly prompt helped. They got changed into their gear and then they talk about it. It's sometimes quite difficult to keep it going I think?

Patient 103: So I stopped for a period of about three weeks, and that was near the end of January, early Feb, something like that. And, so then I picked it up again. So now I'm trying to do it 2–3 times a week. And actually I would like to try and do it more than that, because I did find doing it more often more beneficial, so yeah. So yes, I am still doing it.

3.6.1. Practice duration

Instructors found it difficult to report on practice duration but noticed that the people who were most motivated to practice were those who had most to gain – those with more active symptoms and probably less in control of their health.

Patient 90: Yeah. I, em, I kind of messed around with sort of different times during the day to see which was best for me and the morning, it was good, but er em, I'm quite lazy in the morning, so it's a bit of a push for me to kind of get the 20 min-half an hour in. So, what I tend to do is do it in the evening time, and like, just before my physio, and I found that it actually relaxed the lungs more, so that I could get more, em, productive, so to speak.

3.6.2. Comments on objective quantitative outcomes

Quantitative outcomes in terms of physical and mental health have been published previously [13]. Outcomes were comparable between groups and notably qualitative reports from participants suggested that they were better able to expectorate if they practiced TC before carrying out their physiotherapy exercises. Most outcomes showed small, but not significant improvements for breathing, sleep and mindfulness. The qualitative data when integrated and compared with the quantitative outcomes can explain and frame the participants' perspectives and experiences of the two interventions [21]. This analysis has been able to explore in more depth whether interventions were feasible, identify areas for improvement and how TC can be delivered.

Participants' health status were very variable, the fact that many were asymptomatic, was notable. As the instructors carried out part of the data collection in-person this may well have impacted on the study

outcomes both positively and negatively [22]. Participants may have felt more at ease and been able to give more detailed answers to the teachers because of the amount of time and the different foci in the course of seeing the instructors in their own home, but conversely this may have pressurized participants into giving answers that pleased the instructors or suppressed their real thoughts [22,23]

3.7. Discussion

During the COVID-19 pandemic, people who are immunocompromised, with long term health conditions and those with respiratory problems have required shielding from infection and have been greatly disadvantaged. People need to be connected and supported while being unable to meet face to face [24–26]. This has meant a reliance on the use of the internet and its resources. The qualitative outcomes of this feasibility study have suggested that internet supported teaching of TC could provide such vulnerable groups with opportunities to engage while also helping to maintain and improve health. There was a willingness of patients to participate and utilise this technology in our study which confirms the results found in the systematic review by Cox et al. [7]

The feasibility of teaching on the internet was demonstrated by this study as patients could be recruited and randomized, complete 8 weeks of instruction, found TC delivery acceptable and used the resources. There appeared to be improvements in health status as assessed from reports from patients and their instructors.

3.8. Recruitment to the trial

Many people had not heard of TC and said that they needed to see what it looked like to help them decide whether to take part. Inevitably, some people did not like the idea, others were too busy, had tried TC or another martial art previously, or were already recruited into another study.

Recruitment took much longer than expected and participants who had agreed to join the study often had delays because of treatment issues and illness. Recruitment in healthcare studies, especially chronic conditions or busy teaching hospitals can be difficult. There is evidence that it can be improved with incentives such as access to treatments perceived as beneficial [26]. The clinicians were instrumental in identifying potential participants and promoting the study. The hospital clinic was busy and participants often travelled a long distance and had limited time in the clinic, so discussing the study was not always a priority. The research team made a special effort to be unobtrusive and consistent while recruiting in the clinic, so that the clinical team were familiar with them and did not feel too pressured. Studies show that developing good relationships with clinicians and reassuring them of trustworthiness and lack of impact on their workload enables better recruitment for studies [27]. The recruitment demonstration video in the clinic was immensely useful, especially for children. It made it easier for them to understand the exercise and what would be involved by participating in the study.

