GSC Advanced Research and Reviews

eISSN: 2582-4597 CODEN (USA): GARRC2

Cross Ref DOI: 10.30574/gscarr

Journal homepage: https://gsconlinepress.com/journals/gscarr/

(REVIEW ARTICLE)

Comparative effect of Tai-Chi Chuan Versus Aerobic Exercise in Patients with Parkinson's disease: Systematic Review and Meta-Analysis

Ketut Ganesha Putra Anugraha [1], Nathanael Jonathan Tjipta [1], Rayhan Belva Mahdi [1], Hayuris Kinandita Setiawan [2,*], Eka Arum Cahyaning Putri [2], Sundari Indah Wiyasihati [2] and Misbakhul Munir [2]

[1] *Medical Program, Faculty of Medicine, Universitas Airlangga, Surabaya, Indonesia.*
[2] *Department of Physiology, Faculty of Medicine, Universitas Airlangga, Surabaya, Indonesia.*

GSC Advanced Research and Reviews, 2024, 21(03), 140–150

Publication history: Received on 22 October 2024; revised on 02 December 2024; accepted on 05 December 2024

Article DOI: https://doi.org/10.30574/gscarr.2024.21.3.0478

Abstract

Exercise is seen as an important aspects in the management of Parkinson's disease, one of the most prevalent neurodegenerative diseases in the world. Tai-Chi Chuan, a mind and body exercise, is widely known for its proven benefits in controlling Parkinson's disease symptoms and could be an alternative exercise compared to conventional aerobic exercise. Therefore, this study aims to compare the effect of Tai-Chi Chuan compared to aerobic exercise in patients with Parkinson's disease. Systematic review approach based on the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) was done across 4 databases including PubMed, Scopus, Science direct, and Cochrane. Included studies went through quality assessment using RoB2.0 or ROBINS-I and quantitative assessment using RevMan 5.4.1. From 173 studies, only three studies were eligible. A total of 581 samples were divided into 295 in Tai-Chi and 286 in the aerobic exercise group. Our analysis showed that two studies were low risk in bias and one moderate risk. Tai-Chi group showed a statistically significant better performance in Foot-up and go test [SMD = -0.61; 95% CI (-0.79, -0.44) P = 0.06]and 50-foot walk [SMD = -1.06; 95% CI (-1.86, -0.26) P = 0.009]. Furthermore, Aerobic exercise has a favorable response towards the Beck Depression Inventory-II (BDI-II) and VO2 max without the significance shown. This systematic review and meta-analysis showed favorable response to both exercise in Parkinson's disease. Tai-Chi helps Parkinson's disease in improvements on motor symptoms meanwhile Aerobic exercise in cardiovascular health.

Keywords: Tai Chi; Aerobic Exercise; Parkinson's disease; Neurodegenerative

1. Introduction

Parkinson's disease together with Alzheimer's are two of the most prevalent neurodegenerative diseases worldwide. The latest global prevalence of Parkinson's disease was found to be 106.38 in 100,000 population in 2019 [1]. This figure shows an outstanding 155.50% increase from the year 1990. Furthermore, within this figure, Parkinson's disease is associated with over 329.000 deaths per year in 2019, of which the mortality rate has been increasing from 1.76/100,000 in 1994 to 5.67/100.000 in 2019 [2]. Thus, further investigation is needed regarding the management of Parkinson's disease, particularly in the area of prevention.

One of the prevention of morbidity and mortality in Parkinson's disease is the prescription of exercise [3]. Exercise in Parkinson's disease is associated with reduced morbidity and mortality through the effect of increasing general health-related fitness and controlling both motor and non-motor symptoms [4]. Exercise is proven to reduce motor symptoms such as bradykinesia, rigidity, and postural instability which reduces the risk of falling in patients with Parkinson's disease [5,6]. The most common non-motor symptoms are neuropsychiatric disorders such as depression and anxiety

* Corresponding author: Hayuris Kinandita Setiawan

which could reduce health-related quality of life leading to increased morbidity and mortality rate. Thus, to assess the most suitable type of exercise in Parkinson's disease is beneficial in the management of Parkinson's disease [7].

Tai-Chi Chuan is a traditional Chinese mind-body exercise commonly found in Chinese adults and elderly. Tai-Chi Chuan is widely known for its proven benefits in general fitness, such as increasing balance, strength, aerobic capacity, well-being, sleep quality, flexibility, and immune capacity [8]. Particularly in Parkinson's disease Tai-Chi Chuan has gained popularity as its physical activity is suitable for patients with Parkinson's disease and elderly. Tai-Chi Chuan is known to control motor and nonmotor symptoms as well as reducing complications in patients with Parkinson's disease [9]. Thus, Tai-Chi Chuan could be beneficial as an alternative exercise choice in Parkinson's disease.

Compared to the health benefits of conventional aerobic exercise which has been widely understood, Tai-Chi Chuan could be better in the setting of Parkinson's disease management. Thus, this study aims to assess the comparative effect of Tai-Chi Chuan compared to aerobic exercise in the management of patients with Parkinson's disease.

2. Methods

2.1. Search Strategy

This Review was conducted in accordance to Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) [10]. Four databases including PubMed, Scopus, Cochrane, Science Direct were benefited to retrieve the studies in this review. Keywords for the literature search are based on Mesh Terms: "Tai chi", "Chi, Tai", "Taiji", "Taijiquan", "aerobic exercise", "exercises", "Physical exercises", "Parkinson", "Parkinson's disease", "Primary parkinsonism".

