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RESEARCH ARTICLE

The Application of a Mixed Live and Online Live Streaming Exercise Program of Tai Chi and Its Effect on Dynamic Balance, Physical Function of Lower Limbs and Aerobic Capacity of Adults

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ABSTRACT

This study aimed to investigate the effect of a mixed intervention program, with live and distance online Tai Chi (TC) practice on healthy adult practitioners and its effect on dynamic balance, physical function of lower limbs and aerobic capacity, which were measured at baseline and follow up. The sample of the study consisted of the experimental group (N = 19) of healthy subjects divided into two groups according to their level of experience in Tai Chi (beginner vs. experienced) and 15 healthy subjects (N = 15) of the control group who were sedentary individuals. The experimental group participated in a supervised Tai Chi program lasting 18 weeks, of which 9 weeks of live training sessions (before the pandemic) and 9 further weeks in online distance practice during the pandemic restrictive measures. The exercise frequency was 3 times/week, lasting 90 minutes during live lessons, while the online exercise duration was adjusted to 60 minutes. The Y-Test (Lower Quarter test) was used to measure the dynamic balance. The single limb single hop test measured physical function, while the 6-minute walking test was applied to measure aerobic capacity. The results of the present study showed that a statistically significant difference was observed in the dynamic balance of the left leg between the pre-and post-training measures for the experimental groups, with the experienced group scoring higher. Right leg results revealed improvements for TC practitioners, with the beginners group scoring significantly higher than experienced and control subjects. The asymmetry score changed positively for both experimental groups, with a higher index for the beginners group. Aerobic capacity scores were significantly improved between baseline and final measurements. The TC practitioners scored significantly higher than the control subjects. Furthermore, concerning the results in the physical function of the lower limbs, the TC-experienced group showed greater improvements compared to both TC beginners and the control group. Similar effects concerned right leg results. TC effectively improves balance and physical function of lower limbs in healthy adults due to the activation of different muscle groups, the sequence of movements, the duration, and the nature of the body mind. It should be incorporated in health prevention programs. Due to the pandemic, the implementation of distance learning became a solution for many exercise programs and complemented their content.

Keywords: Aerobic capacity, dynamic balance, physical function lower limbs, Tai Chi.

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1. Introduction

A healthy lifestyle is a result of complex multifactorial parameters that relate to mastery of combination and, furthermore, simplicity of tasks. Physical function can be positively influenced through health-promoting physical activity policies and programs (Haskell *et al*., 2009). Consequently, prevention programs are strongly advised and promoted because their structure includes methodologies and an ideal design of various exercise options to validate the outcomes for the fitness level of adult practitioners. Furthermore, mind-body exercise is important in maintaining and improving physical, mental, and cognitive abilities. Tai Chi Chuan, or otherwise Tai Chi (TC), is an ancient Chinese martial art, and during the last decades, it has developed into a popular alternative exercise system for health promotion because of its multiple benefits on general health. A systematic review by Wayne *et al*. (2014) suggests that TC is safe and, as a combined exercise of the body and mind, it has a positive impact on muscle strength while relaxing, balancing, stretching the practitioner, and consequently improving general health, personal development, and self-defence skills (Wayne & Fuerst, 2013). TC consists of a continuous combination of slow-flowing movement patterns of the torso and lower limbs where practitioners move by shifting their weight and balance, often in single-leg positions. This way, movements allow a relaxed stance, coordination, and postural control. There are different styles in the tradition of Tai Chi Chuan; the most applied are the Chen style, the Yang Style, the Wu and the Sun style. A study by Lan *et al*. (2008) examined the intensity of exercise in TC during a Yang-style routine, and results suggest that this style is an aerobic exercise of moderate intensity with the same execution intensity in all age groups and both sexes. A systematic review of Wang *et al*. (2004) refers to the physiological and psychological benefits of TC practice. It is considered safe and positively affects balance control, flexibility, and cardiovascular fitness in older patients with chronic conditions. The multidimensional content of TC programs also includes meditation and imagery training, improving mental and cognitive abilities. Several studies outlined improvements in self-esteem in healthy individuals and patients that suffer from chronic conditions and positive effects on the cognitive function of older adults (Miller & Taylor-Piliae, 2014; Wang *et al*., 2010). This positively affected their stress, anxiety, depression, and mood disorders. Results of a study by (Chatzipanagioti *et al*., 2022) that examined the effect of a TC program on the sleep quality of healthy adults showed improvements in 6 out of 7 components of the Pittsburgh Sleep Quality Index (PSQI) and PSQI Global score with the subjective sleep quality improving significantly. A randomized control trial examined the effect of TC on the sleep quality, physical performance, and quality of life of Chinese women with knee osteoarthritis (Lü *et al*., 2017) and improvements in sleep disorders among patients that are treated for heart disease, fibromyalgia, arthritis, and cancer (Lan *et al*., 2013). Evaluating the participation motives in TC programs, results show that practitioners exercise more to enhance their vitality, reduce stress and tension, and improve their fitness level (Chatzipanagioti *et al*., 2013).