3.9. Retention

Despite some participants expressing concern about online delivery, it was reassuring to see that most people who withdrew from the study reported reasons other than not liking internet delivery. However, more people withdrew from the study in the internet group (Group B), mainly prior to starting the intervention, and three times as many participants were lost to follow up in the face to face group (Group A). It might be that the distance created by the internet reduced the commitment from this participant group, making it easier to withdraw from the study for this reason. Withdrawal from study has long been a problem in distance and online learning [28]. Future studies might consider ways to strengthen commitment to learning for internet students. This might be

through group interactions and more frequent contact with the instructor and/or the research team in order to encourage long term follow up.

3.10. In-person/face to face versus internet delivery

The study aimed to test whether learning TC over the internet would be acceptable, especially as such delivery could improve access to TC and other exercises for many people in an affordable way. There are clearly issues regarding technology and perceived lower quality teaching for internet taught lessons, despite the same amount of instructor support and contact in both groups, with comments suggesting that the type of technology and physical space available needs to be considered in designing online interventions. We found one other similar study where CF participants learned an exercise over Skype for 20 min at a time, but no mention was made of practical or technology issues [29]. Simple measures such as an HDMI cable to connect laptops to a television screen could enable participants to display the video with improved visual quality and allow a better camera position for the instructor to see the student to aid 3D sight of students and instructors which may improve feedback. Lessons with multiple participants (e.g. family members) might benefit from more than one camera, so the instructor has sight of all students. Future studies also need to consider room space internet connections, including use of wireless broadband connections where fibre-optic broadband is not available. This is particularly important given that connectivity may well impact on the possibility of making these types of lessons available to people in rural areas, and particularly on teaching group lessons, where the demand on data connections will be greater.

Despite the technological issues, the outcomes from these lessons may be similar to those for face to face teaching, and they reduced the travel time and costs for instructors. It may be that internet teaching can be introduced to support long term exercise, and engage people who may use other types of classes in the future, where concerns about, for example, correct posture and movements, are addressed.

Of interest, three times as many participants in the face to face group were lost to follow up after completing the intervention than those in the internet group. The use of electronic questionnaires to collect data in combination with an electronic delivery of the intervention may have strengthened the psychological link between the exercise and the questionnaires resulting in a better completion of the follow-up questionnaires. This in turn may help with the motivation issues raised via the online group. New technological advances allow apps to be developed and include features to encourage participation and even reward participants and completion of questionnaires. This could allow both the questionnaires and the classes to be delivered via a single platform which requires completion of the questionnaire before proceeding with the next session.

There are few studies comparing the teaching of an exercise over the internet with face to face instruction, –only one study on yoga, potentially relevant to TC was identified [30]. In this study, 71 hospitalized COPD participants were randomised to a yoga technique to improve breathing instruction either in person or through tablet computer with a specific, intensive instruction package. Immediate, but not medium-term outcomes indicated marked improvements in breathing techniques and self-efficacy. Participants liked the immediacy and privacy of using a tablet, but the authors concluded that further, more traditional follow up sessions may be required to maintain improvements. Further studies comparing face to face and internet delivery may give greater insight into the factors which may impede quality instruction and hence aid participant engagement.

A Cochrane review of strategies encouraging daily activity in people with CF found participation in prescribed exercise programs is often poor [31], although TC was not included. The potential of strategies such as internet-based advice to encourage regular participation in physical activity was not identified by this review. In our study,

instructor support was an important part of the intervention and was valued by the internet group. This was also demonstrated in a recent trial on self-guided breathing exercises for people with asthma which concluded that participants who only received a DVD compared to one to one tuition would have preferred tuition by a professional, but patients in both arms of the study showed improvements in quality of life [32].

