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THE EFFECT OF ADHERENCE TO A TAI CHI INTERVENTION ON QUALITY OF LIFE OF OLDER PEOPLE LIVING WITH DEMENTIA

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Key Points

1. Adherence to Tai Chi exercise has positive effect on Quality of Life of older people with dementia (PWD).
2. Health issues of PWD and their carers have negative impact on adherence to Tai Chi exercise among PWD.

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Abstract

Background/objectives: Adherence to exercise programs is required to reap their established benefits and to sustain Quality of Life (QoL). This study explored People Living with Dementia's (PLWD) adherence to a Tai Chi exercise program and its effects on their QoL. The study included assessment of factors affecting adherence to a Tai Chi exercise intervention, causes of non-adherence, and effect of adherence on PLWD's QoL.

Methods: This study was part of a Randomized Controlled Trial (RCT) where 41 community dwelling PLWD received a Tai Chi exercise intervention in addition to usual care for 20 weeks. The measures used in this study included PLWD's QoL, global cognitive function, moderate physical activity, intention and confidence to attend classes, record of PLWD's and their carers' health conditions, and percentages of PLWD's Tai Chi class attendance and home practice during the intervention phase. Multiple linear regression, bivariate correlation, and independent sample t-test analyses were conducted to evaluate associations between these variables.

Results: PLWD's overall percentage of class attendance (M (SD) = 69.19 (29.95) demonstrated high adherence. Moreover, QoL of highly adherent PLWD was significantly higher than low adherents. Among all variables PLWD's and carers' health conditions (β = -.64; p < .001, β = -.38; p < .001 respectively) were the dominating factors that reduced PLWD's Tai Chi adherence, while PLWD's moderate physical activity at baseline (β = .27; p = .02) was significant positive predictor.

Significance/Implications: PLWD's and their carers' health issues must be addressed to enhance PLWD's exercise adherence and sustain good QoL.

Key words: Dementia, Quality of life, carers, people living with dementia, exercise intervention, exercise adherence, Tai Chi.

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Introduction

Dementia is a clinical syndrome characterized by difficulties in memory, language, and behaviour that causes impairments in activities of daily living (Robinson et al., 2015). Globally around 50 million people live with dementia (Livingston et al., 2020). The risk of developing dementia increases exponentially with ageing, and because people are living longer, the number of people expected to have dementia is projected to increase to 152 million by 2050 (Livingston et al., 2020). Currently, among all diseases, dementia is the seventh leading cause of death and a major cause of disability and dependence globally for older adults (World Health Organization, 2022). Given the wide-ranging impact dementia has on both the individual and their family carer, it is imperative to enable people living with dementia (PLWD) and their carers to sustain good quality of life with the condition.

Quality of Life (QoL) is a complex term, and there is currently no universally acceptable definition (Selai & Trimble 1999; Ready et al., 2004; Walker & Lowenstein 2009). However, there is general agreement that it is a multidimensional construct that includes psychological, emotional, physical, and social components of wellbeing (Birren & Dieckermann, 1991). Understanding of QoL among PLWD was facilitated by Lawton (1983, 1991, 1997) who proposed that it has both objective and subjective dimensions that are based on four components including the PLWD's behaviour, objective environment, perceived quality of life, and psychological wellbeing. Several studies have identified factors associated with QoL of PLWD. These include greater social engagement and connectiveness and less isolation of PLWD, living in one's own home in the community, better quality of relationship with carers/family members, better QoL of carers, increased levels of daily physical activity and leisure activities and having more autonomy (Clare et al., 2014; Camic et al., 2013; Jing et al., 2016; Martyr er al., 2018; Nikmat et al., 2015). On the other hand, older age (Banerjee et al., 2006), greater severity of

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dementia (Marventano et al., 2015; Mjørud et al., 2014), and increased number of chronic health issues (Jing et al., 2016) have been found to negatively influence QoL.

Tai Chi, a mind-body exercise described as moving meditation (Jin, 1992) has been shown to improve QoL. Mind-body exercise combines intellectual stimulation and physical activity (Wu, 2012), involving conscious control of each body movement in a relaxed state of mind (Chan et al., 2005). Meditation has shown to be effective for attention and executive functions by allocation of resources to these cognitive processes among cognitively intact older and younger adults (Chiesa et al., 2011; Prakash et al., 2012). Previous studies have indicated that social interaction and intellectual stimulation reduce the risk of dementia (Saczynski et al., 2006; Bennett et al., 2006) and is associated with greater volume of brain tissues (Mortimera et al., 2012). Several other studies have also reported benefits of intellectual stimulation and physical activity in delaying age-related cognitive decline which may be helpful in preventing onset of dementia (Whitty et al., 2020). Thus, researchers have identified four potential inter-linked beneficial elements of mind-body exercise: focus on mind, movement, and breathing while being in a deeply relaxed state (Larkey et al., 2009). In addition, practicing in a group also provides the opportunity to socialize with peers and instructors. These characteristics of Tai Chi make it a potentially useful intervention to improve health, wellbeing, cognitive functioning and QoL in PLWD.

Li et al. (2001) recommended Tai Chi for older adults because of its low impact and slow movements that could easily maintain participant interest. Older adults (aged 61-92 years) perceived Tai Chi as age appropriate, enjoyable, and easy to practice for them due to its slow and gentle movements (Kraft et al., 2015). Tai Chi is also reported to be appropriate to practice for

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PLWD in their early stages of dementia (Lyu et al., 2018) and safe for survivors of stroke and individuals with chronic disease including Parkinson's (Li et al., 2012).

To obtain the positive benefits it is important that individuals regularly carry out Tai Chi. As such adherence is a key component of intervention studies aiming to attain health outcomes for older adults, however, there is little consensus on its definition and it's reporting also varies considerably between studies (Hawley-Hague et al., 2016). Identification and understanding of factors influencing adherence is vital as sustained adherence will ultimately result in habit formation and maintenance of physical activity behaviour. Incorporation of these factors in physical activity interventions for older adults is likely to make these interventions more effective and useful for long term health behaviour change among participants.

The theory of planned behaviour (Bozionelos & Bennett, 1999) provides support for the role of previous physical active behaviour and intention as predictors of adherence to physical exercise. Intention to become physically active, and having higher physical activity levels at baseline, have been found to have positive association with physical activity initiation and maintenance among older adults (Van Stralen et al., 2009). Therefore, these factors are of interest with regards to PLWD to promote adherence to exercise.

Factors associated with adherence to exercise in older individuals have been categorized into demographic (e.g., old age), health related (e.g., chronic disease, and poorer health), psychological (fewer perceived barriers to physical activity, enjoyment, greater expected benefits, psychological health, greater self-efficacy, motivation, better perceived health and fitness), social (e.g., social support), environmental (e.g., safety, convenience to access physical activity facilities) (Allen & Morey, 2010) and cognitive ability (Picorelli et al., 2014). Findorff et al. (2009) reported that better general health and cognitive functioning were positively predictive

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of adherence to a walking program, and better QoL and cognitive functioning were predictive of adherence to balance exercises among cognitively intact but sedentary older women.

Despite the above findings with the general older adult population, there is a lack of evidence as to which factors are most predictive of adherence among PLWD. Di Lorito et al. (2020) in their systematic review and meta-analysis identified positive predictive factors of exercise adherence among PLWD and people with Mild Cognitive Impairment including exercise in group settings, individually tailored exercise, and well-communicating, engaging and knowledgeable instructors/professionals. In addition, more severe dementia symptoms were the only negative predictor of adherence among community dwelling PLWD (in terms of their Mini Mental State Examination scores). However, in their review no study has been reported to have used Tai Chi exercise intervention, only four among 41 studies were conducted in UK, among them only two used structured exercise interventions and three involved PLWD, and adherence was not the primary outcome in 98% of all the included studies. Therefore, there is a lack of evidence and scarcity of research regarding factors affecting adherence to exercise intervention among PLWD. The present study aimed to fill this gap in this knowledge by exploring the factors affecting adherence to Tai Chi exercise intervention among community dwelling PLWD.

Identification of factors affecting adherence to physical activity among PLWD is vital to incorporate evidence-based support strategies for adherence to intervention. The aim of this study therefore was to explore PLWD's adherence to Tai Chi exercise intervention and its effect on their QoL. We hypothesized that (H1) PLWD's better QoL and health, cognitive functioning (lower severity of dementia), stronger intention and being physically active at baseline would predict higher adherence to a Tai Chi intervention; (H2) PLWDs' midway intention to come to Tai Chi classes, confidence to do Tai Chi, and enjoyment during classes would have a positive

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association with adherence to Tai Chi intervention, whereas PLWD's poor health would have an inverse association with adherence to Tai Chi intervention; (H3) High adherent PLWD would have a better QoL post-intervention than low adherent ~~and a control arm of~~ PLWD. Finally, we explored the role of the instructor and the size of the classes on the adherence of the participants.

Method

Design

The study was a part of a Randomized Controlled Trial (RCT), the (name of the trial masked for peer review) trial. The larger study was a randomized, assessor-blind, two-arm, parallel group, superiority trial, to test the effect of Tai Chi on improving postural balance among PLWD. It was also a feasibility study for a subsequent definitive trial to test the effect of Tai Chi on preventing falls among PLWD. Dyads were randomized comprising a PLWD and their informal carer, to either a control group (usual care) or an intervention group (usual care plus the Tai Chi intervention) in a 1:1 ratio. Randomization was stratified by site, and minimization was used within each site by treatment condition and 12-month fall history at baseline (fallen / not fallen) (reference masked for peer review). Ethical approval for the main trial was obtained from the NHS Research Ethics Committee (REC) and the Health Research Authority (HRA). The trial was registered at ClinicalTrials.Gov with registration number: (masked for peer review), and the trial protocol was published before recruitment was completed (masked for peer review).

Participants

PLWD and their informal carers (N = 83) were randomized to either an intervention arm (N = 42) or a control arm that received treatment as usual (N = 41). This study focused on detailed analysis of the Tai Chi exercise intervention arm and the secondary outcome of QoL. Inclusion and exclusion criteria have been derived from the main trial (authors' name masked for

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peer review, 2018). Community-dwelling people living with mild to moderate dementia were the target population for the main trial. Both male and females were included. There was no restriction on maximum age. Detailed strategy was devised in the main trial for the recruitment of the participants (authors' names masked for peer review, 2022). Only people with confirmed diagnosis of dementia were included. Participants were recruited from 06/04/2017 to 17/07/2018, with the final follow-up completed on 30/11/2018 (authors' names masked for peer review, 2019).

Procedure

After sufficient participants were recruited into the study, baseline data were collected, and Tai Chi classes arranged at three sites in the South of England. There were seven different venues across the sites in community settings such as village and church halls. Participants (N = 42) allocated to the intervention arm were divided into 10 groups and assigned to different venues according to their convenience and ease of access to the venue. There were two Tai Chi instructors i.e., a male and a female, each was assigned five Tai Chi groups.

Tai Chi classes were offered for 20 weeks. Duration of each Tai Chi class/session was 90 minutes in which 45 minutes were for instructor-led Tai Chi exercise. The instructors provided individual support and guidance during the exercise sessions. The remaining 45 minutes were for socialization with peers and instructors. Adherence to Tai Chi classes was recorded in the form of percentage of class attendance.

Old-frame Chen style of Tai Chi (Nyman et al., 2018, Table 2, p. 5) was offered in the classes. It involved eight warm-up and five Tai Chi form patterns. During warm-up slow and controlled breathing with body movements was emphasized whereas natural breathing during Tai Chi form was encouraged. Each class was designed to end with standing meditation. Tai Chi

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exercise was designed to elicit calm instead of asking participants to be calm. Intervention was designed to progress gradually.