1.1. Balance

Balance is one of the parameters contributing to everyone's healthy life. It relates to many factors that influence confidence and affect the fear of falls for older and younger people. The latter need to improve balance -either statical or dynamic-in context to their performance and functional fitness in various sports. A better quality of life relies on the mechanisms that support people's sense of gravity as a balance component. Balance is the key to a content life, as many other factors and community health programs integrate balance exercises to gain their benefits.

Tai Chi seems to improve balance and reduce the number of falls, positively influencing biomedical and psychosocial frailty markers (Wolf *et al*., 1996). A Gait analysis study comparing experienced TC practitioners with those who exercise by normal walking showed higher results in knee muscle activation profiles and co-contractions by the former group (Tseng *et al*., 2007). The practitioners who do Tai Chi intensively have shown a more effective response to regaining balance due to an improved neuromuscular response of the ankle joint, better neuromuscular coordination, and a better sense of balance (Gatts & Woollacott, 2007). TC practitioners reported superior performance in clinical and laboratory tests compared to non-practitioners, with increased Tai Chi experience associated with improvement in postural control (Mak & Ng, 2003). Balance was ensured by better coordination of Tai Chi practitioners' gait, especially at the beginning of the first step, where there is a greater chance of imbalance or obstruction due to a possible stumbling block (Hass *et al*., 2004). A study by Wu and Keyes (2006) assessed the effect of a 15-week tele-exercise-based TC program, facilitated through video-conferencing, on balance and fear of falls in elderly participants. The results suggest an 18% improvement in fear of falling score, a 43% improvement in single leg stance time, a 21% improvement in Up-and-Go time and a positive result in body sway (>8%) in a static position. This program's participants were interested in continuing tele-exercise, accepting the nature of the exercise.

1.2. Physical Function

A research study by Jain *et al*. (2017) reported that TC participants showed significant improvement in ankle joint proprioception and functional lower extremity strength in comparison to a control group, suggesting that these programs should be considered as alternative practices for fall prevention while also having a positive effect on overall health and mobility. Evaluating a 6-month Tai Chi exercise intervention, significant improvements were reported in the functional status in various activities and functional balance for the TC group in comparison to non-practitioners, which could subsequently result in fewer fall rates (Fuzhong *et al*., 2001; Li *et al*., 2004). Results from a study (Li *et al*., 2009) that examined the effect of TC on muscle strength, the reaction of lower extremities and endurance reported a significant increase in knee flexor muscle strength and a decrease in muscle latency in the Tai Chi group compared to the control group. Authors suggest longer TC interventions to monitor more biomechanical characteristics.

1.3. Aerobic Capacity

TC is considered a low-to-moderate aerobic exercise depending on the style, the range of posture levels, and the intensity of the training parameters (Lan *et al*., 2001). Maximum oxygen consumption (VO2max) is regarded as the optimal measure of aerobic capacity, offering crucial insights into cardiorespiratory function. Accordingly research proof TC as a beneficial exercise for the heart health. In 2024, a new Compendium for Physical Activity (PA) for adults 19–59 years old was conducted (Herrmann *et al*., 2024), after the latest one in 2011, which incorporated the updated list of METs (Metabolic equivalent) values for various activity categories. Additionally, there is a Youth Compendium for ages 5–18 years and one for older Adults over 60 years. Each MET refers to a standard value of resting metabolic rate (rmr) 1MET = 3.5 ml/Kg/min. According to this list, the value range of METs for sedentary behaviours is between 1.0 and 1.5 METs and for light-intensity PAs, between 1.6 and 2.9 METs. Moderate-intensity PA values range between 3.0 and 5.9 METs, while high-intensity PAs result in ≥6.0 METs. TC exercise styles range from 3 to 6 METs, classifying them as having moderate intensity (Miller & Taylor-Piliae, 2014). The Compendiums are used to support any health-related and PA research studies. A TC intervention group and a TC Yang style practitioners report higher level improvements in aerobic capacity than sedentary groups (Taylor-Piliae & Froelicher, 2004), while TC appears to have a positive impact on enhancing aspects of physical fitness (Wehner *et al*., 2021). Research reviews suggest that Tai Chi is a safe exercise that could be incorporated into physical training to improve walking capacity and postural control of patients with osteoarthritis (You *et al*., 2021).