3.11. Practice duration and frequency

By and large, participants maintained a regime of regular practice of TC that suited their personal timetable throughout the study. They were clear that having lessons was a motivating factor. Quantitative data showed that the number of people maintaining practice at three and six months after lessons diminished in both groups. However, exploration of qualitative data demonstrated that even those who were still practicing and some who were not, expressed a desire to maintain it as an exercise as they found it useful. Others felt that continued lessons would motivate them to continue and suggested more direction in terms of when to practice, with perhaps an app to prompt them and help log practice. The lead instructor noted that practice frequency and duration was higher than he expected with normal TC classes. The flexibility of delivery and standing and sitting exercises combined meant that it could also be delivered successfully in hospital and this was welcomed by those participants for whom this option was necessary. Schmidt and colleagues found that participants with CF exercised for an average of 2.31 times a week and a total of 79 min when they conducted a study to introduce unsupervised aerobic exercise over 12 weeks [33]. Their intervention succeeded in increasing the frequency to three times a week and duration to 90 min. Friendly competition has been shown to be a major motivational factor when it comes to exercise [34]. The more supportive nature of TC and the less social method of delivery on a one to one basis might mean that people are less likely to continue over time.

3.12. Outcomes for physical health

Objective quantitative data on changes in physical health as measured by the CFQ-R, PSQI, FFQM, CAMM and clinical data was comparable for both groups [13]. The focus groups and interviews (qualitative data) suggested that the internet group reported better outcomes for breathing, although the quantitative data (CFQ-R) did not bear this out. Feedback from both participants and instructors reported that measurement of breathing (e.g. FEV1 and FVC) 30 min after the TC lessons might have been more informative. Other studies have reported the usefulness of resistance exercise for breathing in CF [35], particularly those that focus on respiratory muscles [31,36]. The effect reported by many participants on their expectoration outcomes from practicing TC prior to airway clearance suggests potentially beneficial relaxation of the airways.

Interestingly, objective, quantitative data on sleep quality (PSQI) was better for the internet group, but was not reflected in the qualitative data. Few TC studies have focused on sleep or fatigue [37], although one reported significant improvements in sleep quality, latency, duration, efficiency and disturbance for the TC group when compared to low-impact exercise [38]. Use of actigraphy and a no-treatment control group have been recommended for future studies, as well as larger sample sizes [38]. The qualitative data suggested participants experienced positive effects on anxiety.

3.13. A potential role for Tai Chi during the COVID-19 pandemic

The COVID-19 pandemic raises particular consideration for the potential use of TC to improve respiratory function. In China, TC has been used during the pandemic by both healthcare workers and patients in recovery from COVID-19, and may be beneficial given the

effect of the virus on lung function and post viral fatigue [39,40]. Systematic reviews of TC have already demonstrated its effectiveness for COPD [41], fatigue [42], cancer related fatigue [43], and self-efficacy [44] and it may also offer additional benefits to people recovering from COVID-19.

The shielding required during the pandemic for people with CF who are at constant risk of respiratory infection, has affected exercise regimens, adherence to regular exercise, wellbeing and increased their sense of isolation. Cystic fibrosis centres around the UK had to adjust service delivery from face to face to virtual, almost overnight. There has been a fast learning curve with virtual services quickly becoming the norm. Physiotherapists at the study centre now provide online daily physio sessions, physio technique reviews, exercise sessions and ambulatory oxygen assessments. As reported in this study, space at home can be a problem for patients and the physiotherapists cannot always see the whole person. With all virtual interaction, background noise and connectivity can be a problem however; there has been very positive patient feedback. This study illustrates the possibilities of virtual patient interaction and current circumstances have led to rapid adoption in healthcare.

At the peak of the UK's COVID-19 crisis, in April 2020, recognizing the potential need for exercise and maintaining wellbeing during shielding, the research team approached the two CF charities that funded this study. We offered to provide our TC video resources free of charge to people with CF via a YouTube link (<https://www.youtube.com/playlist?list=PLPYEPWd1O1qbCnqdY60cxn9xDeHo3vWBg>). The videos were linked to the websites of the funding charities and the Wu Shi Taiji & Qigong Association. The Cystic Fibrosis trust also advertised the site on their social media to aid dissemination and to further engage with the CF community. Six weeks later the resource had been accessed by 439 times, whether these were all separate individuals or revisits to the site is unknown as no personal data was collected on who used the resources. Informal feedback on the YouTube video was requested and contact details provided should users require further advice. This video link was not directly instructor supported as in this study, but could be a possibility in the future.