Given the high level of overlap between Tai Chi styles due to their common core set of principles (Nyman 2021; Wayne, 2013), our focus was less on the style of Tai Chi and more on the experience and approach of the Tai Chi instructors to working with the study population. The lead instructor was highly experienced in working with physically and cognitively frail older adults. Our focus for the intervention was also on quality over quantity of movements, with a focus on performing them slowly and repeatedly to leverage tacit memory, the last form of memory to deteriorate among PLWD. Thus, the approach taken was appropriate for the population studied. Our approach above is reinforced by the current evidence base that largely does not distinguish between Tai Chi styles and their health benefits, e.g. for the prevention of falls (Nyman, 2021).

It is illustrated in the (Name masked for review) Trial protocol "We will partly follow the Positive Emotion-Motivated Tai Chi (PEM-TC) approach developed in the USA (Yao et al., 2008; Yao et al., 2013), in that teaching will be based on implicit learning techniques. Through repetition of movements and positive reinforcement, this approach capitalises on PLWD's capacity to continue to learn motor tasks with the use of muscle or kinaesthetic memory, i.e., unconsciously through making behaviours automatic, despite impaired ability to explicitly recollect such memories (Yao et al., 2008)." (Citation masked for review)

In the (name of the trial masked for peer review) trial the process of recruitment and randomization was ongoing as participants were being recruited during the trial, they were allocated to one of the ten Tai Chi (TC) exercise groups being run according to the closest proximity to the respective participants. However, classes could not take a start until at least two dyads were allocated to a group (i.e., minimum required number of participants). Moreover,

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participants were allowed to join an already running class in the first few weeks, so they may not have attended all the 20 classes. Therefore, classes/sessions did not start for all the 10 groups simultaneously. They started as and when the minimum required number of participants for each group was recruited successfully. In addition, there were some participants who joined from the first session. They were offered 20 sessions, however, due to different reasons they could not attend all the sessions (see Table 4, for causes of nonadherence/absence from Tai Chi class sessions). Hence, all participants could not attend 20 Tai Chi sessions/classes. They received lower than the planned dose of Tai Chi. The number of sessions participants attended varied, which may have affected outcomes of the study. However, those who attended less than 5 sessions were excluded from the median split analysis (N = 37) for adherence to Tai Chi intervention as their attendance was too low to have created an impact on their QoL. Three among the four participants who were excluded from the analysis for having attended less than five sessions had primarily health related reasons for absence from the classes.

Data Collection

The present study was an assessor blind (names of authors masked for reviewers, 2018), therefore, the researcher who collected baseline and post-intervention data was blind to allocation of participants to trial arm until all data (i.e., baseline and post-intervention) was transferred to the clinical trials unit, which monitored the trial. After obtaining informed consent, data was collected from all the participants at their homes at a mutually agreed time of convenience.

At the baseline visit participants' mental capacity to consent was ascertained during the informal conversation before proceeding to acquire their informed consent formally. Afterwards, PLWD were required to complete the M-ACE for assessment of their cognitive functioning. M-

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ACE was scored immediately after its completion as only those participants were eligible to participate in the study who scored above nine. Other baseline data measures related to the present study included participants' intention (based on one item, "if offered the opportunity I intend to do Tai Chi for at least 20 minutes every day for the next five months", which was answered on a seven-point Likert scale where 1 represented agree while seven represented disagree), current moderate physical activity (based on one item, "how often do you usually do moderate physical activity? examples include brisk walking, bike riding, dancing and, swimming". The respondents had to select one out of six options i.e., every day, 2 times per week, 3 times per week, weekly, monthly, rarely/never), and ICECAP-O (Coast, Peters, et al., 2008) for participants' QoL i.e., higher the ICECAP-O scores the better the QoL. ICECAP-O is a capability based QoL scale which includes five attributes of QoL. The attributes of QoL are based on reporting of older adults. Its scoring has a system of the best-worst scaling, which clearly indicates presence or absence of a particular capability. Raw scores were converted into population-weighted tariff scores ranging from 0-1 (higher scores indicate higher quality of life) (Coast, Flynn et al., 2008). ICECAP-O is a psychometrically valid (masked for peer-review) and reliable measure for community dwelling PLWD (masked for peer-review).

All the data was collected in structured interview format. After data collection all data was transferred to the Clinical Trial Unit and participants' basic information along with their date of baseline home visit was recorded in the Trial's local database at (name of the University masked for reviewers). In the (name masked for peer review) trial consent was checked and confirmed from PLWD considering the progressive nature of dementia. This was done explicitly at each home visit and along the research process, through their verbal and non-verbal cues (Wilkinson, 2002). It was in accordance with Good Clinical Practice guidelines instructed by the

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National Institute for Health and Care Research (NIHR), which defines consent as an "ongoing process". The objective was to obtain maximally informed consent from PLWD (Hellström, 2007).

Mid-way data were collected from participants (N = 32) in the intervention condition through structured interviews by a second researcher who was not blind to the trial arms. They were asked about their intention and confidence to come to the remaining 10 Tai Chi classes and enjoyment during the ongoing classes. During the intervention phase causes of absence from classes were recorded by an unblind researcher.

To collect post-intervention data home visits were arranged six months after the baseline home visit to allow participants to have practiced Tai Chi for 20 weeks. Post-intervention home visits replicated the procedures for baseline data collection.

Data Analysis Strategy

Patterns of adherence to Tai Chi intervention among PLWD were explored descriptively. Causes of non-adherence among PLWD in terms of absence from sessions were recorded and assigned to one of six categories: PLWD's health, carer's health, PLWD's medical appointment, carer's medical appointment, holidays, and others/unknown. Descriptive analysis was carried out to see which causes contributed the most towards non-adherence (i.e., absence from sessions).

Multiple linear regression was conducted to test the predictive value of PLWD's baseline scores for QoL (ICECAP-O), cognitive functioning (M-ACE), intention, moderate physical activity, and health issues of PLWD and their carers on Tai Chi class adherence (in terms of percentage of scheduled classes attended) among PLWD.

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Pearson product moment correlations were calculated to explore the association and direction of relationship of midway intention to attend Tai Chi classes, confidence to do Tai Chi, and enjoyment during classes with Tai Chi class attendance among PLWD.

A median split of adherence was conducted to create a low and high adherence group. High and low adherence groups were compared by conducting an independent sample t-test analysis.

Prior to any analysis we examined whether the instructor and size of the group had an influence on adherence. An independent sample t-test was conducted to compare adherence in terms of percentages of attendance of groups supervised by the male and female instructor. There was no significant difference in adherence between the groups supervised by the male (M (SD) = 73.60 (5.94) or female instructor (M (SD) = 69.20 (15.2); t (8) = 0.60, p = .56; Cohen' d = 0.38).

The ten groups were divided into three sub-groups based on number of participants (i.e., group 1 = 2-6, group 2 = 7-9, and group 3 = 10^{+} participants). Kruskal-Wallis statistic did not show a difference in adherence based on group size (χ^2 = 0.89, df = 2, p = .64; Craver V = .24). As such we did not control for instructor or group size in any of our analysis.

Results

Demographic Information and Adherence

Demographic information of PLWD (N= 42) in the Tai Chi exercise trial arm is presented in Table 1. Table 2 presents demographic information of PLWD in high (N = 21) and low (N = 16) adherence groups. Table 3 presents the correlations between PLWD's (N = 41) adherence to Tai Chi exercise intervention and the baseline variables.

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Causes of Non-adherence to Tai Chi Intervention

Overall adherence to the Tai Chi classes by PLWD (N = 42) was a mean of 69.1% (SD = 29.9%) of classes offered. Table 4 presents the frequency of reasons for absence from scheduled Tai Chi classes. Poor health by the PLWD or their carer were the most reported reasons for non-adherence followed by medical appointments (PLWD and carer) and holidays.

Baseline Predictors of Adherence to Tai Chi Intervention among PLWDs (N = 42)

The regression analysis using baseline measures was significant (P < .001) and partially supported hypothesis 1, explaining 70.7% of the variance in PLWD Tai Chi class adherence. Significant baseline predictors of greater PLWD adherence to Tai Chi classes were lower number of health issues of the PLWD (β = -.64; p < .001), lower number of health issues of the carer (β = -.38; p < .001) and higher level of moderate physical activity (β = .27; p = .02). Intention (β = .02; p = .80), QoL (β = -.03; p = .74) and severity of dementia (β = -.08; p = .42) were not significantly associated with adherence.

Midway Analysis: PLWD's Enjoyment, Confidence, and Intention during Tai Chi Classes

Pearson product moment correlations were calculated to assess associations of PLWD's midway enjoyment during classes, their strength of intention and confidence to come to remaining Tai Chi classes with their adherence to intervention classes (N = 32). Large inverse significant associations of adherence were found with intention (r = -.52; p = .002), and confidence (r = -.62; p < .001) and non-significant association with enjoyment (r = .03; p = .86). The associations were not in the expected direction for intention and confidence. However, they were in the expected direction for enjoyment, but the association was non-significant.

Association between PLWD's Adherence to Tai Chi Intervention and Their QoL

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Median split analysis was conducted based on the percentages of class attendance (Median = 75%) and QoL score of high adherent PLWD was compared with low adherent PLWD. High adherent PLWD (N = 21) had significantly higher QoL score (M = .88; SD = .09) as compared to low adherent PLWD (N = 16), (M = .81; SD = .10), t (35) = 2.11, CI = 95% $p <$ .05 with moderate effect size d = .7 (Cohen, 1992). Participants who attended less than 5 sessions due to any reason including health conditions were not included in the median split analysis. Therefore, those who had similar characteristics were included (see Table 2) for comparison of effect of adherence on QoL of PLWD among high vs low adherers. QoL was based on ICECAP-O scores which is based on best-worst scoring system with scores range 0-1. This suggested that the high adherence group's QoL was better than the QoL in the low adherence group.

Discussion

The present study used data from a randomized controlled trial to explore PLWD's adherence to a Tai Chi exercise intervention, predictors of adherence, causes of non-adherence, and association of adherence with QoL. Tai Chi exercise resulted in better QoL in high adherence group as compared to low adherence group. Further, PLWD's and carer's health issues were the major negative factor inhibiting adherence among PLWD, while PLWD's baseline moderate physical activity increased adherence.

The attendance rate in the present study (69.1 %) can be considered good. Attendance at more than two thirds of sessions is regarded as high (Rolland et al., 2007). In addition, attendance rate in the present study is similar to those reported for Tai Chi interventions to prevent falls among cognitively intact community dwelling older adults (71-81%; Nyman, 2021) and for people with MCI and dementia (Di Lorito et al., 2020).

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In line with previous findings in cognitively intact older adults (e.g., Rivera-Torres et al., 2019; Picorelli et al., 2014), health issues of community dwelling PLWD and their carers during the intervention phase were found to have the greatest negative impact on PLWD's adherence to the Tai Chi intervention. The study sample (PLWD) not only had complex health status involving physical and neurological conditions, they also were almost entirely dependent on their carers to participate in Tai Chi classes. Hence, the trial was designed for the dyads to attend and absence of one person for extended sessions would influence the adherence of the other. Generally, participants with better health conditions in terms of fewer health issues, better self-reported health, and taking fewer medicines, report higher class attendance to exercise programs (Picorelli et al., 2014). This has also been shown for exercise programs among institutionalized PLWD (Vseteckova et al., 2018). It is important for future intervention or general health practitioners to consider PLWD's and their carers' health to reduce the effects of health constraints on adherence. This could be achieved by advising to seek support for physical or mental health problems, offering of compensatory classes to those who missed exercise sessions or have additional carers supporting the PLWD.