Studies that were included must follow these inclusion criteria: 1) Diagnosed with Parkinson's disease; 2)The patient's received tai chi as an therapy with aerobic exercise as the comparison; 3) Adult patients; 4) English language; 5) Data reported on numerical values; 6)Full text study;. Exclusion criteria were: 1) Review articles, meta-analysis, case reports. 2) duplicated studies; 3) No comparison of the intended intervention; 4) Insufficient data.

2.2. Data Collection & Extraction

Data collection and extraction of the studies were performed using Microsoft Excel by two authors (K.G.P.A and N.J.T) with the help of other author (R.B.M; H.K.S; E.A.C.P; S.I.W; and M.M) for any ambiguous findings to be discussed. Duplicate studies were excluded after retrieving the search results from each database. Collection of the articles were done by two steps screening: 1) Screening through title and abstract; 2) Full text screening. Included studies then will be assessed for the probability of bias using Cochrane Risk of Bias 2.0 (RoB2.0) tool for RCT studies and Risk Of Bias In Non-randomized Studies (ROBINS) for non-RCT by the help of ROBVIS for the risk of bias visualization [11]. After all authors agreed with the included studies, data that will be extracted were: 1) Characteristic of the studies 2) Baseline and demographic characteristic of the samples 3) Follow up of the outcome used.

2.3. Data Synthesis

Meta-analyses of this study were performed using RevMan 5.4.1. Outcomes that were used are continuous data that presented as mean difference (MD) with 95% confidence interval (CI) and reported in a forest plot. However, if there is a difference of measurement in the outcomes of the study, Standardized Mean Difference (SMD) were used. Heterogeneity will determine whether fixed effect or random effect model for the analysis, with $I^2 \geq 75\%$ considered as high heterogeneity. The concept of p value < 0.05 indicates that the result is statistically significant

3. Results

3.1. Study Selection and Identification

A total of 173 studies from PubMed, ScienceDirect, Scopus, Cochrane went through a series of duplicate elimination, screening based on inclusion and exclusion criteria. The study selection process can be seen in **Figure 1**. Three studies met all the requirements and a few outcomes that could help determine which intervention is better were: Beck Depression Inventory-II (BDI-II), VO2max, Foot Up and Go Test (FUG), and 50-foot walk (50WU).

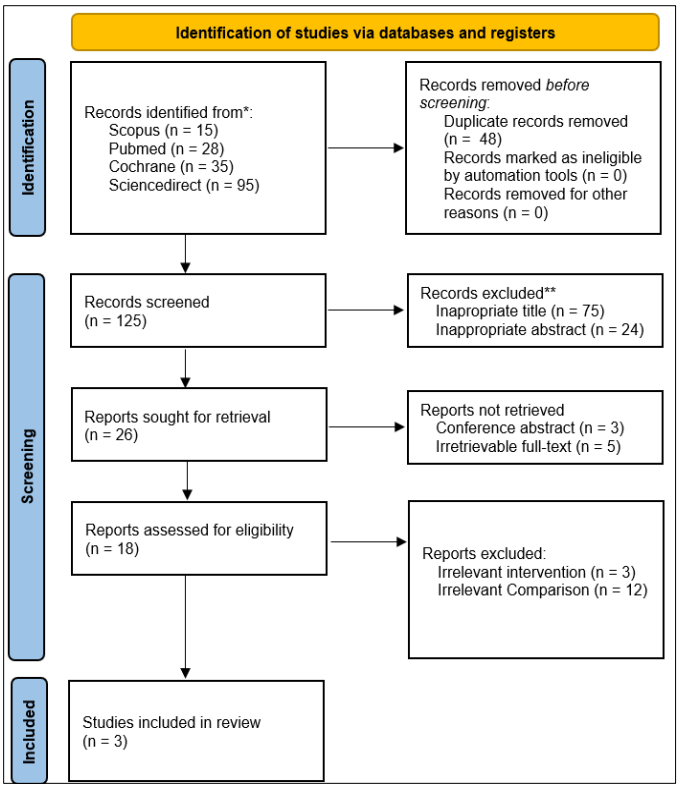

Figure 1 PRISMA Flow Chart

3.2. Demographic and Clinical Characteristics

The demographic and clinical characteristics of the patients displayed in **Table 1**. Three included studies went through data extraction, two of them were Randomized Controlled Trial (RCT) and one Observational/cohort study. All of the studies were found to be performed in Asia, especially Taiwan and China. Total samples accumulated are 581 with 295 in Tai chi group and 286 in Aerobic exercise. The mean age of the samples are about 61.89 – 66.31. A study conducted by Tsai et al [13] showed the longest illness duration that is 12.62 years for Tai-Chi group and 14.65 for Aerobic exercise.

For the tai chi group, Yang style of tai chi were conducted from the included studies with only a study by Li et al [12] performed a 2 months follow up, other study performed a 12 weeks trial. It is the same for the Aerobic exercise group, Tsai et al [13] and Chang et al [14] shown a 12 weeks trial with a frequency of two times per week. The outcome of these studies varied, with two studies reporting BDI-II, VO2 max, and Foot up and go. Meanwhile only one study reported a 50-foot walk test. Each study also has a unique outcome, Tsai et al [13] shown both Tai chi and Aerobic Exercise improve the antioxidant activity and cognitive function, Li et al [12] shown that the post intervention assessment of functional reach and incidence of fall are better in tai chi group compared to the aerobic exercise. For Chang et al [14], it showed that both Tai Chi and aerobic exercise helps motor and neurocognitive performance.