Harvard Medical School, and many other medical institutions including the National Health service in the UK and the National Institute of Health- USA across the world have recognised TC and qigong as a safe, effective therapeutic practices, which are highly adaptable [45]. Classes can be delivered in public health settings and community centres as well as remotely via the internet for isolated or vulnerable individuals.

3.14. Limitations

This study was limited by the relatively small number of participants recruited and the difficulties experienced with recruitment, but over half of participants provided qualitative feedback and this has identified the key issues on how to conduct future definitive studies.

3.15. Conclusion

This study has shown online taught TC is possible for people with CF and qualitative outcomes are comparable to in-person, face to face tuition. For the participants in this study, internet tuition seemed to be convenient, enabled normal family life to continue, and could engage patients who were geographically isolated or unable to join a local group. It could aid community nursing or satellite care once the pandemic has subsided. Both groups felt that TC provided them with a skill for life. Some participants failed to engage with an internet mode of delivery, but generally their engagement with the study was better than the in-person, face to face group. Future studies to verify health outcomes should consider improvements in software and technology, and timing and content of questionnaires, however increasingly there are a number of different platforms available for individual and group

teaching. Wider communities should be able to benefit from being able to access tested and safe web based resources as long as they are based on research evidence.

Author contributions

NR was responsible for the initial concept, was principle investigator and drafted the study protocol. AM developed the Tai Chi resources and was responsible for the delivery of the Tai Chi intervention, collection of data, training the instructors and preparing materials for wider internet use. PR and NR were responsible for drafting the manuscript with critical input from all authors. SM and SC were the clinicians at the hospital responsible for the clinical site and patient recruitment. PR and AL were responsible for patient consent, follow up and data collection. All authors made substantial contributions to conception and design, or acquisition of data, or analysis and interpretation of data.

Financial support

Research grants were received from The Tracie Lawlor Trust for Cystic Fibrosis and The Cystic Fibrosis Trust, UK

Data availability

Any additional data can be supplied on request to the authors.

Declaration of Competing Interest

Prof Nicola Robinson is Editor in Chief and Dr Ava Lorenc is an Associate Editor of the European Journal of Integrative Medicine. All authors declare that they have no conflicts of interest regarding the research conducted and reported in this article.

Acknowledgements

We would like to thank all the study participants for their enthusiasm, engagement and suggestions, and our Tai Chi instructors (Jamie Brown, Jeremy Marshall, Faisal Mian, Nick Goss, Steve McColloch, Matt Cooper) for their involvement and capacity to travel all over the South East regions of the UK, the Wu Shi Taiji and Qi Gong association, UK, and in particular Michael Acton for his advice and guidance on the development of the Tai Chi intervention. Thanks go to Penny Agent and Emma Lake who contributed to the study design and lastly to our funders who made this work possible.

