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Tai Chi and Yoga Performance Prior to Eccentric Exercise Benefits Older Adults with Chronic Conditions. A Pilot Study

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SUMMARY

Background. Previous research indicates that eccentric contraction (ECC) exercise training was more effective for improving the muscle strength, mobility, balance, and postural stability of older adults compared to the concentric contraction (CON) exercise training. Chair yoga (CY) and tai chi (TC) popularity have grown tremendously in the past several years to treat older adults with chronic conditions. The study investigated the effect of CY and TC performance prior to various intensity of ECC exercise induced muscle pain, delayed onset of muscle sores (DOMS), and strength in sedentary older adults. The study also compared the physical status of the sedentary older adults before and after performing the entire exercise protocol.

Methods. Nine sedentary older adults with chronic condition(s) aged between 60 and 90 performed CY and TC prior to ECC exercise protocol for 9 weeks. The medical pre-protocol, ECC exercise with or without CY and TC, subjective (health activities of daily living (ADL) difficulty scale; visual analog scale (VAS), and DOMS, and objective (pressure pain threshold (PPT), and medical post-protocol assessments were carried out. The results of medical pre-protocol and medical post-protocol assessments were compared.

Results. Our results show that functional limitations, DOMS, VAS, and PPT levels were improved when the CY and TC were performed in weeks 2, 4, 6, and 8 compared to when ECC exercise was performed in weeks 3 and 7. The manual muscle testing (MMT), active range of motion (AROM), and maximal voluntary isometric contraction (MVIC) were improved and showed significant differences on the weak muscle groups. The mean Tinetti balance and gait score showed significant difference whereas the general endurance score did not show significant difference.

Conclusions. After 9 weeks, CY, and TC performance prior to ECC exercise improved muscle strength, balance, gait, AROM and ADL activities in the sedentary older adults with chronic conditions. This can potentially prevent age-related mobility and balance as well as its related fall risk.

KEY WORDS

Muscle pain; older adults; muscle strength; balance; gait.

INTRODUCTION

Regular physical exercise helps to improve the physical and mental functions of the older adults and keep them mobile and independent (1). The older adults are sedentary for approximately 10 h per day which is greater than any other age groups. Prolonged period of sitting may cause losing of the muscle mass, and further decline functional mobility and increase risk for falls, weakness, and dependency. Most of the older adults may have one or more chronic health conditions like diabetes (type 2), heart disease, arthritis, or cancer (2). There is always a challenge and difficulty for the older adults with chronic conditions to participate in regular physical exercise programs.

According to the U.S. Centers for Disease Control and Prevention, one in four Americans aged 65+ falls each year; every 11 seconds, an older adult is treated in the emergency room for a fall, and every 19 mins an older adult die from a fall (3). Falls, with or without injury, also carry a heavy quality of life impact. Age-related skeletal muscle mass loss is common in the older adults (4, 5). The lack of physical activity and interaction can also result in the decreased mobility, social isolation, poor muscle strength, and diminished balance (6, 7). The key guideline for the older adults with chronic conditions is to engage themselves in a self-generated or organization generated exercise activity such as walking, running, muscle strengthening program, endurance training, balance training that will enhance them to perform their activities of daily living (ADL) independently (3, 8). So, specifically tailored resistance exercise and balance training programs can be developed for older adults with the chronic conditions that can easily be implemented into clinical practice (9).

In routine exercise, the skeletal muscle generates force by either concentric contraction (CON; shortening) or eccentric contraction (ECC; lengthening). The ECC exercise generates large muscle tension due to the decreased rate of actin-myosin cross-bridge detachment and lower energy expenditure than the CON exercise (10, 11). During CON for the actin-myosin cross-bridge separation, adenosine triphosphate (ATP; energy) is utilized. While during the ECC, the cross-bridges are forcibly separated due to the stretching of the muscle fibers, resulting in less ATP consumption (12). As the ECC exercise has specific physiological and mechanical properties, there is an increasing interest in employing the ECC muscle work for the rehabilitation and clinical purposes (13). But, overstretching due to the ECC does not allow the overlap between myosin and actin filaments, thereby exceeding the allowable capacity for connective tissue and other proteins in the sarcomere, and as a result, repetitive ECC loads can damage the muscle cells and cause muscle pain and delayed onset of muscle soreness (DOMS) (14). ECC exercises performed at a greater intensity led to the muscle inflammation, damage, pain, and temporary DOMS for 2-3 days of post-exercise in the older adults (15-17). However, the initial 2 to 3-week mild to moderate intensity ECC exercises performance showed less DOMS and pain in sedentary older adults (16, 18). Studies have supported that the ECC manual resistance exercise training was more effective for improving the muscle strength, mobility, balance, and postural stability of older adults with chronic conditions compared to the CON exercise training (19-21).