Table 1 Study characteristics

Author, Year	Country	Study Type	Participants	Illness duration (years)	Age
Tsai, 2024 [13]	Taiwan	RCT	TC: 21	TC: 12.62 ± 4.14	TC: 64.67 ± 8.05
			AE: 20	AE: 14.95 ± 2.74	AE: 65.05 ± 6.80
Li, 2020 [12]	China	Cohort	TC: 250	TC: 4.99 ± 2.52	TC: 62.52 ± 5.45
			AE: 250	AE: 5.35 ± 3.01	AE: 61.89 ± 4.55
Chang, 2024 [14]	Taiwan	RCT	TC: 24	TC: 6.75 ± 5.49	TC: 66.31 ± 6.54
			AE: 16	AE: 6.57 ± 7.92	AE: 64.43 ± 7.37

RCT: Randomized Controlled Trial; TC: Tai Chi; AE: Aerobic Exercise

Table 1 Continued

Author, Year	Intervention				Outcome
	Tai-Chi		Aerobic Exercise		
	Frequency + Characteristic	Duration (min)	Frequency + Characteristic	Duration (min)	
Tsai, 2024 [13]	12 Weeks Trial, 3x per week Yang style Taichi	60	12 Weeks Trial, 2x per week 4 min warm up 24 min exercise (8 Cycle of 1 minute 70-75% HR and 2 min of recovery) 2 min cooling down	30	BDI-II Foot up and Go VO2 Max
Li, 2020 [12]	2 Months, 3x per week Yang style Taichi	NR	2 Months, 3x per week	90	Foot up and Go 50-foot walk test
Chang, 2024 [14]	12 Weeks Trial, 2x per week Yang style Taichi	60	12 Weeks Trial, 2x per week 4 min warm up 24 min exercise (8 Cycle of 1 minute 70-75% HR and 2 min of recovery) 2 min cooling down	30	BDI-II VO2 Max

3.3. Risk of Bias

Two studies were found to be a RCT, therefore RoB2 Tool was used to assess the quality of the study. The results of the quality assessment can be seen in **figure 2**. The overall assessment in study conducted by Tsai et al [13] and Chang [14] were found to be low in all the domains. Therefore, the summary or overall risk of bias showed 100% low risk. Since one included study were non-randomized, hence the ROBINS-I was needed to assess the risk of bias. The overall risk of bias, as shown in **figure 3**, were found to be moderate risk of bias due to three domains (Participants selection, intended intervention, and outcomes measurement) being suspected to have a moderate level bias.

Figure 2 RoB2

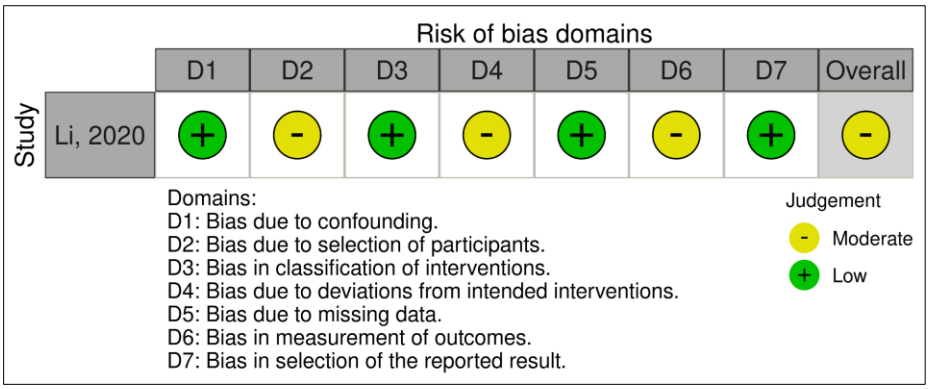

Figure 3 ROBINS-I

3.4. Analysis

3.4.1. Baseline

From the two baseline data that were used to determine if there is any difference in clinical characteristics of the patients, it was found that there were no statistically significant differences between the two groups. **Figure 4** showed the forest and funnel plot of samples duration of Parkinson's disease, and **Figure 5** for the age of the patients. Both analysis showed an I^2 < 75% therefore a fixed-effect model was used. For illness duration the MD: [-0.45; 95% CI (-0.92, 0.02) P = 0.06)] and for age MD [0.64; 95% CI (-0.21, 1.49) P = 0.14)] which indicates no significant difference of the baseline between the two groups.