References

- [1] Cystic Fibrosis Trust. Annual data report 2010. 2010 14/12/2011.
- [2] P. Rodriguez-Miguel, A. Mangieri, K.T. McKie, C. Forseen, R.A. Harris, Mixed venous oxygen saturation is impaired during maximal exercise in patients with cystic fibrosis, *Med. Sci. Sports Exerc.* 48 (5 Suppl 1) (2016) 283.
- [3] T. Radtke, S.J. Nevitt, H. Hebestreit, S. Kriemler, Physical exercise training for cystic fibrosis, *Cochrane Database Systemat. Rev.* 11 (2017), <https://doi.org/10.1002/14651858.CD002768.pub4> Cochrane Database Syst Rev Cochrane Database of Systematic Reviews CD002768.
- [4] N.P. Walsh, M. Gleeson, R.J. Shephard, M. Gleeson, J.A. Woods, N.C. Bishop, et al., Position statement. Part one: immune function and exercise, *Exerc. Immunol. Rev.* 17 (2011) 6–63.
- [5] K. Steel, D. Cox, H. Garry, Therapeutic videoconferencing interventions for the treatment of long-term conditions, *J. Telemed. Telecare* 17 (3) (2011) 109–117, <https://doi.org/10.1258/jtt.2010.100318>.
- [6] O.M. Wilkinson, F. Duncan-Skingle, J.A. Pryor, M.E. Hodson, A feasibility study of home telemedicine for patients with cystic fibrosis awaiting transplantation, *J. Telemed. Telecare* 14 (4) (2008) 182–185, <https://doi.org/10.1258/jtt.2008.070107>.
- [7] N.S. Cox, J.A. Alison, T. Rasekaba, A.E. Holland, Telehealth in cystic fibrosis: a systematic review, *J. Telemed. Telecare* 18 (2) (2012) 72–78.
- [8] R. Jahnke, L. Larkey, C. Rogers, J. Etnier, F. Lin, A comprehensive review of health benefits of qigong and tai chi, *Am. J. Health Promot.* 24 (6) (2010) e1–e25 PM:20594090.
- [9] M.R. Solloway, S.L. Taylor, P.G. Shekelle, I.M. Mialke-Lye, J.M. Beroes, R.M. Shanman, et al., An evidence map of the effect of Tai Chi on health outcomes, *Syst. Rev.* 5 (1) (2016) 126.
- [10] S.P. Ngai, A.Y. Jones, W.W. Tam, Tai Chi for chronic obstructive pulmonary disease (COPD), *Cochrane Database Syst. Rev.* 6 (2016) CD009953.
- [11] W. Wu, X. Liu, L. Wang, Z. Wang, J. Hu, J. Yan, Effects of Tai Chi on exercise capacity and health-related quality of life in patients with chronic obstructive pulmonary disease: a systematic review and meta-analysis, *Int. J. Chron. Obstruct. Pulmon. Dis.* 9 (2014) 1253–1263.
- [12] A. Lorenc, A. Mian, S. Madge, S.B. Carr, N. Robinson, CF-CATS: an uncontrolled feasibility study of using tai chi for adults with cystic fibrosis, *Eur. J. Int. Med.* 5 (6) (2013) 476–486 <http://www.sciencedirect.com/science/article/pii/S187638201300139X>.
- [13] S.B. Carr, P. Ronan, A. Lorenc, A. Mian, S.L. Madge, N. Robinson, Children and Adults Tai Chi Study (CF-CATS2): a randomised controlled feasibility study comparing internet-delivered with face-to-face Tai Chi lessons in cystic fibrosis, *ERJ Open Res.* 4 (2018) 00042–02018 <https://openres.ersjournals.com/content/erjor/4/4/00042-2018.full.pdf>.
- [14] Lorenc A., Ronan P., Mian A., Madge S., Carr S.B., Agent P., et al. Cystic fibrosis-children and adults Tai Chi study (CF CATS2): can Tai Chi improve symptoms and quality of life for people with cystic fibrosis? Second phase study protocol. *Chin. J. Integr. Med.* (2015) doi: 10.1007/s11655-015-2150-1.
- [15] J. Ritchie, *The applications of qualitative research methods*, in: J. Ritchie, J. Lewis (Eds.), *Qualitative Research Practice*, Sage Publications Ltd, London, 2003, pp. 24–46.
- [16] M.B. Miles, A.M. Huberman, *Qualitative Data Analysis: An Expanded Sourcebook*, Sage Publications Inc, California, 1994.
- [17] Stake R.E. *The art of case study research*. Thousand Oaks, California: Sage; 1995.
- [18] R.K. Yin, *Case study research*, Thousand Oaks, Sage, London, New Delhi, 2003.
- [19] P. Pluye, M.-P. Gagnon, F. Griffiths, J. Johnson-Lafleur, A scoring system for appraising mixed methods research, and concomitantly appraising qualitative, quantitative and mixed methods primary studies in Mixed Studies Reviews, *Clin. Res.* 46 (4) (2009) 529–546 <http://www.sciencedirect.com/science/article/B6T7T-4VP173D-1/2/24a0479d666ae8fbc6aa5a5eaf7576>.