This study evaluated the effect of an 18-week Tai Chi Chuan Yang style mixed intervention program with live and live streaming online interactive and supervised distance learning methodology on dynamic balance, physical function (leg power and dynamic balance) of lower limbs, and aerobic fitness of healthy adults. The adaptation of the program into supervised online sessions after 9 weeks of live training was due to the COVID-19 pandemic that influenced the intervention at that time. The online program was facilitated through Internet-based video-conferencing devices. Tai Chi is a multifaceted mind-body intervention ranging from basic movements to complex forms. Undoubtedly, the presence and supervision of a qualified teacher are essential for mastery and effective teaching methodology for all patterns and levels of all education stages.

2. Method

2.1. Participants

The intervention group of TC participants were initially 26 age-matched healthy adult volunteers (7 males and 19 females), with a mean age of 53.9 ± 6.3 years, who were recruited for this study after a presentation of the goals and structure of the research intervention program. The group consisted of 8 experienced Tai Chi practitioners (3 or more years of experience) and a randomized group of 18 Tai Chi beginners who were not engaged in any physical activity or TC training in the previous three months. All participants provided informed consent and completed a brief medical history questionnaire. The three inclusion criteria were: a) for Beginners only: inactivity, as defined by the absence of participation in any structured or regular exercise in the previous three months, and general criteria for all: a) absence of chronic illness, systematic use of medication, and being healthy to the extent that participation in an exercise test and exercise program would not affect any existing disease or health condition, b) willingness to undergo measurements and testing conditions before and after the research, response to questionnaires, and participation in Tai Chi exercise sessions three times weekly for a 12-week intervention program. Due to the COVID-19 pandemic and restrictive measures, the program was adapted from live to distance learning online exercise classes in the 9th week of the

intervention program, which lasted another 9 weeks. The intervention program's final duration was extended to 18 weeks between initial and final measurements.

During the online distance learning classes, a dropout of 7 female beginner participants occurred due to several technical reasons they could not support, like inadequate network connectivity, management and use of the relevant technology and the adapted exercise conditions. Other reasons for withdrawal included professional commitments and lack of time. The dropout rate of volunteers in the online program for the remaining 9 weeks was 21%. The final number of the sample was 19 volunteers (7 males and 12 females). The experienced group were 8, and the beginners decreased to 11 participants.

Control subjects were 15 healthy adults (9 males and 6 females), with a mean age of 53.8 ± 3.67 years, without any physical activity or structured or regular exercise in the previous three months.

The participation of all subjects was monitored through attendance records. Any absence (due to illness or other reasons) could be compensated within the week, both in live and online classes, accordingly.

2.2. Research Design

The TC intervention program was designed for 18 weeks and training units three times a week and of 90 minutes duration per unit. The initial 9 weeks of live supervised training were further extended to 9 more weeks, where adaptions had to be organized to shift to supervised live streaming training due to the COVID-19 pandemic at that time. Data from the research were collected at baseline and after a period of 18 weeks in the Laboratory of Rehabilitation of the Department of Physical Education & Sport Science of the Democritus University of Thrace in Komotini and the indoor facilities of a community-based non-profit organization in the town of Xanthi. A letter of consent for the use of the indoor facilities of the organization was handed for the realization of the practical sessions in the Tai Chi intervention program. The protocol of this study was approved by the ethical committee of the Democritus University of Thrace. Adherence to the intervention was set a priori as attendance in 80% of the Tai Chi Chuan classes.

Both TC groups were taught the traditional Yang style TC and supervised by a Physical education teacher who was also an experienced certified Tai Chi Chuan and Qigong teacher.

Each session consisted of 10–15-minute warm-up routines, Qi gong elements, general stretching and meridian stretching. The main session included learning the fundamentals and basics of TC and tai chi. At the end was a 5-minute cooling down recovery session with relaxation exercises, tapping, and Qi brushing of acupuncture points and energy meridians. Each lesson was enriched with relaxing musical accompaniment.

2.3. Training Protocol

The main elements of the TC session included basic routines and footwork, practice and understanding of the basic yin-yang principles of Tai Chi Chuan, walking techniques and standing routines, proprioception exercises, single leg balance routines, sinking and 'rooting' routines, basic principles of weight shifting, body-mechanical alignments, lower limb strength and core stability exercises, breathing and relaxation techniques, meditation, imagery practice, coordination exercises of core and lower limb in various directions, axes and levels. A form of 13 elements of the traditional Yang style was taught. The TC teacher coordinated the whole group of volunteers, made postural and movement corrections and gave feedback.