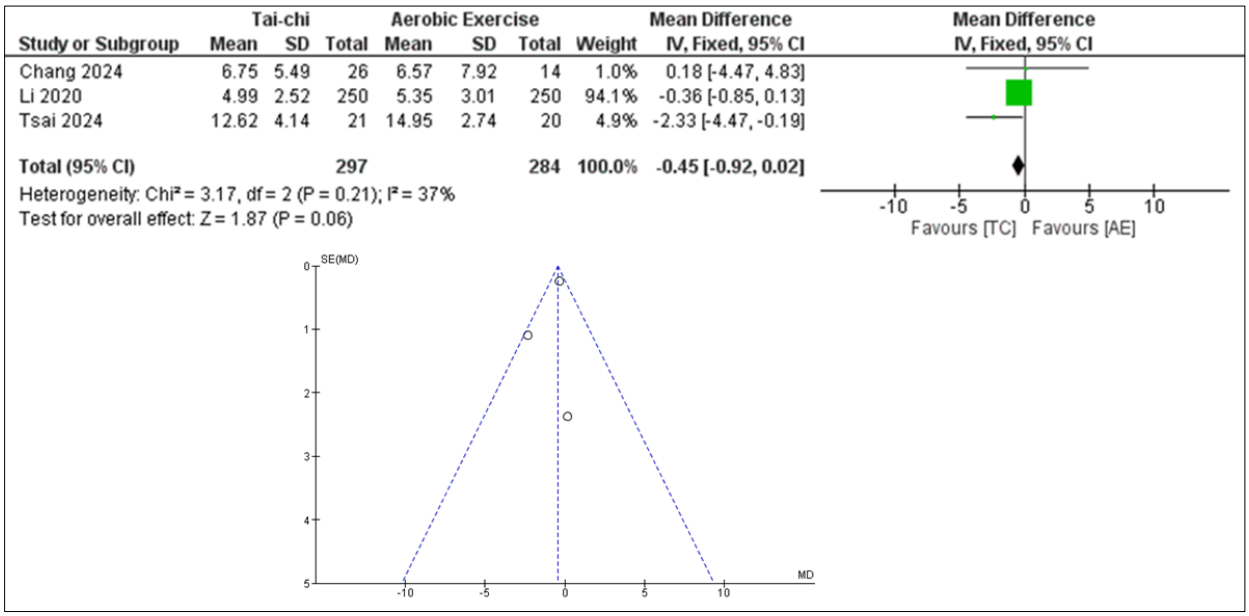

Figure 4 Analysis of the illness duration between tai chi group and aerobic exercise group. a) forest plot of the analysis. b) Funnel plot

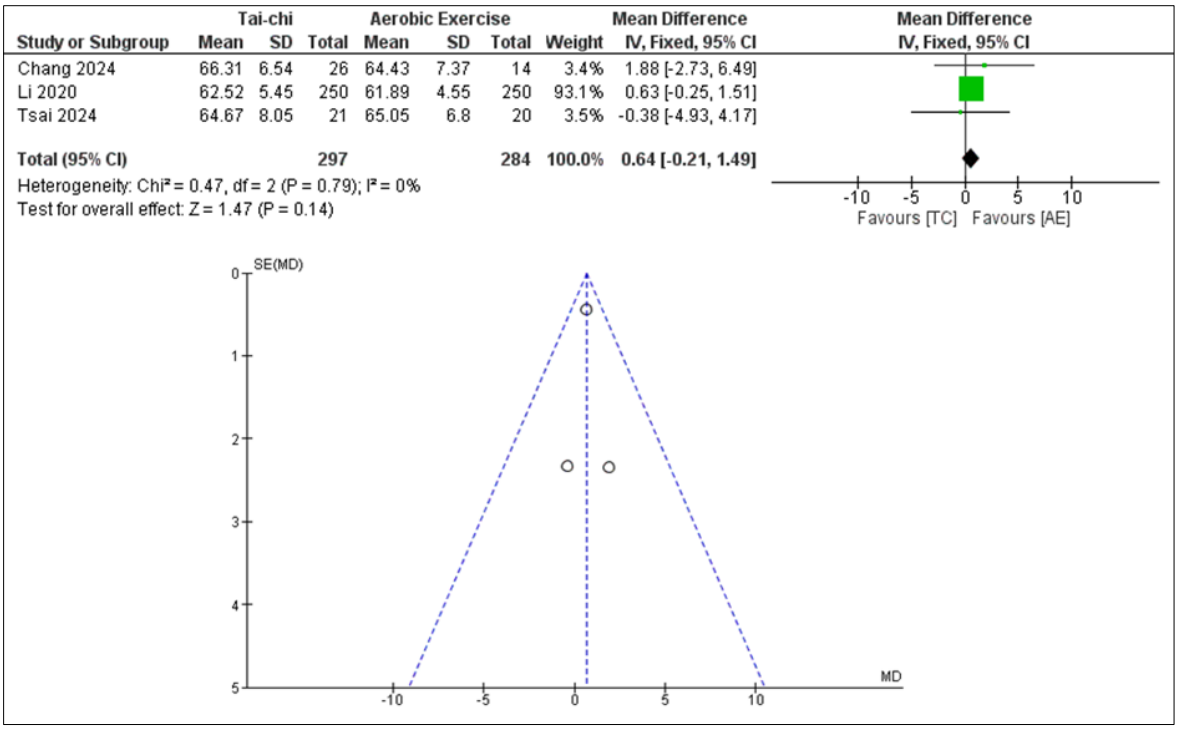

Figure 5 Analysis of the age baseline data between tai chi and aerobic exercise group. a) Forest plot. b) funnel plot

3.5. OUTCOME

3.5.1. BDI-II

The analysis result of BDI-II as an outcome is depicted in **figure 6**. Heterogeneity was presented with I^2 = 0% which indicates low heterogeneity, therefore a fixed-effect model were used. There were no statistically significant differences between BDI-II in group Taichi or aerobic exercise (P = 0.72). The MD [0,62; 95% CI (-2.77, 4.00)] was found to be a little bit in favor of aerobic exercise, nevertheless it is far from significant.