- [20] M. Sandelowski, One is the liveliest number: the case orientation of qualitative research, *Res. Nurse Health* 19 (1996) 525–529.
- [21] J.W. Creswell, V.L. Plano Clark, *Designing and Conducting Mixed Methods Research*, Sage Publications Ltd, London, 2007.
- [22] S. Oltmann, Qualitative interviews: a methodological discussion of the interviewer and respondent contexts, *Forum Qual. Soc. Res.* 17 (2) (2016), <http://www.qualitative-research.net/index.php/fqs/article/view/2551/3998>.
- [23] I. Procter, M. Padfield, The effect of the interview on the interviewee, *Int. J. Soc. Res. Meth.* 1 (2) (1998) 123–136, <https://doi.org/10.1080/13645579.1998.10846868>.
- [24] T. Abel, D. McQueen, The COVID-19 pandemic calls for spatial distancing and social closeness: not for social distancing!, *Int. J. Public Health* 65 (3) (2020) 231 <https://pubmed.ncbi.nlm.nih.gov/32239256>.
- [25] T. Abel, D. McQueen, The COVID-19 pandemic calls for spatial distancing and social closeness: not for social distancing!, *Int. J. Public Health* 65 (3) (2020) 231.
- [26] K. White, E. Holden, R. Byng, E. Mullan, W. Kuyken, Under/over-recruitment to mental health trials, *Acta Psych. Scand.* 116 (2) (2007) 158, <https://doi.org/10.1111/j.1600-0447.2007.01061.x>.
- [27] P. Roach, J.A. Duxbury, K. Wright, D. Bradley, N. Harris, Conducting research on acute mental health admission wards, *Nurse Res.* 16 (4) (2009) 65–72 <http://search.ebscohost.com/login.aspx?direct=true&db=c8h&AN=2010381756&site=ehost-live>.
- [28] Kim T-d, Yang M-y, J. Bae, Min B-a, I. Lee, J. Kim, Escape from infinite freedom: effects of constraining user freedom on the prevention of dropout in an online learning context, *Comp. Hum. Behav.* 66 (2017) 217–231 <http://www.sciencedirect.com/science/article/pii/S074756321630646X>.
- [29] O.W. Tomlinson, J. Trott, B. Bowhay, J. Shelley, B. Enderby, R. Chauhan, et al., P155 Feasibility of using online video calling to engage patients in the management of cystic fibrosis, *J. Cyst. Fibros.* 17 (2018) S102–S1S3 <http://www.sciencedirect.com/science/article/pii/S1569199318304508>.
- [30] H.-Y. Chan, Y.-T. Dai, I.C. Hou, Evaluation of a tablet-based instruction of breathing technique in patients with COPD, *Int. J. Med. Informat.* 94 (Supplement C) (2016) 263–270 <http://www.sciencedirect.com/science/article/pii/S1386505616301472>.
- [31] N.S. Cox, J.A. Alison, A.E. Holland, Interventions for promoting physical activity in people with cystic fibrosis, *Cochrane Database Systemat. Rev.* 12 (2013) CD009448, <https://doi.org/10.1002/14651858.CD009448.pub2>.
- [32] M. Thomas, A. Bruton, P. Little, S. Holgate, A. Lee, L. Yardley, et al., A randomised controlled study of the effectiveness of breathing retraining exercises taught by a physiotherapist either by instructional DVD or in face-to-face sessions in the management of asthma in adults, *Health Technol. Assess.* 21 (53) (2017) 1–162.
- [33] A.M. Schmidt, U. Jacobsen, V. Bregnballe, H.V. Olesen, T. Ingemann-Hansen, M. Thastum, et al., Exercise and quality of life in patients with cystic fibrosis: a 12-week intervention study, *Physiother. Ther.* 27 (8) (2011) 548–556 <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3172143/>.
- [34] J. Zhang, D. Brackbill, S. Yang, J. Becker, N. Herbert, D. Centola, Support or competition? How online social networks increase physical activity: a randomized controlled trial, *Prev. Med. Rep.* 4 (2016) 453–458.
- [35] I. Shaw, J.E. Kinsey, R. Richards, B.S. Shaw, Individualized supervised resistance training during nebulization in adults with cystic fibrosis, *Pak. J. Med. Sci.* 32 (5) (2016) 1152–1157.
- [36] C. Bieli, S. Summermatter, U. Boutellier, A. Moeller, Respiratory muscle training