In accordance with the TPB those participants who had higher levels of baseline moderate physical activity showed greater adherence (Bozionelos & Bennett, 1999). However, the participants cognitive status (severity of dementia) and their intentions to be physically active did not support TPB of previous findings (van Stralena et al., 2009). The association between intentions to be physically active and actual participation has been non-significant. Moreover, in the present study, carers' intention to attend Tai Chi classes was not analyzed. This could also contribute to PLWD's intention-behavior-gap, which could be explored in future research~~Moreover, in the present study, carers' intention to attend Tai Chi classes was not~~

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~~analyzed that could also contribute to PLWD's intention-behavior-gap, which could be explore in future research~~. It has been estimated that the intention-behavior gap is 46% for the general population and 32% for older individuals. In addition, of those who started participation, 42% maintained the behavior (Rhodes & de Bruijn, 2013). This indicates that other factors not included in the TPB influence adoption and maintenance of exercise behavior.

Contrary to expectation, PLWD's mid-way intention to come to Tai Chi classes and confidence to do Tai Chi, appeared to have an inverse association with PLWD's adherence to Tai Chi classes. PLWD mid-way enjoyment during classes was found to have a positive association with adherence to intervention, but the association was non-significant. These findings were unexpected, and may suggest some other significant variables could pay a role to explain behavioral adherence, requiring further research in this phenomenon~~These findings were unexpected and might be due to cognitive disability of the participants or the suitability of instruments used to measure these constructs for this population~~.

As expected, increased levels of adherence to the Tai Chi intervention were associated with higher levels of QoL post-intervention supporting previous findings on the positive effect of Tai Chi on QoL in cognitively intact older adult (Tajik et al., 2018; Wang et al., 2020) and PLWD (masked for peer-review). This indicates that Tai Chi is an appropriate intervention strategy to enhance QoL of community based PLWD and should be considered to be included in policy recommendations.

The present study had some limitations that may be overcome in future studies. The study involved community dwelling PLWD, therefore, the findings cannot be generalized to PLWD residing in the care homes. The sample was recruited as dyads (i.e., PLWD + carers) due to which PLWD's adherence to intervention became dependent on carers continuous participation.

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Therefore, in some cases carers' health conditions also affected adherence of PLWD. Recruiting more than one carer with each PLWD to provide replacement for each other may have helped to overcome some practical constraints which prohibited PLWD from adherence. In addition, behaviour change techniques (BCTs) are reported to support adherence to exercise intervention among PLWD and older adults with MCI (Van der Wardt et al., 2017). In (name of the trial masked for reviewers) trial BCTs were used to encourage Tai Chi class participation and home practice. Effect of BCTs (i.e., joint action plan, joint coping plan, self-monitoring, feedback from Tai Chi instructor on home practice, and provision of alarm clock to set as a reminder) on home practice were evaluated and will be discussed elsewhere. However, effect of BCTs (i.e., social support from Tai Chi instructor and other participants, feedback on class performance from Tai Chi instructor, and a reminder phone call if two consecutive classes were missed) on class-based adherence to Tai Chi intervention among PLWD could not be explored.

Conclusion

The present study highlighted that while PLWD's and their carer's health inhibit PLWD's adherence to a Tai Chi exercise intervention, greater adherence to Tai Chi led to higher levels of quality of life. Therefore, to enhance PLWD's exercise adherence their health issues may also be addressed by either enhancing duration of exercise intervention or arranging compensatory classes to those who missed exercise sessions. Findings of the present study may be used in future research involving predictors and facilitators of exercise adherence, effect of exercise intervention on QoL of PLWD, and techniques of effective delivery of exercise intervention among PLWD.

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Table 1

Participants' demographic information.

Characteristics of PLWD (N = 42)	Values
Age in years mean (SD)	77.86 (8.32)
Gender n (%)	
Male	24 (57)
Female	18 (42)
Ethnicity n	
White	42 (100)
Education n	
None	2 (5)
Primary school	2 (5)
Secondary school	21 (50)
Higher education, College, University	12 (29)
Further education, professional qualification	5 (12)
Number of participants withdrawn completely from 1st session	1 (2)
*Number of participants did not attend any session without withdrawing	1 (2)
PLWD relationship with carer n	
Spouse	34 (81)
Parent	3 (71)
Sibling	4 (10)
Other	1 (2)
Living situation n	
Living alone	4 (10)
Living with family and friends	38 (91)
Dementia diagnosis n	
Alzheimer's	30 (71)
Vascular	1 (2)
Mixed Alzheimer's and Vascular	9 (21)
Other	2 (5)

* The dyad did not withdraw from the study, but they did not attend any Tai Chi sessions. They provided the baseline and post-intervention data.

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Table 2

Baseline Demographic information of participants (N = 37) with high and low class adherence to Tai Chi exercise intervention based on median split of 75 which refers to percentage of class attendance.

Characteristics	PLWD with high class adherence (N = 21)	PLWD with low class adherence (N = 16)
	(Median = 75)	
Age in years mean (SD)	79.9 (7.9)	78.7 (7.5)
Gender n (%)		
Male	13 (62)	8 (50)
Female	8 (38)	8 (50)
Ethnicity n (%)		
White	21 (100)	16 (100)
Education n (%)		
None	1 (5)	1 (6)
Primary school	1 (5)	1(6)
Secondary school	11 (52)	8 (50)
Higher education, College, University	5 (24)	4 (25)
Further education, professional qualification	3 (14)	2 (12)
PLWD relationship with carer n (%)		
Spouse	15 (71)	12 (75)
Parent	2 (10)	3 (19)
Sibling	3 (14)	-
Other	1 (5)	1 (6)
Living situation n (%)		
Living alone	2 (10)	1
Living with family and friends	19 (90)	15 (94)
Dementia diagnosis n (%)		
Alzheimer's	14 (67)	12 (75)
Vascular	1 (5)	-
Mixed Alzheimer's and Vascular	5 (24)	3 (19)
Other	1 (5)	1 (6)
Moderate Physical Activity (Baseline)		
Everyday	9 (43)	2 (12)
Weekly	1 (5)	1 (6)
Two Times per Week	2 (10)	2 (12)

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Monthly	1 (5)	1 (6)
Three Times per Week	4 (19)	2 (12)
Rarely/Never	4 (19)	8 (50)
Vigorous Physical Activity		
Weekly	1 (5)	-
Monthly	1 (5)	1 (6)
Rarely	19 (90)	15 (94)
Falls in Last one Month		
Yes	3 (14)	3 (19)
No	18 (86)	13 (81)
Comorbidities		
None	11 (52)	7 (44)
One	4 (19)	6 (38)
Two	4 (19)	2 (12)
Three	1 (5)	1 (6)
Four	1 (5)	-

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Table 3

Pearson product moment correlations between people living with dementia's (PLWD) adherence to Tai Chi intervention classes and baseline factors: PLWD health issues, carer's health issues, PLWD's intention, quality of life (QoL), level of moderate physical activity, and severity of dementia (N = 41).

	Variables	2	3	4	5	6	7
1	PLWD's adherence[1]	-.64**	-.45***	-.05	-.07	-.35*	-.16
2	Health issues (PLWD)		-.02	-.006	.03	-.01	.14
3	Health issues (Carer)			-.10	.01	.28	.001
4	PLWD intention[2]				.03	.48**	-.15
5	PLWD's QoL					-.04	.28*
6	PLWD's physical activity[3]						.15
7	Severity of dementia						

*$p < .05$, **$p = .001$, ***$p < .001$

[1]PLWD's adherence to Tai Chi classes.

[2]PLWD intention to do Tai Chi for next 20 weeks.

[3]Level of moderate physical activity of PLWD.

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Table 4

Categories of causes of non-adherence to Tai Chi intervention among PLWDs and their carer (N = 42).

PLWD ID	Causes of non-adherence and number of sessions affected (n)							Total no. of absents	Total sessions offered	% of overall attendance
	PLWD's health	Carer's health	PLWD's medical appointment	Carer's medical appointment	PLWD SAE*	Holidays	Others** / Unknown			
03003	2	10	2	-	-	-	-	14	20	30
03005	11	-	-	-	-		-	11	20	45
03006	-	-	1	-	-	-	-	1	20	95
02002	6	1	-	1	-	1	-	7	11	36
02004	-	-	-	6	-	-	-	6	12	50
01002	-	1	-	-	-	2	1	4	20	80
01008	-	-	1	-	3	-	-	4	20	80
03007	20	-	-	-	-	-	-	20	20	0
03008	-	1	-	-	-	-	1	2	11	82
01015	-	-	-	-	-	-	-	-	1	100
01021	-	-	-	-	-	-	-	-	16	100
01006	5	-	-	-	-	-	1	6	12	50
01009	-	1	1	-	-	-	-	2	20	90
01012	-	-	-	-	-	-	-	-	20	100
01022	2	3	-	-	-	-	-	5	18	72
01023	1	-	-	-	-	-	-	1	20	95
01025	7	-	-	-	-	-	-	7	20	65
01031	-	-	-	-	-	-	-	-	12	100
01034	14	1	-	-	-	1	-	16	20	20
01035	-	-	-	-	-	-	-	-	20	100
01036	-	-	-	-	-	2	1	3	20	85
01039	-	-	-	-	-	-	2	2	20	90
01043	WT	WT	WT	WT	WT	WT	WT	WT***	0	0
01045	-	-	-	-	-	-	-	-	20	100
01055	15	-	-	-	-	-	-	15	19	21

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01047	1	-	-	-	-	3	1	5	20	75
01049	-	4	-	-	-	5	-	9	12	25
01052	1	-	-	-	-	-	2	3	20	85
01053	-	-	-	-	-	-	2	2	20	90
01064	-	-	-	-	-	-	3	3	19	84
01059	-	-	-	-	-	2	-	2	20	90
01057	-	-	-	-	-	2	6	8	20	60
01062	-	-	-	-	-	5	7	12	20	40
01066	-	-	-	-	-	-	1	1	20	95
01076	-	-	-	-	-	3	2	5	15	67
01070	-	-	1	-	-	2	-	3	16	81
01072	1	11	-	-	-	-	1	13	16	19
01075	-	1	-	-	-	1	5	7	16	56
01080	-	-	-	-	-	-	1	1	3	67
01067	-	-	-	-	-	-	-	-	2	100
01078	-	-	-	-	-	-	-	-	2	100
01081	-	-	-	-	-	-	1	1	7	86
M (SD)	6.61(6.43)	3.40(3.89)	1.20(.44)	3.50(3.53)	6(-)	2.41(1.37)	2.23(1.92)	6.09(5.05)	51.71(6.26)	69.07(29.89)
min-max	1-20	1-11	1-2	1-6	6	1-5	1-7	1-20	0-20	0-100

*Serious Adverse Event (SAE) that was not related to Tai Chi practise.

** Causes which were very specific to individual cases and couldn't be categorized.

*** The dyad completely withdrew from the study from the first session onwards.

WT = withdrew from study

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THE EFFECT OF ADHERENCE TO A TAI CHI INTERVENTION ON QUALITY OF LIFE OF OLDER PEOPLE LIVING WITH DEMENTIA

For Peer Review

Abstract

Background/objectives: Adherence to exercise programs is required to reap their established benefits and to sustain Quality of Life (QoL). This study explored People Living with Dementia's (PLWD) adherence to a Tai Chi exercise program and its effects on their QoL. The study included assessment of factors affecting adherence to a Tai Chi exercise intervention, causes of non-adherence, and effect of adherence on PLWD's QoL.

Methods: This study was part of a Randomized Controlled Trial (RCT) where 41 community dwelling PLWD received a Tai Chi exercise intervention in addition to usual care for 20 weeks. The measures used in this study included PLWD's QoL, global cognitive function, moderate physical activity, intention and confidence to attend classes, record of PLWD's and their carers' health conditions, and percentages of PLWD's Tai Chi class attendance and home practice during the intervention phase. Multiple linear regression, bivariate correlation, and independent sample t-test analyses were conducted to evaluate associations between these variables.