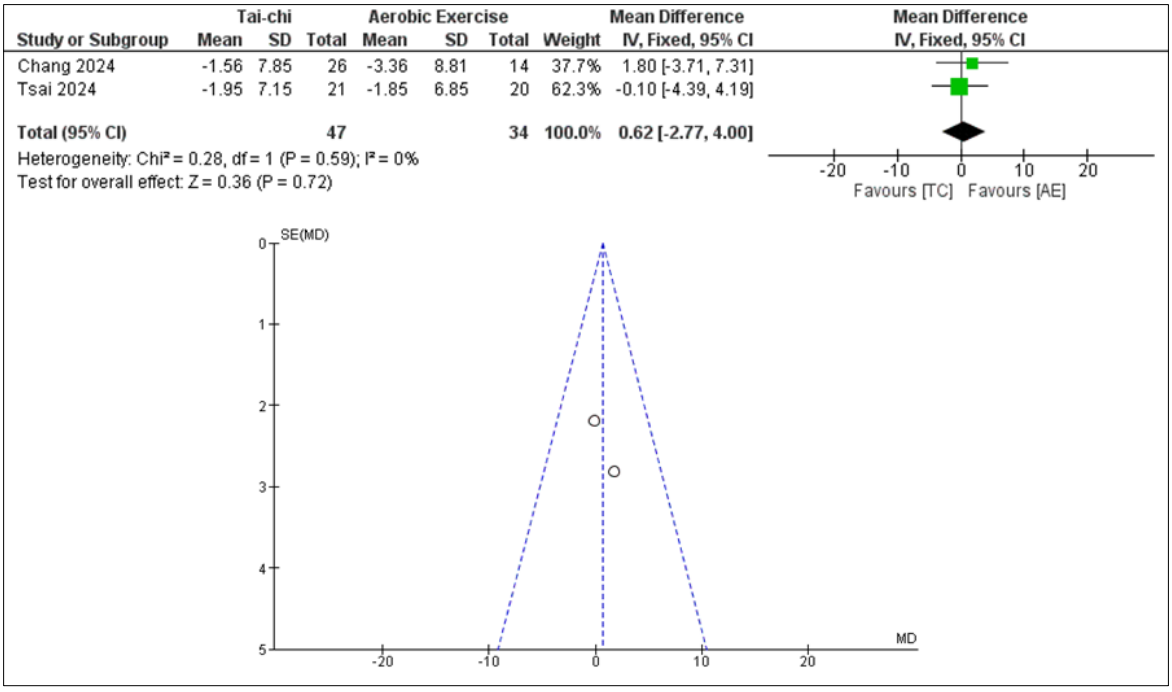

Figure 6 Analysis of BDI-II between Tai Chi and Aerobic Exercise Group. a) Forest Plot. b) Funnel Plot

3.5.2. VO2 Max

The analysis of VO2max is represented in **figure 7**. Heterogeneity was tend to be low due to the I^2= 0%, hence a fixed-effect model was used. The result showed VO2max increased in favor of aerobic exercise, however it is not statistically significant [MD = -4.89; 95% CI (-10.36, 0.58) P = 0.08].

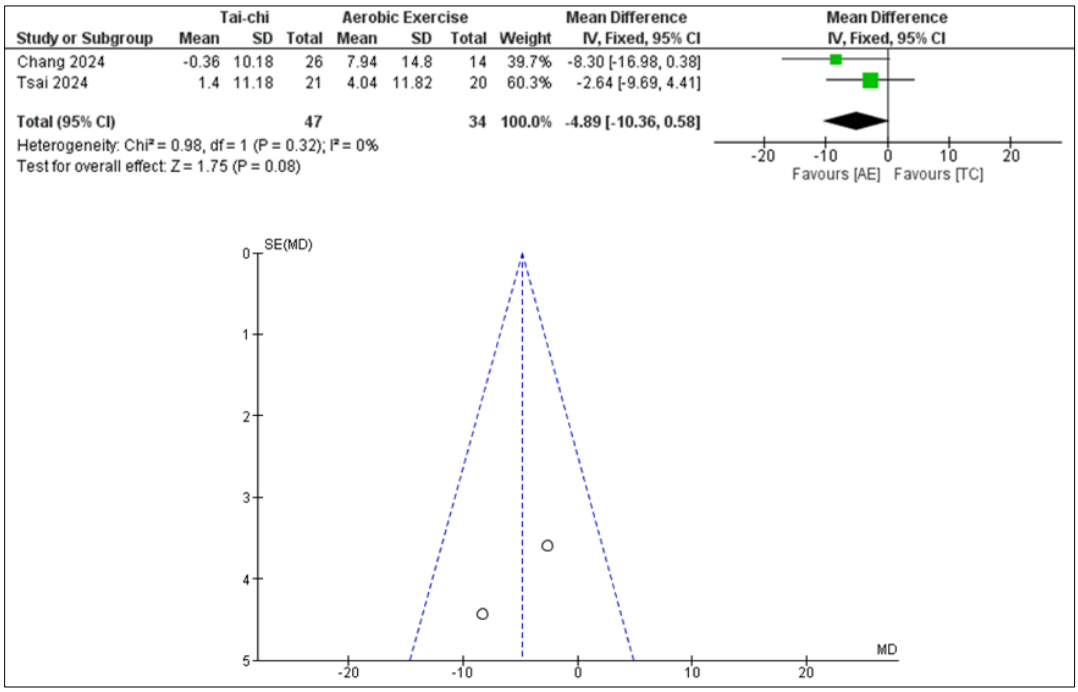

Figure 7 Analysis of VO2Max between Tai chi and Aerobic exercise group. a) forest plot b) funnel plot

3.5.3. Foot Up and GO

The analysis of the foot up and go are presented in forest plot in **figure.8.** For this analysis, Standardized Mean Difference (SMD) were benefited due to the included studies used a different type of foot up and go test. Li et al [12] conducted an 10-Foot-Up and Go test meanwhile Tsai et al [13] performed a 8-Foot Up and Go test. Heterogeneity was slightly high with I^2 = 72% however it is still below 75% and it is not significant to the analysis (p = 0.06). Therefore a fixed-effect model was used with the result of statistically significant decrease in time for the tai chi group compared to the aerobic exercise (p < 0.00001). The alleviation performance of Foot up and go test can be seen in SMD = -0.61; 95% CI (-0.79, -0.44).