Yoga and tai chi (TC) popularity have grown tremendously in the past several years to treat many diseases. Performing yoga and TC poses have tremendous health benefits like relief pain (22-28), improve flexibility and balance (27, 28), and muscle strength (22, 29). A significant number of older adults cannot participate in traditional yoga due to problems with the balance, lack of muscle strength, or fear of falling caused by impaired balance. Chair yoga (CY) is practiced sitting on a chair or standing while holding the chair for support (30). CY and TC are gentle and easy-to-learn that are appropriate for older adults who cannot participate in traditional yoga or exercise and are shown to be associated with decreased pain, improved physical function (28, 31), decreased depression, and improved life satisfaction compared to other interventions (25, 32-35).

Yoga and TC exercise can be combined with ECC or CON exercise session. Yoga and TC can be performed before or after every ECC or CON exercise session depending on the intensity, type, and repetitions of the ECC or CON exercise session. In the published literature search, we found a few studies showing the effect of yoga poses on ECC exercise induced DOMS, pain, strength, and balance in the younger population (36-38). There is a need for the research focusing on the sedentary older adults with chronic conditions to see the effect of CY and TC on various intensity of ECC exercise induced DOMS, pain, strength, and balance. Hypothesis of this study was that the performance of CY and TC prior to lower intensity ECC exercise will lower DOMS, pain, and improve strength, balance, and functional limitations. Current study might help to determine the ideal intensity of ECC exercise which can be performed by the older adults with chronic conditions comfortably.

Therefore, the first aim of our study was to investigate the effect of CY and TC performance prior to various intensity of ECC exercise induced muscle pain, DOMS, and strength in sedentary older adults.

The second aim was to compare the physical status (balance, gait, AROM, muscle strength, and functional limitations) of the sedentary older adults before and after performing the entire exercise protocol.

METHODS

Participants

In the cross-sectional pilot study, a total of 13 sedentary older adults were screened and 4 were excluded for the reasons described in **figure 1**. Nine sedentary older adults (6 women and 3 men; aged between 60 and 90) with chronic condition(s) were recruited after the screening process. The selected participants were independent to complete their ADLs without assistive devices. The informed consent was obtained before

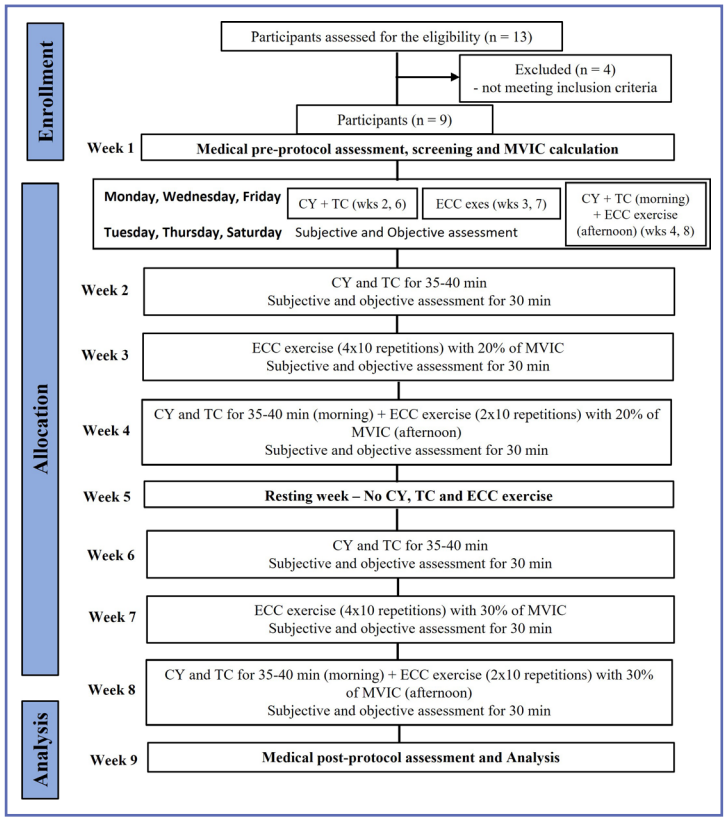

Figure 1. Simplified experimental design and testing procedure.

enrolling the participants. The study was approved by the author's Institutional Review Board (19.05.08-004). Physician approval was also obtained for all the participants. The study was carried out at the Bessy Commons assisted living facility, Scarborough, Maine, USA. The author of this study has followed the international ethical principles as well as the ethical standards of Helsinki. The inclusion and exclusion criteria and the do's and don'ts of the study participants are listed in the **table I**.