2.4. Structure and Design of the Live Streaming Intervention

After the 9th week, due to the COVID-19 pandemic, the intervention was transformed into a live streaming program. During the pandemic, the need for live streaming exercise became a must-have, gaining more popularity. A new perspective for exercising at home emerged. The contents of the intervention were adapted by the same instructor. The teaching methods were enhanced in terms of feedback and more detailed verbal and visual guidance at all times in order to control the correct execution of the movements, support the content of the intervention program and enhance the participation motivation of the group. The duration of the lessons shifted to 60 minutes, with the content of the lessons remaining the same while shorter time units and an increase of repetitions of the movements became necessary.

Some of the key points in the structure of live streaming teaching are: 'Shaping' the environment-'Marking' the room-Technical issues and materials-Costs of production–Preps-Methodology–follow-ups–feedback-Group dynamics-Motivation and communication-Self-control-Intros and closures.

The configuration of the space required guidance from the TC groups so that they could respond better to the conditions of the online training. The orientation within the exercise space at home during the video-conferencing time plays an important role because the content and the execution of the TC

forms often require changes of direction and coordination in many levels and axes. A greater demand for concentration and focus of attention plays a crucial role for both instructor and practitioner. For effective implementation of online education through a corresponding platform, numerous factors should be considered during the preparation phase, leading to a successful distance learning live streaming session (Daskalaki *et al*., 2021). Adequate shaping of the teaching area, especially when the instructor chooses to work from home and get familiar with the use and application of new technologies. The monitoring aspects influence the successful interaction between the sample group and the instructor.

Other guidelines that have been incorporated into this TC intervention program are:

- Orientation in exercise space: Placement of objects or signals pointing North or South or clockwise movement.

- The efficient management of new technologies by the instructor affects the settings of the space from which the broadcast will take place with the appropriate technical conditions, i.e., the correct location of the camera and use of lights and sound. The colors of the instructors' clothing should be appropriate and adjusted to the background, avoiding confusion about the practitioner's vision.

- The beginning and closure of the course should always be properly prepared. Good communication with the instructor is crucial in all phases, and at the end of sessions, one should create a pleasant routine of reward and relaxation upon leaving to make them look forward to the next session and incorporate this bond between the educator and the practitioner.

- The corrections of movements and postures rely on the effective handling of the camera, the microphone and the media that are used. The subjects of the TC group were advised to use a laptop or desktop computer or possibly connect to a television monitor to enhance image quality. It is recommended that a separate lesson be dedicated to the introduction to media use. Organizing a testing session is always effective before the launching of the first video-conferencing practical session. Problems can be discussed and solved. The quality of the Internet connection can affect the quality of the course.

- Setting up technical rules and principles of interaction. All participants' cameras should always be open to secure adequate control in terms of their movement execution, their postures, and the general flow of the course.

- Shaping an undistracted environment without interruptions and interference is a key condition. If weather conditions were friendly, opening windows were advised to maintain fresh air circulation. The choice of the appropriate size of the practice area at home and the moving of furniture may be necessary for a comfortable environment during the online classes. Furthermore, the determination to maintain a good mood and pleasant atmosphere will successfully influence the conditions of the class. Flexibility, adaptability, and good time management should be mastered by everyone in the course.

2.5. Measures

2.5.1. Dynamic Balance: Y Test

The Y test (Lower quarter test) was used to evaluate the dynamic balance and stability of the lower extremities. This test measures Physical performance, functional symmetry, dynamic balance and core control. It can identify athletes with a higher risk of lower extremity injury (Shaffer *et al*., 2013). The Lower quarter test measures the balance and stability of the lower extremities, while the Upper quarter measures that of the upper extremities. It includes a test kit and a booklet to record values/scores at all levels. It is an evolution of research on the SEBT (The Star Excursion Balance Test) with excellent reliability in healthy subjects (Powden *et al*., 2019). The test is performed at a single-leg position. Each limb has three attempts in three directions: forward, back on the outside side, and back on the inside side. The results are calculated from a composite score before the start and after the end of the intervention program. At the same time, asymmetry can be estimated by comparing the results from each arm with a rate of less than 4%, which is a good symmetry index.

The Y test showed good test-retest reliability and excellent reliability with an ICC correlation coefficient of 0.88–0.99 (Plisky *et al*., 2009; Shaffer *et al*., 2013).

2.5.2. Physical Function of Lower Limbs: Single Limb Single Hop Test

The single hop test measured physical function, strength and stability of lower limbs. It is performed in a standing position, in a single-leg stance, while hands are positioned on the waist. The purpose of this test is to jump on one leg as far as possible and land firmly on the same leg, maintaining stability. The distance is measured between the initial and final positions, from the starting line to the back of the heel of the landing leg. 2 pretest trials and 2 final jumps are recorded in each leg. The test shows a high range of Intraclass correlation coefficient (ICC > 0.90) (Ross *et al*., 2002) for test-retest reliability.