Results: PLWD's overall percentage of class attendance (M (SD) = 69.19 (29.95) demonstrated high adherence. Moreover, QoL of highly adherent PLWD was significantly higher than low adherents. Among all variables PLWD's and carers' health conditions (β = -.64; p < .001, β = -.38; p < .001 respectively) were the dominating factors that reduced PLWD's Tai Chi adherence, while PLWD's moderate physical activity at baseline (β = .27; p = .02) was significant positive predictor.

Significance/Implications: PLWD's and their carers' health issues must be addressed to enhance PLWD's exercise adherence and sustain good QoL.

Key words: Dementia, Quality of life, carers, people living with dementia, exercise intervention, exercise adherence, Tai Chi.

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Introduction

Dementia is a clinical syndrome characterized by difficulties in memory, language, and behaviour that causes impairments in activities of daily living (Robinson et al., 2015). Globally around 50 million people live with dementia (Livingston et al., 2020). The risk of developing dementia increases exponentially with ageing, and because people are living longer, the number of people expected to have dementia is projected to increase to 152 million by 2050 (Livingston et al., 2020). Currently, among all diseases, dementia is the seventh leading cause of death and a major cause of disability and dependence globally for older adults (World Health Organization, 2022). Given the wide-ranging impact dementia has on both the individual and their family carer, it is imperative to enable people living with dementia (PLWD) and their carers to sustain good quality of life with the condition.

Quality of Life (QoL) is a complex term, and there is currently no universally acceptable definition (Selai & Trimble 1999; Ready et al., 2004; Walker & Lowenstein 2009). However, there is general agreement that it is a multidimensional construct that includes psychological, emotional, physical, and social components of wellbeing (Birren & Dieckermann, 1991). Understanding of QoL among PLWD was facilitated by Lawton (1983, 1991, 1997) who proposed that it has both objective and subjective dimensions that are based on four components including the PLWD's behaviour, objective environment, perceived quality of life, and psychological wellbeing. Several studies have identified factors associated with QoL of PLWD. These include greater social engagement and connectiveness and less isolation of PLWD, living in one's own home in the community, better quality of relationship with carers/family members, better QoL of carers, increased levels of daily physical activity and leisure activities and having more autonomy (Clare et al., 2014; Camic et al., 2013; Jing et al., 2016; Martyr er al., 2018; Nikmat et al., 2015). On the other hand, older age (Banerjee et al., 2006), greater severity of

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dementia (Marventano et al., 2015; Mjørud et al., 2014), and increased number of chronic health issues (Jing et al., 2016) have been found to negatively influence QoL.

Tai Chi, a mind-body exercise described as moving meditation (Jin, 1992) has been shown to improve QoL. Mind-body exercise combines intellectual stimulation and physical activity (Wu, 2012), involving conscious control of each body movement in a relaxed state of mind (Chan et al., 2005). Meditation has shown to be effective for attention and executive functions by allocation of resources to these cognitive processes among cognitively intact older and younger adults (Chiesa et al., 2011; Prakash et al., 2012). Previous studies have indicated that social interaction and intellectual stimulation reduce the risk of dementia (Saczynski et al., 2006; Bennett et al., 2006) and is associated with greater volume of brain tissues (Mortimera et al., 2012). Several other studies have also reported benefits of intellectual stimulation and physical activity in delaying age-related cognitive decline which may be helpful in preventing onset of dementia (Whitty et al., 2020). Thus, researchers have identified four potential inter-linked beneficial elements of mind-body exercise: focus on mind, movement, and breathing while being in a deeply relaxed state (Larkey et al., 2009). In addition, practicing in a group also provides the opportunity to socialize with peers and instructors. These characteristics of Tai Chi make it a potentially useful intervention to improve health, wellbeing, cognitive functioning and QoL in PLWD.

Li et al. (2001) recommended Tai Chi for older adults because of its low impact and slow movements that could easily maintain participant interest. Older adults (aged 61-92 years) perceived Tai Chi as age appropriate, enjoyable, and easy to practice for them due to its slow and gentle movements (Kraft et al., 2015). Tai Chi is also reported to be appropriate to practice for

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PLWD in their early stages of dementia (Lyu et al., 2018) and safe for survivors of stroke and individuals with chronic disease including Parkinson's (Li et al., 2012).

To obtain the positive benefits it is important that individuals regularly carry out Tai Chi. As such adherence is a key component of intervention studies aiming to attain health outcomes for older adults, however, there is little consensus on its definition and it's reporting also varies considerably between studies (Hawley-Hague et al., 2016). Identification and understanding of factors influencing adherence is vital as sustained adherence will ultimately result in habit formation and maintenance of physical activity behaviour. Incorporation of these factors in physical activity interventions for older adults is likely to make these interventions more effective and useful for long term health behaviour change among participants.

The theory of planned behaviour (Bozionelos & Bennett, 1999) provides support for the role of previous physical active behaviour and intention as predictors of adherence to physical exercise. Intention to become physically active, and having higher physical activity levels at baseline, have been found to have positive association with physical activity initiation and maintenance among older adults (Van Stralen et al., 2009). Therefore, these factors are of interest with regards to PLWD to promote adherence to exercise.

Factors associated with adherence to exercise in older individuals have been categorized into demographic (e.g., old age), health related (e.g., chronic disease, and poorer health), psychological (fewer perceived barriers to physical activity, enjoyment, greater expected benefits, psychological health, greater self-efficacy, motivation, better perceived health and fitness), social (e.g., social support), environmental (e.g., safety, convenience to access physical activity facilities) (Allen & Morey, 2010) and cognitive ability (Picorelli et al., 2014). Findorff et al. (2009) reported that better general health and cognitive functioning were positively predictive

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of adherence to a walking program, and better QoL and cognitive functioning were predictive of adherence to balance exercises among cognitively intact but sedentary older women.

Despite the above findings with the general older adult population, there is a lack of evidence as to which factors are most predictive of adherence among PLWD. Di Lorito et al. (2020) in their systematic review and meta-analysis identified positive predictive factors of exercise adherence among PLWD and people with Mild Cognitive Impairment including exercise in group settings, individually tailored exercise, and well-communicating, engaging and knowledgeable instructors/professionals. In addition, more severe dementia symptoms were the only negative predictor of adherence among community dwelling PLWD (in terms of their Mini Mental State Examination scores). However, in their review no study has been reported to have used Tai Chi exercise intervention, only four among 41 studies were conducted in UK, among them only two used structured exercise interventions and three involved PLWD, and adherence was not the primary outcome in 98% of all the included studies. Therefore, there is a lack of evidence and scarcity of research regarding factors affecting adherence to exercise intervention among PLWD. The present study aimed to fill this gap in this knowledge by exploring the factors affecting adherence to Tai Chi exercise intervention among community dwelling PLWD.

Identification of factors affecting adherence to physical activity among PLWD is vital to incorporate evidence-based support strategies for adherence to intervention. The aim of this study therefore was to explore PLWD's adherence to Tai Chi exercise intervention and its effect on their QoL. We hypothesized that (H1) PLWD's better QoL and health, cognitive functioning (lower severity of dementia), stronger intention and being physically active at baseline would predict higher adherence to a Tai Chi intervention; (H2) PLWDs' midway intention to come to Tai Chi classes, confidence to do Tai Chi, and enjoyment during classes would have a positive

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association with adherence to Tai Chi intervention, whereas PLWD's poor health would have an inverse association with adherence to Tai Chi intervention; (H3) High adherent PLWD would have a better QoL post-intervention than low adherent PLWD. Finally, we explored the role of the instructor and the size of the classes on the adherence of the participants.

Method

Design

The study was a part of a Randomized Controlled Trial (RCT), the (name of the trial masked for peer review) trial. The larger study was a randomized, assessor-blind, two-arm, parallel group, superiority trial, to test the effect of Tai Chi on improving postural balance among PLWD. It was also a feasibility study for a subsequent definitive trial to test the effect of Tai Chi on preventing falls among PLWD. Dyads were randomized comprising a PLWD and their informal carer, to either a control group (usual care) or an intervention group (usual care plus the Tai Chi intervention) in a 1:1 ratio. Randomization was stratified by site, and minimization was used within each site by treatment condition and 12-month fall history at baseline (fallen / not fallen) (reference masked for peer review). Ethical approval for the main trial was obtained from the NHS Research Ethics Committee (REC) and the Health Research Authority (HRA). The trial was registered at ClinicalTrials.Gov with registration number: (masked for peer review), and the trial protocol was published before recruitment was completed (masked for peer review).

Participants

PLWD and their informal carers (N = 83) were randomized to either an intervention arm (N = 42) or a control arm that received treatment as usual (N = 41). This study focused on detailed analysis of the Tai Chi exercise intervention arm and the secondary outcome of QoL. Inclusion and exclusion criteria have been derived from the main trial (authors' name masked for

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peer review, 2018). Community-dwelling people living with mild to moderate dementia were the target population for the main trial. Both male and females were included. There was no restriction on maximum age. Detailed strategy was devised in the main trial for the recruitment of the participants (authors' names masked for peer review, 2022). Only people with confirmed diagnosis of dementia were included. Participants were recruited from 06/04/2017 to 17/07/2018, with the final follow-up completed on 30/11/2018 (authors' names masked for peer review, 2019).

Procedure

After sufficient participants were recruited into the study, baseline data were collected, and Tai Chi classes arranged at three sites in the South of England. There were seven different venues across the sites in community settings such as village and church halls. Participants (N = 42) allocated to the intervention arm were divided into 10 groups and assigned to different venues according to their convenience and ease of access to the venue. There were two Tai Chi instructors i.e., a male and a female, each was assigned five Tai Chi groups.

Tai Chi classes were offered for 20 weeks. Duration of each Tai Chi class/session was 90 minutes in which 45 minutes were for instructor-led Tai Chi exercise. The instructors provided individual support and guidance during the exercise sessions. The remaining 45 minutes were for socialization with peers and instructors. Adherence to Tai Chi classes was recorded in the form of percentage of class attendance.

Old-frame Chen style of Tai Chi (Nyman et al., 2018, Table 2, p. 5) was offered in the classes. It involved eight warm-up and five Tai Chi form patterns. During warm-up slow and controlled breathing with body movements was emphasized whereas natural breathing during Tai Chi form was encouraged. Each class was designed to end with standing meditation. Tai Chi

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exercise was designed to elicit calm instead of asking participants to be calm. Intervention was designed to progress gradually.

Given the high level of overlap between Tai Chi styles due to their common core set of principles (Nyman 2021; Wayne, 2013), our focus was less on the style of Tai Chi and more on the experience and approach of the Tai Chi instructors to working with the study population. The lead instructor was highly experienced in working with physically and cognitively frail older adults. Our focus for the intervention was also on quality over quantity of movements, with a focus on performing them slowly and repeatedly to leverage tacit memory, the last form of memory to deteriorate among PLWD. Thus, the approach taken was appropriate for the population studied. Our approach above is reinforced by the current evidence base that largely does not distinguish between Tai Chi styles and their health benefits, e.g. for the prevention of falls (Nyman, 2021).