- improves respiratory muscle endurance but not exercise tolerance in children with cystic fibrosis, *Pediatr. Pulmonol.* 52 (3) (2017) 331–336, <https://doi.org/10.1002/ppul.23647>.
- [37] A.P. Verhagen, M. Immink, A. van der Meulen, S.M. Bierma-Zeinstra, The efficacy of Tai Chi Chuan in older adults: a systematic review, *Fam. Pract.* 21 (1) (2004) 107–113.
- [38] K.J. Fuzhong LiFisher, Tai Chi and self-rated quality of sleep and daytime sleepiness in older adults: a randomized controlled trial, *J. Am. Geriatr. Soc.* 52 (6) (2004) 892–900 <http://search.ebscohost.com/login.aspx?direct=true&db=pbh&AN=13154176&site=ehost-live>.
- [39] Hospital in Wuhan uses TCM to treat novel coronavirus patients 2020 [Available from: <http://en.people.cn/n3/2020/0228/c98649-9663201-9.html>].
- [40] P. Li, J. Liu, Y. Lu, X. Liu, Z. Wang, W Wu, Effects of long-term home-based Liuzijue exercise combined with clinical guidance in elderly patients with chronic obstructive pulmonary disease, *Clin. Interv. Aging* 13 (2018) 1391–1399.
- [41] L.L. Wu, Z.K. Lin, H.D. Weng, Q.F. Qi, J. Lu, K.X. Liu, Effectiveness of meditative movement on COPD: a systematic review and meta-analysis, *Int. J. Chron. Obstruct. Pulmon. Dis.* 13 (2018) 1239–1250.
- [42] Y. Xiang, L. Lu, X. Chen, Z Wen, Does Tai Chi relieve fatigue? A systematic review and meta-analysis of randomized controlled trials, *PLoS ONE* 12 (4) (2017) e0174872, <https://doi.org/10.1371/journal.pone.0174872>.
- [43] P.M. Wayne, M.S. Lee, J. Novakowski, K. Osypiuk, J. Ligibel, L.E. Carlson, et al., Tai Chi and Qigong for cancer-related symptoms and quality of life: a systematic review and meta-analysis, *J. Cancer Survivorship* 12 (2) (2018) 256–267, <https://doi.org/10.1007/s11764-017-0665-5>.
- [44] Y. Tong, L. Chai, S. Lei, M. Liu, L Yang, Effects of Tai Chi on self-efficacy: a systematic review, *Evidence-Based Complement. Alternat. Med.* 2018 (2018) 1701372, <https://doi.org/10.1155/2018/1701372>.
- [45] P.M. Wayne, M.L. Fuerst, *The Harvard Medical School Guide to Tai Chi: 12 Weeks to a Healthy Body, Strong Heart, and Sharp Mind*, Harvard Health Publications, London, 2013.