3.5.4. 50 Foot walk test

The analysis of the 50-foot walk test are presented in forest plot in **figure 9.** Only one study reported this outcome therefore no funnel plot is shown. The result shown a statistically significant decrease in time for the 50-foot walk test in the Tai Chi group compared to aerobic exercise with SMD = -1.06; 95% CI (-1.86, -0.26) p = 0.009.

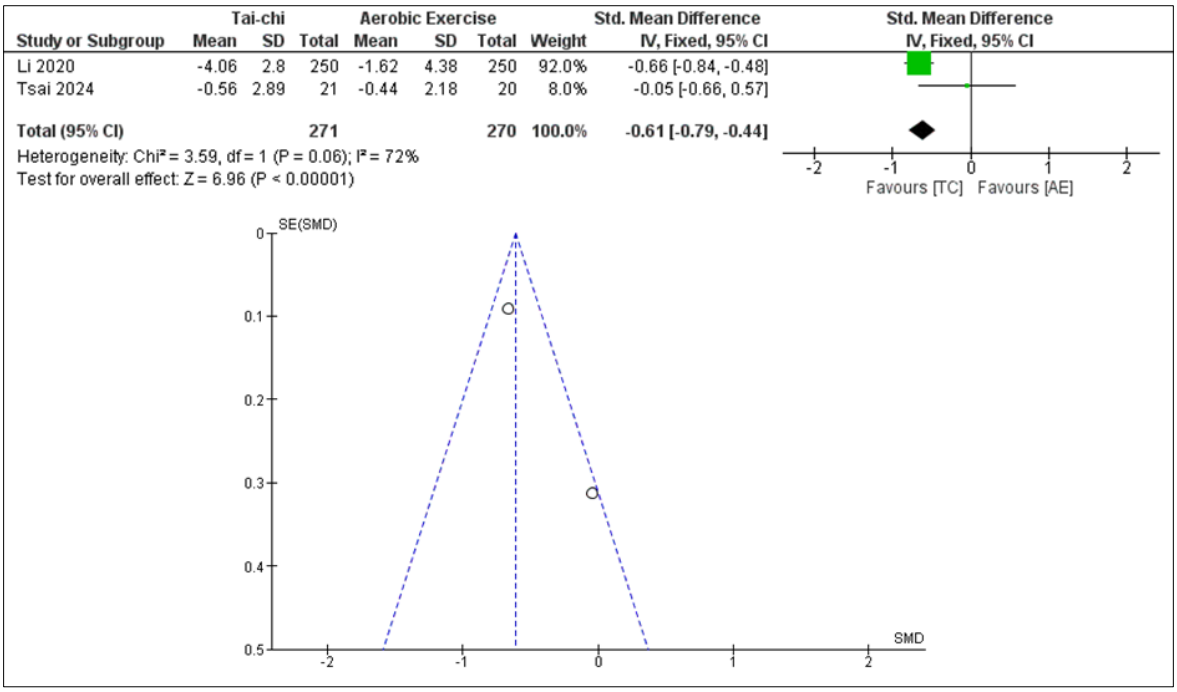

Figure 8 Analysis of Foot-up and Go test between Tai chi and Aerobic Exercise group. a) forest plot b) funnel plot

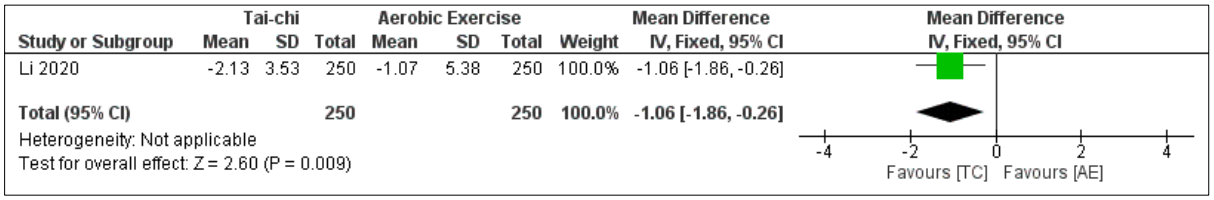

Figure 9 Forest plot of 50-Foot Walk test between Tai chi group and aerobic exercise

3.5.5. Sensitivity analysis

From the analysis that was done, the funnel plot of each outcome showed that there were no outlier. Therefore no sensitivity analysis needed to be done.

4. Discussion

4.1. Main Findings

This Meta-Analysis study was conducted to compare the effectiveness between Tai-Chi Chuan and aerobic exercise in patients with Parkinson's disease. Outcomes used to assess the efficacy were BDI-II, VO2 Max, Foot-up and go, and 50-foot Walk test. The result is varied amongst the outcomes, with Aerobic exercise performed a MD of 0.62 (p = 0.72) for BDI-II which means the score were slightly more reduced in this group. However the non-significant results means there was no difference between both groups in terms of this outcome. Aerobic exercise was also ahead in improving VO2 max with MD of -4.89 (P = 0.08), however this finding was also not significant statistically. For the other group, Tai-Chi Chuan showed a statistically significant improvement from two outcomes compared to Aerobic Exercise. Foot-up and go test showed an SMD of -0.61 (p < 0.00001) and 50WU showed an SMD of -1.09 (p = 0.009) These tests are the representative of the health conditions and symptoms in Parkinson's disease that is discussed later in this article.