It is illustrated in the (Name masked for review) Trial protocol "We will partly follow the Positive Emotion-Motivated Tai Chi (PEM-TC) approach developed in the USA (Yao et al., 2008; Yao et al., 2013), in that teaching will be based on implicit learning techniques. Through repetition of movements and positive reinforcement, this approach capitalises on PLWD's capacity to continue to learn motor tasks with the use of muscle or kinaesthetic memory, i.e., unconsciously through making behaviours automatic, despite impaired ability to explicitly recollect such memories (Yao et al., 2008)." (Citation masked for review)

In the (name of the trial masked for peer review) trial the process of recruitment and randomization was ongoing as participants were being recruited during the trial, they were allocated to one of the ten Tai Chi (TC) exercise groups being run according to the closest proximity to the respective participants. However, classes could not take a start until at least two dyads were allocated to a group (i.e., minimum required number of participants). Moreover,

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participants were allowed to join an already running class in the first few weeks, so they may not have attended all the 20 classes. Therefore, classes/sessions did not start for all the 10 groups simultaneously. They started as and when the minimum required number of participants for each group was recruited successfully. In addition, there were some participants who joined from the first session. They were offered 20 sessions, however, due to different reasons they could not attend all the sessions (see Table 4, for causes of nonadherence/absence from Tai Chi class sessions). Hence, all participants could not attend 20 Tai Chi sessions/classes. They received lower than the planned dose of Tai Chi. The number of sessions participants attended varied, which may have affected outcomes of the study. However, those who attended less than 5 sessions were excluded from the median split analysis (N = 37) for adherence to Tai Chi intervention as their attendance was too low to have created an impact on their QoL. Three among the four participants who were excluded from the analysis for having attended less than five sessions had primarily health related reasons for absence from the classes.

Data Collection

The present study was an assessor blind (names of authors masked for reviewers, 2018), therefore, the researcher who collected baseline and post-intervention data was blind to allocation of participants to trial arm until all data (i.e., baseline and post-intervention) was transferred to the clinical trials unit, which monitored the trial. After obtaining informed consent, data was collected from all the participants at their homes at a mutually agreed time of convenience.

At the baseline visit participants' mental capacity to consent was ascertained during the informal conversation before proceeding to acquire their informed consent formally. Afterwards, PLWD were required to complete the M-ACE for assessment of their cognitive functioning. M-

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ACE was scored immediately after its completion as only those participants were eligible to participate in the study who scored above nine. Other baseline data measures related to the present study included participants' intention (based on one item, "if offered the opportunity I intend to do Tai Chi for at least 20 minutes every day for the next five months", which was answered on a seven-point Likert scale where 1 represented agree while seven represented disagree), current moderate physical activity (based on one item, "how often do you usually do moderate physical activity? examples include brisk walking, bike riding, dancing and, swimming". The respondents had to select one out of six options i.e., every day, 2 times per week, 3 times per week, weekly, monthly, rarely/never), and ICECAP-O (Coast, Peters, et al., 2008) for participants' QoL i.e., higher the ICECAP-O scores the better the QoL. ICECAP-O is a capability based QoL scale which includes five attributes of QoL. The attributes of QoL are based on reporting of older adults. Its scoring has a system of the best-worst scaling, which clearly indicates presence or absence of a particular capability. Raw scores were converted into population-weighted tariff scores ranging from 0-1 (higher scores indicate higher quality of life) (Coast, Flynn et al., 2008). ICECAP-O is a psychometrically valid (masked for peer-review) and reliable measure for community dwelling PLWD (masked for peer-review).

All the data was collected in structured interview format. After data collection all data was transferred to the Clinical Trial Unit and participants' basic information along with their date of baseline home visit was recorded in the Trial's local database at (name of the University masked for reviewers). In the (name masked for peer review) trial consent was checked and confirmed from PLWD considering the progressive nature of dementia. This was done explicitly at each home visit and along the research process, through their verbal and non-verbal cues (Wilkinson, 2002). It was in accordance with Good Clinical Practice guidelines instructed by the

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National Institute for Health and Care Research (NIHR), which defines consent as an "ongoing process". The objective was to obtain maximally informed consent from PLWD (Hellström, 2007).

Mid-way data were collected from participants (N = 32) in the intervention condition through structured interviews by a second researcher who was not blind to the trial arms. They were asked about their intention and confidence to come to the remaining 10 Tai Chi classes and enjoyment during the ongoing classes. During the intervention phase causes of absence from classes were recorded by an unblind researcher.

To collect post-intervention data home visits were arranged six months after the baseline home visit to allow participants to have practiced Tai Chi for 20 weeks. Post-intervention home visits replicated the procedures for baseline data collection.

Data Analysis Strategy

Patterns of adherence to Tai Chi intervention among PLWD were explored descriptively. Causes of non-adherence among PLWD in terms of absence from sessions were recorded and assigned to one of six categories: PLWD's health, carer's health, PLWD's medical appointment, carer's medical appointment, holidays, and others/unknown. Descriptive analysis was carried out to see which causes contributed the most towards non-adherence (i.e., absence from sessions).

Multiple linear regression was conducted to test the predictive value of PLWD's baseline scores for QoL (ICECAP-O), cognitive functioning (M-ACE), intention, moderate physical activity, and health issues of PLWD and their carers on Tai Chi class adherence (in terms of percentage of scheduled classes attended) among PLWD.

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Pearson product moment correlations were calculated to explore the association and direction of relationship of midway intention to attend Tai Chi classes, confidence to do Tai Chi, and enjoyment during classes with Tai Chi class attendance among PLWD.

A median split of adherence was conducted to create a low and high adherence group. High and low adherence groups were compared by conducting an independent sample t-test analysis.

Prior to any analysis we examined whether the instructor and size of the group had an influence on adherence. An independent sample t-test was conducted to compare adherence in terms of percentages of attendance of groups supervised by the male and female instructor. There was no significant difference in adherence between the groups supervised by the male (M (SD) = 73.60 (5.94) or female instructor (M (SD) = 69.20 (15.2); t (8) = 0.60, p = .56; Cohen' d = 0.38).

The ten groups were divided into three sub-groups based on number of participants (i.e., group 1 = 2-6, group 2 = 7-9, and group 3 = 10^{+} participants). Kruskal-Wallis statistic did not show a difference in adherence based on group size (χ^2 = 0.89, df = 2, p = .64; Craver V = .24). As such we did not control for instructor or group size in any of our analysis.

Results

Demographic Information and Adherence

Demographic information of PLWD (N= 42) in the Tai Chi exercise trial arm is presented in Table 1. Table 2 presents demographic information of PLWD in high (N = 21) and low (N = 16) adherence groups. Table 3 presents the correlations between PLWD's (N = 41) adherence to Tai Chi exercise intervention and the baseline variables.

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Causes of Non-adherence to Tai Chi Intervention

Overall adherence to the Tai Chi classes by PLWD (N = 42) was a mean of 69.1% (SD = 29.9%) of classes offered. Table 4 presents the frequency of reasons for absence from scheduled Tai Chi classes. Poor health by the PLWD or their carer were the most reported reasons for non-adherence followed by medical appointments (PLWD and carer) and holidays.

Baseline Predictors of Adherence to Tai Chi Intervention among PLWDs (N = 42)

The regression analysis using baseline measures was significant (P < .001) and partially supported hypothesis 1, explaining 70.7% of the variance in PLWD Tai Chi class adherence. Significant baseline predictors of greater PLWD adherence to Tai Chi classes were lower number of health issues of the PLWD (β = -.64; p < .001), lower number of health issues of the carer (β = -.38; p < .001) and higher level of moderate physical activity (β = .27; p = .02). Intention (β = .02; p = .80), QoL (β = -.03; p = .74) and severity of dementia (β = -.08; p = .42) were not significantly associated with adherence.

Midway Analysis: PLWD's Enjoyment, Confidence, and Intention during Tai Chi Classes

Pearson product moment correlations were calculated to assess associations of PLWD's midway enjoyment during classes, their strength of intention and confidence to come to remaining Tai Chi classes with their adherence to intervention classes (N = 32). Large inverse significant associations of adherence were found with intention (r = -.52; p = .002), and confidence (r = -.62; p < .001) and non-significant association with enjoyment (r = .03; p = .86). The associations were not in the expected direction for intention and confidence. However, they were in the expected direction for enjoyment, but the association was non-significant.

Association between PLWD's Adherence to Tai Chi Intervention and Their QoL

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Median split analysis was conducted based on the percentages of class attendance (Median = 75%) and QoL score of high adherent PLWD was compared with low adherent PLWD. High adherent PLWD (N = 21) had significantly higher QoL score (M = .88; SD = .09) as compared to low adherent PLWD (N = 16), (M = .81; SD = .10), t (35) = 2.11, CI = 95% $p <$ .05 with moderate effect size d = .7 (Cohen, 1992). Participants who attended less than 5 sessions due to any reason including health conditions were not included in the median split analysis. Therefore, those who had similar characteristics were included (see Table 2) for comparison of effect of adherence on QoL of PLWD among high vs low adherers. QoL was based on ICECAP-O scores which is based on best-worst scoring system with scores range 0-1. This suggested that the high adherence group's QoL was better than the QoL in the low adherence group.

Discussion

The present study used data from a randomized controlled trial to explore PLWD's adherence to a Tai Chi exercise intervention, predictors of adherence, causes of non-adherence, and association of adherence with QoL. Tai Chi exercise resulted in better QoL in high adherence group as compared to low adherence group. Further, PLWD's and carer's health issues were the major negative factor inhibiting adherence among PLWD, while PLWD's baseline moderate physical activity increased adherence.

The attendance rate in the present study (69.1 %) can be considered good. Attendance at more than two thirds of sessions is regarded as high (Rolland et al., 2007). In addition, attendance rate in the present study is similar to those reported for Tai Chi interventions to prevent falls among cognitively intact community dwelling older adults (71-81%; Nyman, 2021) and for people with MCI and dementia (Di Lorito et al., 2020).

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In line with previous findings in cognitively intact older adults (e.g., Rivera-Torres et al., 2019; Picorelli et al., 2014), health issues of community dwelling PLWD and their carers during the intervention phase were found to have the greatest negative impact on PLWD's adherence to the Tai Chi intervention. The study sample (PLWD) not only had complex health status involving physical and neurological conditions, they also were almost entirely dependent on their carers to participate in Tai Chi classes. Hence, the trial was designed for the dyads to attend and absence of one person for extended sessions would influence the adherence of the other. Generally, participants with better health conditions in terms of fewer health issues, better self-reported health, and taking fewer medicines, report higher class attendance to exercise programs (Picorelli et al., 2014). This has also been shown for exercise programs among institutionalized PLWD (Vseteckova et al., 2018). It is important for future intervention or general health practitioners to consider PLWD's and their carers' health to reduce the effects of health constraints on adherence. This could be achieved by advising to seek support for physical or mental health problems, offering of compensatory classes to those who missed exercise sessions or have additional carers supporting the PLWD.

In accordance with the TPB those participants who had higher levels of baseline moderate physical activity showed greater adherence (Bozionelos & Bennett, 1999). However, the participants cognitive status (severity of dementia) and their intentions to be physically active did not support TPB of previous findings (van Stralena et al., 2009). The association between intentions to be physically active and actual participation has been non-significant. Moreover, in the present study, carers' intention to attend Tai Chi classes was not analyzed. This could also contribute to PLWD's intention-behavior-gap, which could be explored in future research. It has been estimated that the intention-behavior gap is 46% for the general population and 32% for

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older individuals. In addition, of those who started participation, 42% maintained the behavior (Rhodes & de Bruijn, 2013). This indicates that other factors not included in the TPB influence adoption and maintenance of exercise behavior.

Contrary to expectation, PLWD's mid-way intention to come to Tai Chi classes and confidence to do Tai Chi, appeared to have an inverse association with PLWD's adherence to Tai Chi classes. PLWD mid-way enjoyment during classes was found to have a positive association with adherence to intervention, but the association was non-significant. These findings were unexpected and may suggest some other significant variables could pay a role to explain behavioral adherence, requiring further research in this phenomenon.

As expected, increased levels of adherence to the Tai Chi intervention were associated with higher levels of QoL post-intervention supporting previous findings on the positive effect of Tai Chi on QoL in cognitively intact older adult (Tajik et al., 2018; Wang et al., 2020) and PLWD (masked for peer-review). This indicates that Tai Chi is an appropriate intervention strategy to enhance QoL of community based PLWD and should be considered to be included in policy recommendations.