2.5.3. Aerobic Fitness: 6-Minute Walking Test

This test is measuring aerobic capacity and endurance. It is an easy, safe and validated test (Kervio *et al*., 2003) that involves 6 minutes of continuous brisk walking upon the signal of the examiner from a starting line with a change of direction every 30 m around a cone. The distance walked over time is recorded. The instruments used were a timer, two cones and a large measuring tape. It was executed under the same ground conditions as the outdoor facilities of the Department of Physical Education and Sport Science at the Democritus University of Thrace, both at baseline and after the intervention.

3. Statistical Analysis

The data analysis was conducted using IBM SPSS (Statistical Package for Social Sciences) Statistics version 29.0.0.0 for Windows. Additionally, tests for normality of distribution and equality of variances were performed for all variables analyzed in the study. A significance level of $p < 0.05$ was set for all analyses in the study. Initial and final measurements were conducted. The control group was evaluated with initial and final measurements during the same period.

For the statistical analysis of data pertaining to the functional test components (dynamic balance by the Y Balance Test and aerobic capacity), a two-way repeated measures ANOVA was employed. This analysis included one repeated factor (by time × 2) and one independent factor (by group level × 3) to examine potential differences in the dependent variables between measurements (initial, final) and program groups (two Tai Chi intervention groups, beginners and experienced, one control group). If the interaction between the factors or their main effects were statistically significant, the LSD multiple comparison test was subsequently applied to assess the differences between the various levels of the factors (multiple comparisons test). Levene's test was conducted to verify the equality of variances, and the Kolmogorov-Smirnov test was used to assess normality, both supporting the assumptions. A two-way ANCOVA analysis of covariance was utilized to account for initial performance differences in lower limb physical function. The dependent variables were the measurements of lower limb function for both the left and right leg, with initial measurements serving as covariates. The Kolmogorov-Smirnov test was used to assess normality, supporting the hypothesis, while Levene's test for equality of variances indicated that the variables in this test did not exhibit homogeneity of variances in absolute terms. The dependent variables were the measurements of lower limb function for both the left and right legs, with initial measurements serving as covariates. Descriptive statistics were used to present the mean values and standard deviations of the variables for all groups at pre and post-test measurements.

4. Results

4.1. Dynamic Balance

Regarding the evaluation of dynamic balance using the Y Balance Test performed with the left limb, a Two-Way Repeated Measures ANOVA revealed a statistically significant interaction between the two factors (time and group level) for the left limb ($F = 3.464$, $p = 0.044 < 0.05$) in dynamic balance. Analyzing the interaction for each level of the "group by level" factor (TC beginners, TC experienced, Control Group), a statistically significant effect of the repeated "time" factor was found only in the "TC beginners" level ($p = 0.004 < 0.05$), while the other levels did not show statistically significant differences. Since the "group by level" factor has three levels (TC beginners, TC experienced, and Control Group), the multiple comparisons test revealed at the final measurement that two TC intervention groups improved, reporting statistically significantly higher performance scores than the control group. However, there was no statistically significant difference between the beginners and experienced groups in dynamic balance (Table I and Fig. 1a).

The results of dynamic balance using the Y Balance Test for the right limb revealed a non-statistically significant interaction between the two factors (time and group by level) ($F = 1.368$, $p = 0.27 > 0.05$). However, a statistically significant main effect of the repeated factor "time" ($F = 9.045$, $p = 0.005$) was observed on dynamic balance across the three groups. Conversely, there was no statistically significant main effect of the "group by level" factor ($F = 2.507$, $p = 0.098 > 0.05$) on dynamic balance. The beginners group demonstrated a statistically significantly greater improvement in the dynamic balance between initial and final measurements compared to the experienced practitioners group. The control group did not show the same level of improvement (Table I and Fig.1b).

4.2. Asymmetry Score

Regarding the asymmetry index between the two extremities, it was observed that the three groups (TAI CHI novices, TAI CHI experienced, Control Group) did not exhibit the same pattern of evolution. Conclusively, both levels of the TAI CHI groups demonstrated a good symmetry index, with the