4.2. Tai-Chi Chuan increases mobility and reducing fall risk in Parkinson's disease

Many clinical reviews have assessed the wide advantage of Tai-Chi Chuan in general fitness and particularly in chronic diseases. One of which is a clinical review done by Huston and McFarlane in 2016 which encompasses the benefits of Tai-Chi Chuan through 120 systematic reviews and meta-analysis [8]. One of the benefits with strong excellent evidence is regarding fall prevention and improving Parkinson's disease symptoms control. Our current evidence also suggest

that fall prevention is best achieved with Tai-Chi Chuan exercise as it shows higher ability to complete the 50-foot walk up test (50WU) and Foot up and go test (FUG). Both of this test emphasized mobility and flexibility because both of the tests include activity of walking firmly and doing turns in the shortest time possible. Furthermore 50WU and FUG tests are proven to be a reliable tools to access balance, mobility, and flexibility in healthy adults and in adults with comorbidities, one of which is Parkinson's [15–17].

Fall risk in Parkinson's disease is an important aspect to be assessed as it is correlated with a high risk of morbidity and mortality [18]. Prediction of fall risk in patients with Parkinson's can also be assessed using the FUG test [19]. It is known that patients with Parkinson's are particularly susceptible to falls as motor symptoms such as bradykinesia, rigidity, dyskinesia, gait freezing, and postural changes may occur and worsen over time (6). All of these motor symptoms highlight the lack of flexibility and mobility in patients with Parkinson's disease.

A study found that reduced mobility, shown by deduction of walking speed, is associated with higher mortality in patients with Parkinson's disease [20]. Thus, 50WU and FUG tests could also assess the risk of mortality in patients with Parkinson's disease. With the improvement of performance speed in 50WU and FUG tests, our study is in line with current evidence regarding the efficacy of Tai-Chi Chuan exercise in improving motor symptoms in Parkinson's disease. Our study suggests that Tai-Chi Chuan is beneficial for increasing mobility and reducing fall risk in patients with Parkinson's disease.

4.3. Aerobic exercise increases cardiovascular fitness in Parkinson's disease

Aerobic exercise in all of the studies uses either stationary bicycle or treadmill or dance [12–14]. Aerobic exercises were mostly done in a moderate to high-intensity interval training. Aerobic exercise in this review significantly increases VO2max of patients with Parkinson's disease. This finding is in line with the current evidence which states that aerobic exercise increases cardiovascular fitness, and also improves bone health and reducing mortality rate in Parkinson's disease [21]. Furthermore, aerobic exercise shows decreased cardiovascular disease risk in patients with Parkinson's disease [22]. As for cardiovascular fitness, VO2max is deemed to be one of the most important aspect to assess cardiovascular fitness in Parkinson's disease [23]. Thus our review suggests that aerobic exercise is a suitable exercise to increase cardiovascular capacity in patients with Parkinson's disease.

4.4. Tai-Chi Chuan and Aerobic Exercise Effect on Non-motor symptoms of Parkinson's disease

One of the major concerns in patients with Parkinson disease is the emergence of non-motor symptoms. One of the most significant non-motor symptoms spectrum is the neuropsychiatric disorders, including anxiety, depression, cognitive dysfunction, and dementia [24]. These neuropsychiatric symptoms are associated with a higher risk of morbidity and mortality in Parkinson's disease as it is related with reduced health-related quality of life [7]. Depressive symptoms particularly are common and are often underdiagnosed and undertreated in Parkinson's disease [25]. Even though current evidence shows that exercise have beneficial effect in mental state of patients with Parkinson's disease, studies shows inconsistent outcomes [26,27]. This is due to the fact that psychiatric disorders are multifactorial and complex condition with a wide range of risk factors. Small sample size and neglection of risk factors associated with depression may alter the outcome of depressive symptoms in this review. However, our review shows that the effect of Tai-Chi Chuan exercise to improve depressive symptoms in Parkinson's disease through BDI-II self-questionnaire does not differ significantly compared to aerobic exercise.

5. Conclusion

Parkinson's disease is still known as one of the neurodegenerative disease that leads in morbidity and mortality. This systematic review and meta-analysis have shown that both Tai-chi and aerobic exercise could benefit Parkinson's disease patients depending on the aspect. As for the motor symptoms, tai chi has an advantage over aerobic exercise due to the better performance on foot-up and go test and 50-foot walk. Nevertheless, Aerobic leads in cardiovascular health condition and slightly in the neuropsychiatric. The presence of this study is to prove the benefit of exercise for parkinson's disease, however future clinical trial is still needed to evaluate the response.

Compliance with ethical standards

Acknowledgments

The Authors would like to thank the Department of Physiology, Faculty of Medicine, Universitas Airlangga for facilitating this project.

Disclosure of conflict of interest

The authors have no conflict of interest to declare.

References

[1] Ou Z, Pan J, Tang S, Duan D, Yu D, Nong H, et al. Global Trends in the Incidence, Prevalence, and Years Lived With Disability of Parkinson's Disease in 204 Countries/Territories From 1990 to 2019. Front Public Heal. 2021;9(December).

[2] Lampropoulos IC, Malli F, Sinani O, Gourgoulianis KI, Xiromerisiou G. Worldwide trends in mortality related to Parkinson's disease in the period of 1994–2019: Analysis of vital registration data from the WHO Mortality Database. Front Neurol. 2022;13.

[3] Langeskov-Christensen M, Franzén E, Grøndahl Hvid L, Dalgas U. Exercise as medicine in Parkinson's disease. J Neurol Neurosurg Psychiatry. 2024;1077–88.

[4] Bhalsing KS, Abbas MM, Tan LCS. Role of Physical Activity in Parkinson's Disease. Ann Indian Acad Neurol. 2018;21:242–9.

[5] Zhang M, Li F, Wang D, Ba X, Liu Z. Exercise sustains motor function in Parkinson's disease: Evidence from 109 randomized controlled trials on over 4,600 patients. Front Aging Neurosci. 2023;15.