The present study had some limitations that may be overcome in future studies. The study involved community dwelling PLWD, therefore, the findings cannot be generalized to PLWD residing in the care homes. The sample was recruited as dyads (i.e., PLWD + carers) due to which PLWD's adherence to intervention became dependent on carers continuous participation. Therefore, in some cases carers' health conditions also affected adherence of PLWD. Recruiting more than one carer with each PLWD to provide replacement for each other may have helped to overcome some practical constraints which prohibited PLWD from adherence. In addition, behaviour change techniques (BCTs) are reported to support adherence to exercise intervention

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among PLWD and older adults with MCI (Van der Wardt et al., 2017). In (name of the trial masked for reviewers) trial BCTs were used to encourage Tai Chi class participation and home practice. Effect of BCTs (i.e., joint action plan, joint coping plan, self-monitoring, feedback from Tai Chi instructor on home practice, and provision of alarm clock to set as a reminder) on home practice were evaluated and will be discussed elsewhere. However, effect of BCTs (i.e., social support from Tai Chi instructor and other participants, feedback on class performance from Tai Chi instructor, and a reminder phone call if two consecutive classes were missed) on class-based adherence to Tai Chi intervention among PLWD could not be explored.

Conclusion

The present study highlighted that while PLWD's and their carer's health inhibit PLWD's adherence to a Tai Chi exercise intervention, greater adherence to Tai Chi led to higher levels of quality of life. Therefore, to enhance PLWD's exercise adherence their health issues may also be addressed by either enhancing duration of exercise intervention or arranging compensatory classes to those who missed exercise sessions. Findings of the present study may be used in future research involving predictors and facilitators of exercise adherence, effect of exercise intervention on QoL of PLWD, and techniques of effective delivery of exercise intervention among PLWD.

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Table 1

Participants' demographic information.

Characteristics of PLWD (N = 42)	Values
Age in years mean (SD)	77.86 (8.32)
Gender n (%)	
Male	24 (57)
Female	18 (42)
Ethnicity n	
White	42 (100)
Education n	
None	2 (5)
Primary school	2 (5)
Secondary school	21 (50)
Higher education, College, University	12 (29)
Further education, professional qualification	5 (12)
Number of participants withdrawn completely from 1st session	1 (2)
*Number of participants did not attend any session without withdrawing	1 (2)
PLWD relationship with carer n	
Spouse	34 (81)
Parent	3 (71)
Sibling	4 (10)
Other	1 (2)
Living situation n	
Living alone	4 (10)
Living with family and friends	38 (91)
Dementia diagnosis n	
Alzheimer's	30 (71)
Vascular	1 (2)
Mixed Alzheimer's and Vascular	9 (21)
Other	2 (5)

* The dyad did not withdraw from the study, but they did not attend any Tai Chi sessions. They provided the baseline and post-intervention data.

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Table 2

Baseline Demographic information of participants (N = 37) with high and low class adherence to Tai Chi exercise intervention based on median split of 75 which refers to percentage of class attendance.

Characteristics	PLWD with high class adherence (N = 21)	PLWD with low class adherence (N = 16)
	(Median = 75)	
Age in years mean (SD)	79.9 (7.9)	78.7 (7.5)
Gender n (%)		
Male	13 (62)	8 (50)
Female	8 (38)	8 (50)
Ethnicity n (%)		
White	21 (100)	16 (100)
Education n (%)		
None	1 (5)	1 (6)
Primary school	1 (5)	1(6)
Secondary school	11 (52)	8 (50)
Higher education, College, University	5 (24)	4 (25)
Further education, professional qualification	3 (14)	2 (12)
PLWD relationship with carer n (%)		
Spouse	15 (71)	12 (75)
Parent	2 (10)	3 (19)
Sibling	3 (14)	-
Other	1 (5)	1 (6)
Living situation n (%)		
Living alone	2 (10)	1
Living with family and friends	19 (90)	15 (94)
Dementia diagnosis n (%)		
Alzheimer's	14 (67)	12 (75)
Vascular	1 (5)	-
Mixed Alzheimer's and Vascular	5 (24)	3 (19)
Other	1 (5)	1 (6)
Moderate Physical Activity (Baseline)		
Everyday	9 (43)	2 (12)
Weekly	1 (5)	1 (6)
Two Times per Week	2 (10)	2 (12)

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Monthly	1 (5)	1 (6)
Three Times per Week	4 (19)	2 (12)
Rarely/Never	4 (19)	8 (50)
Vigorous Physical Activity		
Weekly	1 (5)	-
Monthly	1 (5)	1 (6)
Rarely	19 (90)	15 (94)
Falls in Last one Month		
Yes	3 (14)	3 (19)
No	18 (86)	13 (81)
Comorbidities		
None	11 (52)	7 (44)
One	4 (19)	6 (38)
Two	4 (19)	2 (12)
Three	1 (5)	1 (6)
Four	1 (5)	-

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Table 3

Pearson product moment correlations between people living with dementia's (PLWD) adherence to Tai Chi intervention classes and baseline factors: PLWD health issues, carer's health issues, PLWD's intention, quality of life (QoL), level of moderate physical activity, and severity of dementia (N = 41).

	Variables	2	3	4	5	6	7
1	PLWD's adherence[1]	-.64**	-.45***	-.05	-.07	-.35*	-.16
2	Health issues (PLWD)		-.02	-.006	.03	-.01	.14
3	Health issues (Carer)			-.10	.01	.28	.001
4	PLWD intention[2]				.03	.48**	-.15
5	PLWD's QoL					-.04	.28*
6	PLWD's physical activity[3]						.15
7	Severity of dementia						

$^{*}p < .05$, $^{**}p = .001$, $^{***}p < .001$

[1]PLWD's adherence to Tai Chi classes.

[2]PLWD intention to do Tai Chi for next 20 weeks.

[3]Level of moderate physical activity of PLWD.

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Table 4

Categories of causes of non-adherence to Tai Chi intervention among PLWDs and their carer (N = 42).

PLWD ID	Causes of non-adherence and number of sessions affected (n)							Total no. of absents	Total sessions offered	% of overall attendance
	PLWD's health	Carer's health	PLWD's medical appointment	Carer's medical appointment	PLWD SAE*	Holidays	Others** / Unknown			
03003	2	10	2	-	-	-	-	14	20	30
03005	11	-	-	-	-		-	11	20	45
03006	-	-	1	-	-	-	-	1	20	95
02002	6	1	-	1	-	1	-	7	11	36
02004	-	-	-	6	-	-	-	6	12	50
01002	-	1	-	-	-	2	1	4	20	80
01008	-	-	1	-	3	-	-	4	20	80
03007	20	-	-	-	-	-	-	20	20	0
03008	-	1	-	-	-	-	1	2	11	82
01015	-	-	-	-	-	-	-	-	1	100
01021	-	-	-	-	-	-	-	-	16	100
01006	5	-	-	-	-	-	1	6	12	50
01009	-	1	1	-	-	-	-	2	20	90
01012	-	-	-	-	-	-	-	-	20	100
01022	2	3	-	-	-	-	-	5	18	72
01023	1	-	-	-	-	-	-	1	20	95
01025	7	-	-	-	-	-	-	7	20	65
01031	-	-	-	-	-	-	-	-	12	100
01034	14	1	-	-	-	1	-	16	20	20
01035	-	-	-	-	-	-	-	-	20	100
01036	-	-	-	-	-	2	1	3	20	85
01039	-	-	-	-	-	-	2	2	20	90
01043	WT	WT	WT	WT	WT	WT	WT	WT***	0	0
01045	-	-	-	-	-	-	-	-	20	100
01055	15	-	-	-	-	-	-	15	19	21

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01047	1	-	-	-	-	3	1	5	20	75
01049	-	4	-	-	-	5	-	9	12	25
01052	1	-	-	-	-	-	2	3	20	85
01053	-	-	-	-	-	-	2	2	20	90
01064	-	-	-	-	-	-	3	3	19	84
01059	-	-	-	-	-	2	-	2	20	90
01057	-	-	-	-	-	2	6	8	20	60
01062	-	-	-	-	-	5	7	12	20	40
01066	-	-	-	-	-	-	1	1	20	95
01076	-	-	-	-	-	3	2	5	15	67
01070	-	-	1	-	-	2	-	3	16	81
01072	1	11	-	-	-	-	1	13	16	19
01075	-	1	-	-	-	1	5	7	16	56
01080	-	-	-	-	-	-	1	1	3	67
01067	-	-	-	-	-	-	-	-	2	100
01078	-	-	-	-	-	-	-	-	2	100
01081	-	-	-	-	-	-	1	1	7	86
M (SD)	6.61(6.43)	3.40(3.89)	1.20(.44)	3.50(3.53)	6(-)	2.41(1.37)	2.23(1.92)	6.09(5.05)	51.71(6.26)	69.07(29.89)
min-max	1-20	1-11	1-2	1-6	6	1-5	1-7	1-20	0-20	0-100

*Serious Adverse Event (SAE) that was not related to Tai Chi practise.

** Causes which were very specific to individual cases and couldn't be categorized.

*** The dyad completely withdrew from the study from the first session onwards.

WT = withdrew from study

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Response to Authors' Comments:

S.No	Comments	Response
	The authors changed the term from PWD to PWLD. Please make sure to use PWLD throughout the text including discussions, tables and figures. It would be more effective to use the tool "search" for PWD to have the consistency.	In procedure section (P. 9 L. 9 & 15) the term PWD has been replaced with PLWD.
	Purpose (p.8 L3). Since the comparison with the control group has been deleted in the results session, please revise the hypothesis 3.	Suggested change has been made in hypothesis 3 (p. 7 L. 3).
	Discussion (p.18 L16 -17) This is unexpected findings. perhaps revise the sentence as follows: (These findings were unexpected, and may suggest some other significant variables could pay a role to explain behavioral adherence, requiring further research in this phenomenon)	The suggested change has been made (P. 17 L. 7-9).
	Minor editing -Discussion (p18, L3). to be physical active -> to be physically active -L4. TPB or previous -> TPB of previous -L6-7. This sentence needs to be revised..hard to follow (i.e., Moreover, in the present study, carers' intention to attend Tai Chi classes was not analyzed. This could also contribute to PLWD's intention-behavior-gap, which could be explored in future research)	The requested editing has been done in the discussion section (P. 16 L. 18, 19, 20-23).