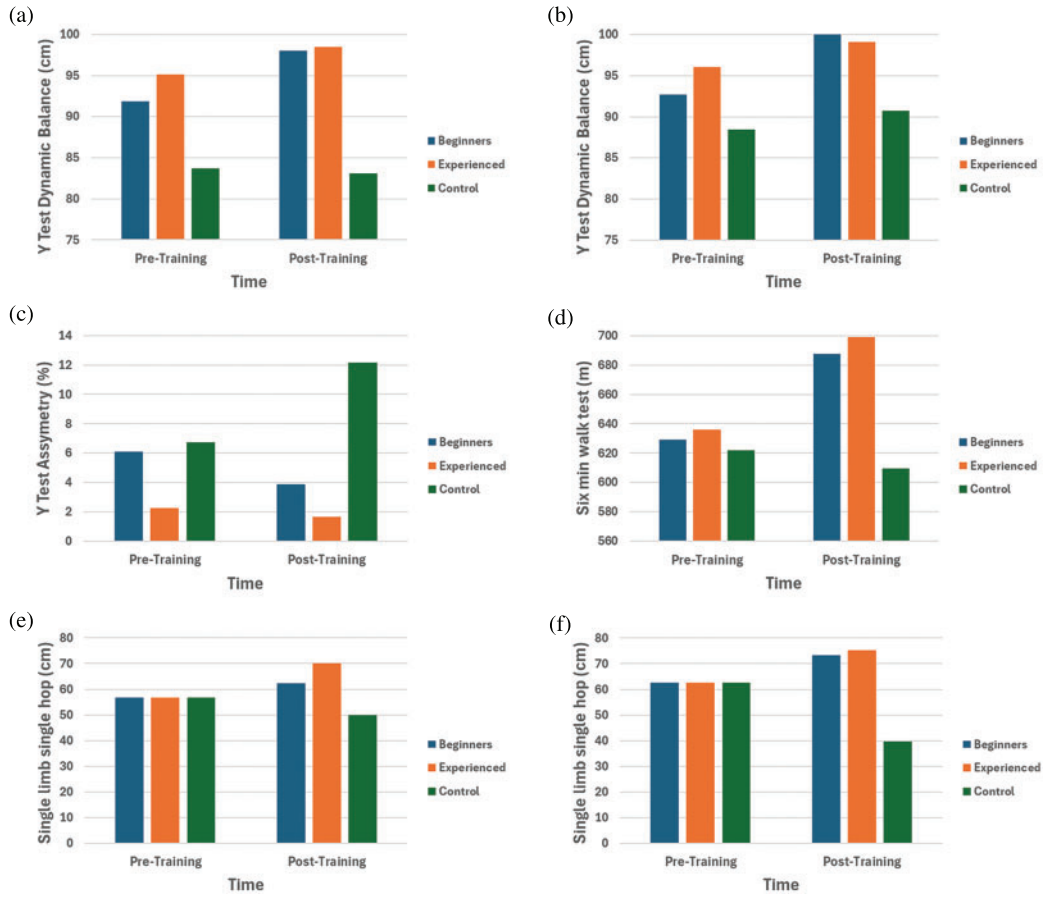

Fig. 1. Means values for (a) Y test dynamic balance left leg, (b) Y test dynamic balance right leg, (c) Y test asymmetry, (d) aerobic capacity, (e) single limb single hop left leg, and (f) single limb single hop right leg.

TABLE I: Results in Means, Standard Deviation, (ANOVA) Two-Way Analysis of Variance Repeated Measures

	Pre-training			Post-training		
	TC beginners M ± SD	TC experienced M ± SD	Control M ± SD	TC Beginners M ± SD	TC experienced M ± SD	Control M ± SD
Dynamic balance LLeg (cm)	91.87 ± 9.91	95.09 ± 9.51	83.73 ± 12.75	98.05 ± 8.47*	98.45 ± 10.14	83.07 ± 9.81
Dynamic balance RLeg	92.72 ± 14.92	96.02 ± 8.20	88.46 ± 7.98	100.02 ± 8.90*	99.08 ± 10.21	90.74 ± 10.02
Asymmetry index (%)	6.11 ± 6.44	2.26 ± 1.87	6.73 ±7.28	3.87 ± 2.67	1.67 ± 1.37	12.14 ± 10.05
Aerobic capacity (m)	629.05 ± 1.58	636.15 ± 42.47	622.02 ± 89.93	687.62 ± 54.00*	698.98 ± 35.59*	609.40 ± 91.14

Note: *p < 0.05, M = Mean, SE = Standard Error.

asymmetry percentage decreasing below 4% in the beginners and the experienced individuals, further improving this percentage in contrast to control subjects (Table I and Fig. 1c).

4.3. Aerobic Capacity

Regarding the evaluation of aerobic capacity using the 6-minute walk test, the application of a Two-Way Repeated Measures ANOVA (2x2) revealed a statistically significant interaction between the two factors (time and group by level) ($F = 19.756$, $p = 0.001 < 0.05$) on aerobic capacity. A statistically significant effect of the repeated "time" factor was found in the two levels of the Tai Chi intervention group, while the "Control Group" level did not show a statistically significant change. Furthermore, a statistically significant effect of the "group by level" factor was found only at the final measurement time point ($F = 5.852$, $p = 0.007 < 0.05$). LSD multiple comparisons test revealed that in the first measurement, the three levels did report significant differences in aerobic capacity, with the Control Group having the lowest performance and the experienced group having the highest. In contrast, in the second measurement, both the beginners ($p = 0.009 < 0.05$) and the experienced ($p = 0.007 <$