[6] Mylius V, Zenev E, Brook CS, Brugger F, Maetzler W, Gonzenbach R, et al. Imbalance and Falls in Patients with Parkinson's Disease: Causes and Recent Developments in Training and Sensor-Based Assessment. Brain Sci. 2024;14(7).

[7] Martinez-Martin P, Rodriguez-Blazquez C, Kurtis MM, Chaudhuri KR. The impact of non-motor symptoms on health-related quality of life of patients with Parkinson's disease. Mov Disord. 2011;26(3):399–406.

[8] Huston P, McFarlane B. Health benefits of Tai Chi. Heal Promot Community Sing as a Veh to Promot Heal. 2013;62:39–57.

[9] Li G, Huang P, Cui S, He Y, Tan Y, Chen S. Effect of long-term Tai Chi training on Parkinson's disease: A 3.5-year follow-up cohort study. J Neurol Neurosurg Psychiatry. 2023;95(3):222–8.

[10] Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. BMJ. 2021;372.

[11] McGuinness LA, Higgins JPT. Risk-of-bias VISualization (robvis): An R package and Shiny web app for visualizing risk-of-bias assessments. Res Synth Methods. 2021;12(1):55–61.

[12] Li Q, Liu J, Dai F, Dai F. Tai chi versus routine exercise in patients with early-or mild-stage parkinson's disease: A retrospective cohort analysis. Brazilian J Med Biol Res. 2020;53(2):1–7.

[13] Tsai CL, Chien CY, Pan CY, Tseng YT, Wang TC, Lin TK. Effects of long-term Tai Chi vs. aerobic exercise on antioxidant activity and cognitive function in individuals with Parkinson's disease. Behav Brain Res [Internet]. 2025;476(1):115274. Available from: https://doi.org/10.1016/j.bbr.2024.115274

[14] Chang CL, Lin TK, Pan CY, Wang TC, Tseng YT, Chien CY, et al. Distinct effects of long-term Tai Chi Chuan and aerobic exercise interventions on motor and neurocognitive performance in early-stage Parkinson's disease: a randomized controlled trial. Eur J Phys Rehabil Med. 2024;60(4):621–33.

[15] Christopher A, Kraft E, Olenick H, Kiesling R, Doty A. The reliability and validity of the Timed Up and Go as a clinical tool in individuals with and without disabilities across a lifespan: a systematic review: Psychometric properties of the Timed Up and Go. Disabil Rehabil [Internet]. 2021;43(13):1799–813. Available from: https://doi.org/10.1080/09638288.2019.1682066

[16] da Rosa Tavares JE, Ullrich M, Roth N, Kluge F, Eskofier BM, Gaßner H, et al. uTUG: An unsupervised Timed Up and Go test for Parkinson's disease. Biomed Signal Process Control [Internet]. 2023;81(April 2022):104394. Available from: https://doi.org/10.1016/j.bspc.2022.104394

[17] Rosenfeldt AB, Penko AL, Bazyk AS, Streicher MC, Dey T, Alberts JL. The 2-min walk test detects dual-task deficits in individuals with Parkinson's disease. J Aging Phys Act. 2019;27(6):843–7.

[18] Grimbergen YAM, Schrag A, Mazibrada G, Borm GF, Bloem BR. Impact of falls and fear of falling on health-related quality of life in patients with Parkinson's disease. J Parkinsons Dis. 2013;3(3):409–13.

[19] Nocera JR, Stegemoller EL, Malaty IA, Okun MS, Marsiske M, Hass CJ, et al. Using the Timed Up & Go Test in a Clinical Setting to Predict Falling in Parkinson's Disease. Acrh Phys Med Rehabil. 2013;94(7):1300–5.

[20] Matinolli M, Korpelainen JT, Sotaniemi KA, Myllylä V V., Korpelainen R. Recurrent falls and mortality in Parkinson's disease: A prospective two-year follow-up study. Acta Neurol Scand. 2011;123(3):193–200.

[21] Schootemeijer S, van der Kolk NM, Bloem BR, de Vries NM. Current Perspectives on Aerobic Exercise in People with Parkinson's Disease. Neurotherapeutics. 2020;17(4):1418–33.

[22] Yaghoobi H, Mohammadi S, Sardashti S, Abbaspour S, Hossein-Abadi TS. Comparison of the Effect of Aerobic and Resistance Training on Cardiovascular Risk Factors in Parkinson's Women. Open Nurs J. 2019;13(1):186–92.

[23] Jensen FB, Dalgas U, Brincks J, Langeskov-Christensen M. Validity and reliability of VO2-max testing in persons with Parkinson's disease. Park Relat Disord [Internet]. 2023;109(February):105324. Available from: https://doi.org/10.1016/j.parkreldis.2023.105324

[24] Poewe W. Non-motor symptoms in Parkinson's disease. Eur J Neurol. 2008;15(SUPPL. 1):14–20.

[25] Orayj K, Almeleebia T, Vigneshwaran E, Alshahrani S, Alavudeen SS, Alghamdi W. Trend of recognizing depression symptoms and antidepressants use in newly diagnosed Parkinson's disease: Population-based study. Brain Behav. 2021;11(8):1–8.

[26] Wu PL, Lee M, Huang TT. Effectiveness of physical activity on patients with depression and Parkinson's disease: A systematic review. PLoS One. 2017;12(7):1–14.

[27] Tian J, Kang Y, Liu P, Yu H. Effect of Physical Activity on Depression in Patients with Parkinson's Disease: A Systematic Review and Meta-Analysis. Int J Environ Res Public Health. 2022;19(11).