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The present study was a part of a Randomized Controlled Trial, The TACIT Trial. The CONSORT checklist for The TACIT Trial was included in the supplementary material for the main trial outcome paper (please see citation below).
Nyman, S. R., Ingram, W., Sanders, J., Thomas, P. W., Thomas, S., Vassallo, M., Raftery, J., Bibi, I., & Barrado- Martín, Y. (2019). Randomised Controlled Trial Of The Effect Of Tai Chi On Postural Balance Of People With Dementia. Clinical interventions in aging, 14, 2017–2029. https://doi.org/10.2147/CIA.S228931

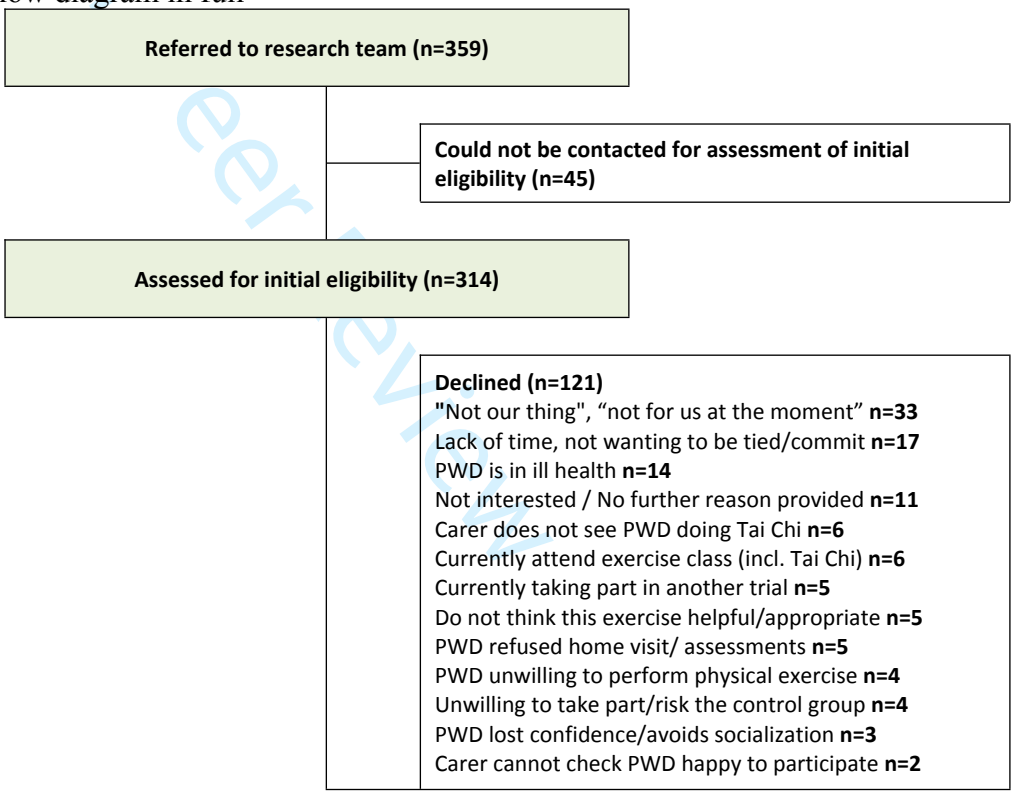
Therefore, creating another checklist for the present article would not be appropriate given that:

i. The checklist has already been created and published for the main trial (detail as above).
ii. The present article involves secondary analyses from the main trial.

Note: (CONSORT list and supplementary material for the above mentioned article is provided below)

SUPPLEMENTARY MATERIAL

Figure S1: CONSORT flow diagram in full



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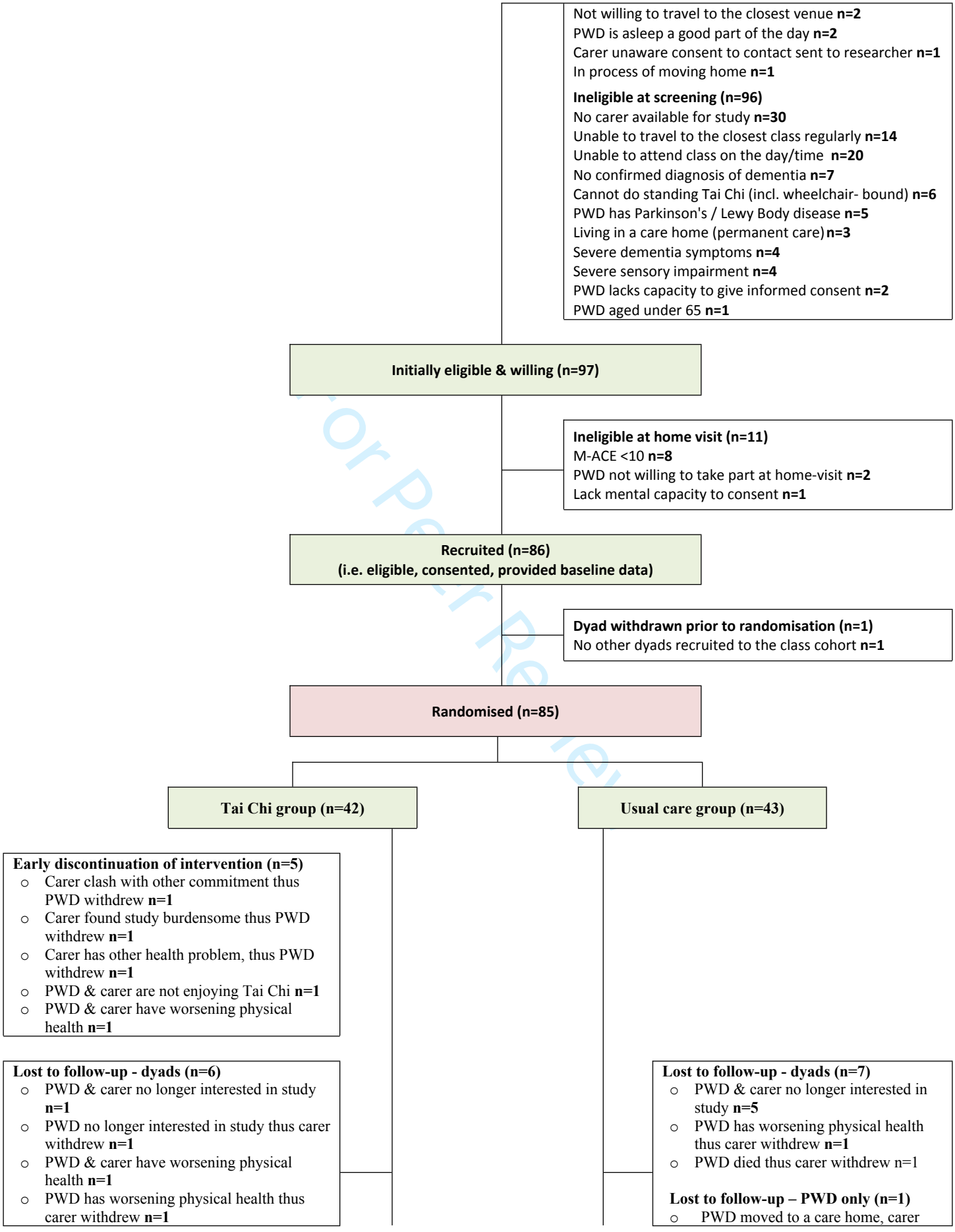
Not willing to travel to the closest venue n=2
PWD is asleep a good part of the day n=2
Carer unaware consent to contact sent to researcher n=1
In process of moving home n=1
Ineligible at screening (n=96)
No carer available for study n=30
Unable to travel to the closest class regularly n=14
Unable to attend class on the day/time n=20
No confirmed diagnosis of dementia n=7
Cannot do standing Tai Chi (incl. wheelchair- bound) n=6
PWD has Parkinson's / Lewy Body disease n=5
Living in a care home (permanent care) n=3
Severe dementia symptoms n=4
Severe sensory impairment n=4
PWD lacks capacity to give informed consent n=2
PWD aged under 65 n=1
Initially eligible & willing (n=97)
Ineligible at home visit (n=11)
M-ACE <10 n=8
PWD not willing to take part at home-visit n=2
Lack mental capacity to consent n=1
Recruited (n=86)
(i.e. eligible, consented, provided baseline data)
Dyad withdrawn prior to randomisation (n=1)
No other dyads recruited to the class cohort n=1
Randomised (n=85)
Tai Chi group (n=42)
Usual care group (n=43)
Early discontinuation of intervention (n=5)
Carer clash with other commitment thus PWD withdrew n=1
Carer found study burdensome thus PWD withdrew n=1
Carer has other health problem, thus PWD withdrew n=1
PWD & carer are not enjoying Tai Chi n=1
PWD & carer have worsening physical health n=1
Lost to follow-up - dyads (n=6)
PWD & carer no longer interested in study n=1
PWD no longer interested in study thus carer withdrew n=1
PWD & carer have worsening physical health n=1
PWD has worsening physical health thus carer withdrew n=1
Lost to follow-up - dyads (n=7)
PWD & carer no longer interested in study n=5
PWD has worsening physical health thus carer withdrew n=1
PWD died thus carer withdrew n=1
Lost to follow-up – PWD only (n=1)
PWD moved to a care home, carer

- Clash with other joint commitment thus both withdrew **n=1**
- PWD did not wish to continue (reason not given) thus carer withdrew **n=1**

provided follow-up data

Analysed with primary outcome (n=36)

Analysed with primary outcome [1,2] (n=35)

1. *Includes 1 dyad where PWD provided data but not TUG/measures that involved standing.*
2. *Excludes 1 dyad where Carer provided primary outcome but PWD did not.*

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Table S1: Description of the Tai Chi exercise intervention

1. Tai Chi classes
Over the 20 weeks, participants progressed to learn 8 warm-ups (Baduanjin; raising the sky, gathering the heavens, cow looks at the moon, directing the ocean, shaolin archer, qi gong punching, separating heaven and earth, and shaking the earth) and 5 Tai Chi form patterns using old-frame Chen style (grand ultimate beginning, immortal pounds mortar, lazy to roll sleeves, six seals and four closes, and single whip). These were gradually introduced over the 20 weeks with each earlier warm-up and Tai Chi pattern repeated. The Tai Chi instructors kept a record of dyads' weekly class attendance.
2. Home-based Tai Chi practice
Between the second and fourth class, a Tai Chi instructor visited each dyad in their own home. Dyads were given a pack containing a colourful home exercise booklet and weekly homework sheets, to serve as a reminder of what had been covered in the classes each week and to prompt practice of Tai Chi at home. The carers were asked to facilitate the PWD to carry out Tai Chi for 20 minutes daily.
3. Behaviour change
At the home visit, the Tai Chi instructor performed a risk assessment of the environment where Tai Chi was to be carried out. The Tai Chi instructor re-affirmed the benefits of doing Tai Chi and the central role of the home-based exercises to obtain these benefits.[1] The instructor then facilitated the dyad to make joint action and coping plans.[2-7] For action planning, dyads decided together when and where they would do their Tai Chi practice. For coping planning, the PWD and their carer anticipated any personal barriers that may arise for them whilst carrying out Tai Chi practice and what they could plan to do to overcome them. Other techniques already embedded within the design of the intervention included self-monitoring (dyads recorded their weekly completion of Tai Chi practice and handed this to the instructor at the next class), feedback on performance and adherence (from the instructor each week), and social support (from the instructor and peers in the class).[8] Dyads were also provided a small branded alarm clock as a prompt to do their daily Tai Chi practice. If dyads did not attend a Tai Chi class for two consecutive weeks for an unknown reason, at the next scheduled weekly telephone call with the PWD, the researcher encouraged the dyad to continue attending.