TABLE II: Results in Adjusted Means, Covariates Appearing at Initial Measurements

Single limb single hop test	Pre-training			Post-training		
	TC beginners	TC experienced	Control	TC beginners M ± SE	TC experienced M ± SE	Control M ± SE
LLeg	56.79	56.79	56.79	62.25 ± 3.81	70.10 ± 4.55*	49.87 ± 3.04
RLeg	62.67	62.67	62.67	73.29 ± 4.03*	75.12 ± 4.40*	39.72 ± 2.93

Note: *$p < 0.05$, M = Mean, SE = Standard Error.

0.05) had statistically significantly higher performance than the Control Group, while there was no statistically significant difference in aerobic capacity between the beginners and the experienced group, with the beginners having slightly lower performance (Table I and Fig. 1d).

4.4. Physical Function of Lower Limbs

For the assessment of the physical function of the left leg, after statistically controlling for the covariate "initial measurement of the left foot" ($F = 25.01$, $p = 0.001 < 0.05$), analysis of covariance (ANCOVA) revealed a statistically significant interaction between the two factors (time and intervention group by level) ($F = 12.11$, $p = 0.001 < 0.05$). This suggests that lower limb function changes vary over time at the intervention group level. A significant main effect of the intervention group on lower limb function ($F = 4.83$, $p = 0.015 < 0.05$) suggested that there was a significant impact on the physical function of the lower limbs. There was also a significant main effect of the time factor ($F = 25.01$, $p = 0.001 < 0.05$), indicating a significant difference from baseline to follow-up measurement of the physical function of the leg. Post-hoc comparisons revealed that there were positive effects on both TC groups, with the experienced group improving significantly compared to both TC beginners and the control group (Table II, Fig. 1e). Similar significant results were reported for the right leg with adjusted means revealing important differences between experimental groups and the control group (Table II and Fig. 1f).

5. Discussion

The results of the present study revealed a significant effect on dynamic balance and an improvement of asymmetry score on both legs between baseline and final measurements. Both experimental groups reported a significantly higher score in dynamic balance than the control subjects. At the same time, beginners demonstrated a statistically significantly greater improvement in a dynamic balance between initial and final measurements compared to the experienced practitioner's group. As a multidimensional mechanism, Tai Chi training affects balance through interdisciplinary characteristics of its moderate exercise nature. The activation of different muscle groups, the sequence of movements, the duration, and the exercise of the body and mind may positively affect the control of the body's posture and the better sense of its position in space. Similar findings were revealed after the evaluation of the assessment of the physical function of lower limbs with posthoc comparisons referring to greater improvements in the TC-experienced group in comparison to both TC beginners and the control group. The single-limb single-hop test results suggest improvements in lower limb strength. Combining the results of both factors, a study by Li *et al*. (2004) implied that improved functional balance may also positively influence the rates of falls in older adults.

The present study's findings also showed that TC exercise seems to be an effective method for improving aerobic capacity in adults.

Regarding dynamic balance training, the use of TC programs is supported by existing literature.

More specifically, analyzing the biomechanical characteristics of TC Yang Style practice in healthy subjects, mainly concerning the rooting technique that refers to the foot-ground contact parameters, the study of Wu and Hitt (2005) revealed that, as walking speed is considered moderately slow in the patterns of TC forms in contrast to normal walking, the weight shift and dispositioning of the body throughout the training implies a better body and postural control during the Tai Chi gait which can be referred as an effect on dynamic balance. Laboratory studies show that Tai Chi improves the strength of the lower limbs, especially the knee and ankle, thus supporting posture control (Wu & Millon, 2008). In addition, it has been supported that TC enhances proprioception parameters that improve balance. According to the study of Guo *et al*. (2014), who compared twenty-five subjects divided into two groups of sixteen TC practitioners according to their level of experience and nine control subjects, results showed that the TC group reported better balance ability due to a 44% better variance in medial-lateral sway direction and 53% improvement of variance in anteroposterior sway direction.

Furthermore, in view of the present study results and research design, Tai Chi training included repeated weight shifts, trunk rotations, fine muscle adjustments, and leg stances that all affect postural control, stability and flexibility of lower extremities against external stimulation. Consequently, dynamic balance relates to those adjustments (Gómez-Campos *et al*., 2023; Tse & Bailey, 1992). Investigating the effect of long-term TC on postural balance and H-reflex in a similar study (Guan & Koceja, 2011), it has been supported that sustained Tai Chi practice has a positive influence and may induce adaptations in reflex modulation over time. The study investigated 16 healthy adults divided into two groups of 8 experienced and 8 non-experienced TC participants and one control group. Four conditions assessments also revealed a significant reduction in sway among the TC groups across all scenarios compared to control subjects.