For Peer Review

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Table S2: Baseline descriptive statistics for people with dementia

	Usual care group (n=43)	Tai Chi group (n=42)
Gender n (%) Male Female	 27 (63%) 16 (37%)	 24 (57%) 18 (43%)
Age mean (SD), range	78.2 (7.5) 61.9-97.4	77.9 (8.3) 59.0-88.0
Relationship status n (%) Single Married/civil partnership With partner Divorced/dissolved partnership Widowed	 - 36 (84%) 1 (2%) - 6 (14%)	 2 (5%) 34 (81%) - 2 (5%) 4 (10%)
Current living arrangements n (%) Living alone Living with family/ friends Living in sheltered housing	 3 (7%) 40 (93%) -	 4 (10%) 38 (90%) -
Highest educational attainment n (%) None Primary school Secondary school University/ higher education Further education/ professional qualification	 1 (2%) - 25 (58%) 12 (28%) 5 (12%)	 2 (5%) 2 (5%) 21(50%) 12 (29%) 5 (12%)
Ethnicity n (%) White Asian Black	 41 (95%) 1 (2%) 1 (2%)	 42 (100%) - -
Type of dementia n (%) Alzheimer's Vascular Alzheimer's and vascular Other	 26 (60%) 5 (12%) 6 (14%) 6 (14%)	 30 (71%) 1 (2%) 9 (21%) 2 (5%)
Time since diagnosis (years) median (IQR)	1.39 (2.62) 0.10-7.54	1.13 (2.45) 0.20-7.72
Other long term conditions (see below)* n (%) No One Two Three or more	 19 (44%) 13 (30%) 8 (19%) 3 (7%)	 20 (48%) 14 (33%) 6 (14%) 2 (5%)
Uses a walking aid n (%) No Yes	 31 (72%) 12 (28%)	 29 (69%) 13 (31%)

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Number of medications currently taken n (%) 0 1 2 3+ missing	 2 (5%) 4 (10%) 6 (14%) 30 (71%) 1	 - 5 (12%) 3 (7%) 34 (81%)
Falls in past 12 months n (%) None Yes, no injury Yes, minor injury Yes, moderate injury Yes, severe injury	 25 (58%) 7 (16%) 6 (14%) 4 (9%) 1 (2%)	 23 (55%) 7 (17%) 6 (14%) 3 (7%) 3 (7%)
Falls in past month n (%) None Yes, no injury Yes, minor injury Yes, moderate injury Yes, severe injury	 39 (91%) 2 (5%) 2 (5%) - -	 36 (86%) - 6 (14%) - -
Current level of moderate physical activity n (%) Every day 3 times per week 2 times per week Weekly Monthly Rarely/ never	 9 (21%) 4 (9%) 4 (9%) 4 (9%) - 22 (51%)	 15 (36%) 7 (17%) 3 (7%) 2 (5%) 2 (5%) 13 (31%)
Current level of vigorous physical activity n (%) Every day 2 times per week 3 times per week Weekly Monthly Rarely/ never	 - - - 1 (2%) 1 (2%) 41 (95%)	 1 (2%) - - 2 (5%) 1 (2%) 38 (90%)
Recruitment site n (%) National Health Service 1 National Health Service 2 National Health Service 3	 11 (26%) 30 (70%) 2 (5%)	 10 (24%) 30 (71%) 2 (5%)
*Long term health conditions at baseline (ranked by most frequent and including only those affecting 3 or more participants)		
Musculoskeletal n (%)	9 (21%)	5 (12%)

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Cardiovascular n (%)	6 (14%)	7 (17%)
Respiratory problems n (%)	3 (7%)	6 (14%)
Diabetes n (%)	5 (12%)	4 (10%)
Blood pressure n (%)	3 (7%)	6 (14%)
Renal tract n (%)	5 (12%)	1 (2%)

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Table S3: Baseline descriptive statistics for informal carers

	Usual care group (n=43)	Tai Chi group (n=42)
Gender n (%)		
Male	8 (19%)	10 (24%)
Female	35 (81%)	32 (76%)
Age mean (SD) range	70.8 (10.4) 47.5-88.8	72.0 (9.9) 43.4-87.9
Relationship to PWD n (%)		
Spouse/ partner	33 (77%)	34 (81%)
Son/ daughter	5 (12%)	3 (7%)
Brother/ sisterhood	2 (5%)	4 (10%)
Friend	2 (5%)	-
Other	1 (2%)	1 (2%)
Living with PWD n (%)		
Yes	38 (88%)	36 (86%)
No	5 (12%)	6 (14%)
Relationship status n (%)		
Single	2 (5%)	2 (5%)
Married/civil partnership	37 (86%)	36 (86%)
With partner	2 (5%)	1 (2%)
Divorced/dissolved partnership	2 (5%)	2 (5%)
Widowed	-	1 (2%)
Current living arrangements n (%)		
Living alone	1 (2%)	2 (5%)
Living with family/ friends	42 (98%)	40 (95%)
Highest educational attainment n (%)		
None	2 (5%)	-
Primary school	1 (2%)	2 (5%)
Secondary school	19 (44%)	22 (52%)
University/ higher education	14 (33%)	15 (36%)
Further education/ professional qualification	7 (16%)	3 (7%)
Ethnicity n (%)		
White	42 (98%)	42 (100%)
Asian	1 (2%)	-

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Table S4: Adverse and serious adverse events

Number of serious adverse events related to Tai Chi classes (Tai Chi arm only) PWD Carer	 0 0
Number of serious adverse events related to Tai Chi home exercises (Tai Chi arm only) PWD Carer	 0 0
Number of serious adverse events related to balance tests (both arms combined) PWD Carer	 0 0
Other unrelated serious adverse events (i) Overall PWD Carer (ii) Tai Chi arm PWD Carer (iii) Control arm PWD Carer	 9 in 7 people 3 in 3 people 5 in 4 people 3 in 3 people 4 in 3 people 0
Number of adverse events related to Tai Chi classes (Tai Chi arm only) PWD Carer	 1 AE in 1 person (possibly related) 1 AE in 1 person (possibly related)
Number of adverse events related to Tai Chi home exercises (Tai Chi arm only) PWD Carer	 1 AE in 1 person (probably related) 0
Number of adverse events related to balance tests (both arms combined) PWD Carer	 0 0

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Other unrelated adverse events (iv) Overall PWD Carer (v) Tai Chi arm PWD Carer (vi) Control arm PWD Carer	 3 AE in 3 people 2 AE in 2 people 3 AE in 3 people 2 AE in 2 people 0 0
Changes in any health factors over the course of the trial that might influence primary outcome measure at follow-up (medication, walking aid, anxiety/depression, dementia symptoms, emergency department admission, hospital inpatient, elective surgery, major life event, other health change) n (%) PWD (i) Tai Chi arm only (ii) Control arm only Carer (i) Tai Chi arm only (ii) Control arm only	 25/36 (69%) 27/36 (75%) 31/36 (86%) 28/36 (78%)

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Table S5: Willingness to pay for Tai Chi

	Overall	Tai Chi group	Control group
Willing to pay for Tai Chi classes for 5 months			
Yes n (%)	54% (38/70) 15 missing	46% (16/35) 7 missing	63% (22/35) 8 missing
Median (IQR) amount willing to pay (£)	5.00 (4.50) 2.50-15.00, n=37 mean 5.58; SD 2.85 1 missing	5.00 (4.75) 2.50-12.00, n=16 mean 5.28; SD 2.66	5.00 (4.50) 3.00-15.00, n=21 mean 5.81; SD 3.03 1 missing
Willing to pay for own transport costs			
Yes n (%)	59% (41/69) 16 missing	53% (18/34) 8 missing	66% (23/35) 8 missing
Willing to pay for Tai Chi instructor home visit			
Yes n (%)	42% (30/72) 13 missing	33% (12/36) 6 missing	50% (18/36) 7 missing
Median (IQR) amount willing to pay (£)	10.00 (8.00) 5.00-25.00, n=29 mean 12.36; SD 5.70 1 missing	10.00 (3.00) 6.00-20.00, n=11 mean 11.23; SD 3.62 1 missing	12.50(15.00) 5.00-25.00, n=18 mean 13.06; SD 6.67
Willing to pay for Tai Chi classes for 5 months if reduced falls by 20%			
Yes n (%)	63% (45/72) 13 missing	56% (20/36) 6 missing	69% (25/36) 7 missing
Median (IQR) amount willing to pay (£)	5.00 (4.00) 1.00-12.00, n=43 mean 5.84; SD 2.52 2 missing	5.00 (4.50) 1.00-12.00, n=20 mean 5.45; SD 2.67	5.00 (3.00) 3.00-10.00, n = 23 mean 6.17; SD 2.39 2 missing

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Willing to pay for own transport costs if reduced falls by 20% Yes n (%)	67% (48/72) 13 missing	58% (21/36) 6 missing	75% (27/36) 7 missing
Willing to pay for Tai Chi instructor home visit if reduced falls by 20% Yes n (%)	54% (38/70) 15 missing	46% (16/35) 7 missing	63% (22/35) 8 missing
Median (IQR) amount willing to pay (£)	5.00 (4.50) 2.50-15.00, n=37 mean 5.58; SD 2.85 1 missing	5.00 (4.75) 2.50-12.00, n=16 mean 5.28; SD 2.66	5.00 (4.50) 3.00-15.00, n=21 mean 5.81; SD 3.03 1 missing

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CONSORT 2010 checklist of information to include when reporting a randomised trial*

Section/Topic	Item No	Checklist item	Reported on page No
Title and abstract			
	1a	Identification as a randomised trial in the title	Title page
	1b	Structured summary of trial design, methods, results, and conclusions (for specific guidance see CONSORT for abstracts)	1
Introduction			
Background and objectives	2a	Scientific background and explanation of rationale	2
	2b	Specific objectives or hypotheses	2-3
Methods			
Trial design	3a	Description of trial design (such as parallel, factorial) including allocation ratio	4
	3b	Important changes to methods after trial commencement (such as eligibility criteria), with reasons	4
Participants	4a	Eligibility criteria for participants	4-5
	4b	Settings and locations where the data were collected	4-5
Interventions	5	The interventions for each group with sufficient details to allow replication, including how and when they were actually administered	5-6, Table S1
Outcomes	6a	Completely defined pre-specified primary and secondary outcome measures, including how and when they were assessed	6-8
	6b	Any changes to trial outcomes after the trial commenced, with reasons	n/a
Sample size	7a	How sample size was determined	8
	7b	When applicable, explanation of any interim analyses and stopping guidelines	n/a
Randomisation:			
Sequence generation	8a	Method used to generate the random allocation sequence	4
	8b	Type of randomisation; details of any restriction (such as blocking and block size)	4
Allocation concealment mechanism	9	Mechanism used to implement the random allocation sequence (such as sequentially numbered containers), describing any steps taken to conceal the sequence until interventions were assigned	4
Implementation	10	Who generated the random allocation sequence, who enrolled participants, and who assigned participants to interventions	4
Blinding	11a	If done, who was blinded after assignment to interventions (for example, participants, care providers, those assessing outcomes) and how	6-7
	11b	If relevant, description of the similarity of interventions	n/a
Statistical methods	12a	Statistical methods used to compare groups for primary and secondary outcomes	9

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	12b	Methods for additional analyses, such as subgroup analyses and adjusted analyses	9
Results			
Participant flow (a diagram is strongly recommended)	13a	For each group, the numbers of participants who were randomly assigned, received intended treatment, and were analysed for the primary outcome	Figures 1 and S1
	13b	For each group, losses and exclusions after randomisation, together with reasons	Figures 1 and S1
Recruitment	14a	Dates defining the periods of recruitment and follow-up	10
	14b	Why the trial ended or was stopped	n/a
Baseline data	15	A table showing baseline demographic and clinical characteristics for each group	Tables 1, S2 and S3
Numbers analysed	16	For each group, number of participants (denominator) included in each analysis and whether the analysis was by original assigned groups	Tables 2 and 3
Outcomes and estimation	17a	For each primary and secondary outcome, results for each group, and the estimated effect size and its precision (such as 95% confidence interval)	Tables 2 and 3
	17b	For binary outcomes, presentation of both absolute and relative effect sizes is recommended	Table 3
Ancillary analyses	18	Results of any other analyses performed, including subgroup analyses and adjusted analyses, distinguishing pre-specified from exploratory	11-12
Harms	19	All important harms or unintended effects in each group (for specific guidance see CONSORT for harms)	11
Discussion			
Limitations	20	Trial limitations, addressing sources of potential bias, imprecision, and, if relevant, multiplicity of analyses	16-17
Generalisability	21	Generalisability (external validity, applicability) of the trial findings	16
Interpretation	22	Interpretation consistent with results, balancing benefits and harms, and considering other relevant evidence	13-16
Other information			
Registration	23	Registration number and name of trial registry	1
Protocol	24	Where the full trial protocol can be accessed, if available	4
Funding	25	Sources of funding and other support (such as supply of drugs), role of funders	20-22

*We strongly recommend reading this statement in conjunction with the CONSORT 2010 Explanation and Elaboration for important clarifications on all the items. If relevant, we also recommend reading CONSORT extensions for cluster randomised trials, non-inferiority and equivalence trials, non-pharmacological treatments, herbal interventions, and pragmatic trials. Additional extensions are forthcoming: for those and for up to date references relevant to this checklist, see www.consort-statement.org.

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