Regarding physical function, researchers (Song *et al*., 2014) implied that short-term TC exercise is not as effective as longer termed programs concerning its influence on fitness conditions of lower limb strength, BMD and balance in healthy female subjects. In this case, at least 12 weeks of TC training was suggested to outline the important improvements more effectively. According to a study by Jain *et al*. (2017), a 10-week supervised TC intervention was applied to examine the effect on lower extremity mobility and strength, ankle proprioception, and postural adaptation in older adults. After pre and post-measurements, the results reported improvements in the TC group for backward ankle proprioception and functional lower extremity strength compared to the control group. The authors suggested TC as an effective alternative exercise method that improves general health, mobility, and strength.

Regarding aerobic capacity, the present study found that both beginners and those who were experienced had statistically significantly higher performance than the control group. At the same time, there was no statistically significant difference in aerobic capacity between the beginners and the experienced group, with the beginners having slightly lower performance in accordance with other authors. A study by Hartman *et al*. (2000) that examined the effect of TC training in older subjects with knee osteoarthritis reported that approximately an hour of Tai Chi training is comparable to walking 6 km in terms of exercise intensity. They reported an improvement in stamina, with the experimental group scoring significantly better than the control group, which only underwent physical therapy. Lan *et al.* (2004) reported that Yang-style TC is an aerobic exercise of moderate intensity that is beneficial for the general function of practitioners. According to the study by Lan *et al.* (2004), there were improvements in parameters in cardiorespiratory responses to exercise, like aerobic capacity and ventilatory efficiency, between practitioners of TC and Qigong compared to a control group. TC exercise was reported to have, on one hand, better training effects than Qigong, while Qigong enhanced breathing efficiency through improved level of oxygen uptake due to the diaphragmatic breathing technique.

Furthermore, a study by Zhuo *et al*. (1984) found that a long TC form responded to an energy cost of 4.1 METs and mean values of VO2 of 1.03 L/min or 14.5 mL/kg/min. This study examined the physiological demands of this exercise. Eleven healthy males, with an average age of 28.4 years, were evaluated for oxygen consumption and related metabolic variables, heart rate, and blood pressure during the Long-Form Tai Chi Chuan of Yang's style. These findings indicate that Long-Form TC can be classified as moderate exercise, with an intensity that does not exceed 50% of an individual's maximum oxygen intake.

Due to the restrictive measures of the pandemic, the structured TC lessons had an encouraging effect on the trainees by creating a routine of human communication where discussions about everyday life thrived between the modules of the lesson and created a pleasant note between the participants and the instructor. The meetings were often characterized as 'psychotherapeutic' - in the sense that they probably had some positive effect on the general emotional and mental condition of the practitioners. This assumption is also indicated in the study of Li *et al*. (2002), where Tai Chi programs enhanced self-esteem, physical condition, and improved quality of life.

6. Conclusion

Based on the overall results of this study, the conditions of 18 weeks of TC intervention were adequate in duration. Thus, they positively impacted the improvement of the physical function and balance in the lower limbs. In contrast, physical fitness and endurance are enhanced through Yang-style TC forms because of the increased positive effect on aerobic capacity. Due to the pandemic, the mixed intervention program in Tai Chi was a necessary solution, as was the case with many exercise programs. The advantages of the distance learning online Tai Chi program seem to be its good adaptability, security, and ease of attendance; the improvement of psychology; the motivation for active participation; and the possibility of attending classes with teachers from other places or abroad.

The study's limitations were the difficulties in managing the video-conferencing conditions in the online program. Those are identified as internet connection problems, familiarity with new technologies, limited space to practice at home, reduced ability to correct practitioners, lack of human contact and adjusted in-depth training at all levels. However, it is an important tool that additionally enhances the possibilities of exercise and enriches the practice of Tai Chi during times of crisis. A constant growth of studies that examine the effect of alternative mind-body exercise during the pandemic of Covid19 is a fact. Furthermore, some advantages of online classes are that they are safe, time-saving, and adaptable to various conditions and the needs of practitioners. A growing need for online classes has emerged because they respond to the needs of people with busy lifestyles as a good solution to working out at home.

This way, structured and well-prepared TC lessons could be an effective tool that could complement live training. As there is a lack of studies incorporating these methodologies, the effect of mixed live and online research designs may be the subject of further research.

The authors also suggest that the implementation of TC programs should be designed for a minimum of 10–12 weeks to affect better factors that relate to the functional ability of healthy individuals.

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Conflict of Interest

The authors declare that they do not have any conflict of interest.

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