Procedures

The simplified experimental design and testing procedures are summarized in **figure 1**.

Week 1

Health screening (height, weight, body mass index (BMI), blood pressure (BP), and heart rate (HR)) was performed for the participants (**table II**). BP and HR were checked every day before starting the exercise session, and post-exercise session. The eligible participants were recruited for the study after recording the medical pre-protocol assessments listed in the **table III**. The entire study protocol was thoroughly

Table I. Inclusion/exclusion criteria and do's/don'ts of the study participants.

Inclusion criteria	**Exclusion criteria**
(Must have at least one condition)	
Diabetes, peripheral neuropathy	Bedridden, difficulty breathing at rest
Peripheral vascular disease	Total assistance with all activities
Acute/chronic kidney disease (stage I and 2)	Wheelchair-bound, cardiac palpitations
Chronic obstructive pulmonary disease (COPD)	Parkinson's disease
History of stroke, joint pain (arthritis)	Patient with 24 h care
Congestive heart failure, anxiety, and cancer	High blood pressure (systolic>140/diastolic>90)
Do's	**Don'ts**
Perform their normal activities of daily living	Consuming any anti-inflammatory drugs
	Nutritional supplements 2 h prior exercise
	Alcohol 12 h prior to the exercise
	Any stretching exercises
	Therapeutic/prophylactic interventions
	Heavy weightlifting
	Unaccustomed new physical activities

Table II. Demographical characteristics of the study participants during the screening process.

Gender	Women	Men	
Participants	6	3	
	Mean ± SD	Mean ± SD	P-value
Age (years)	81.5 ± 3.56	77.4 ± 5.25	0.589 (ns)
Height (cm)	166 ± 2.89	174.12 ± 4.10	0.045**
Body weight (Kg)	63 ± 4.56	74 ± 3.27	0.009**
Body mass index (BMI)	20.28 ± 2.01	21.02 ± 2.32	0.757 (ns)
Blood pressure (BP)	120/81 ± 3/1	121/82 ± 4/2	1.563 (ns)
Heart rate (HR)	86 ± 4	92 ± 5	0.894 (ns)

SD: standard deviation; ns: not significance; *: significance.

Table III. List of medical pre- and post-protocol assessments performed in the participants selection process.

	Screening assessments	Eligibility Requirement
1	Initial screening questionnaire to assess the participants health status by marking	
	all true statements and physical activity readiness questionnaire (PAR-Q)	
2	Functional limitations of the participants by setting certain ADL activities	
3	Active range of motions (AROM) in the upper and lower extremity joints	
	using Taytools digital goniometer with stainless steel blades	
4	Manual muscle testing (MMT) on the shoulder, elbow, hip, and knee muscle groups	> 3/5
5	Tinetti balance and gait assessment	> 20/28
6	General endurance test (2-min walk test)	200 sq. ft/2-min
7	Rating of perceived exertion (range 0-10) after the 2-min walk test	5

explained to the participants using demonstrations. During the training, the principal investigator (PI), a certified yoga-tai chi instructor and 3 research assistants constantly monitored the participants and were prepared for any emergencies.

The maximal voluntary isometric contraction (MVIC; muscle strength) calculation was carried out and documented on the ten selected muscle groups using a hand-held dynamometer (Lafayette Instrument, Manual Muscle Testing (MMT) Device, Pro-Health Care, USA): a) Elbow flexion at 90°; b) Elbow extension at 90°; c) Shoulder abduction at 0°; d) Shoulder flexion at 0°; e) Shoulder extension at 0°; f) Hip flexion at 90°; g) Hip extension at 90°; h) Hip abduction at 90°; i) Knee extension at 90° and j) Knee flexion at 90° (39, 40). The selected ten muscle groups for the study were elbow flexors, elbow extensors, shoulder flexors, shoulder extensors, shoulder abductors, hip flexors, hip extensors, hip abductors, knee flexors, and knee extensors (**figure 2**). MVIC calculation was done on the selected ten muscle groups on the first day of every week.

Weeks 2-8

Hair yoga (CY) and tai chi (TC) sessions were conducted for the participants on Monday, Wednesday, and Friday of weeks 2, 4, 6 and 8 for about 35-40 min/day. ECC exercise were performed by the participants on Monday, Wednesday, and Friday of weeks 3, 4, 7 and 8 with adequate resting period. The subjective (health activities of daily living (ADL) difficulty scale, visual analog scale (VAS) and DOMS) and objective (pressure pain threshold (PPT)) assessments were carried out on Tuesday, Thursday, and Saturday of all the weeks (except week 5) for about 30 min/day. Week 5 was given as a resting week for the participants (**figure 1**).

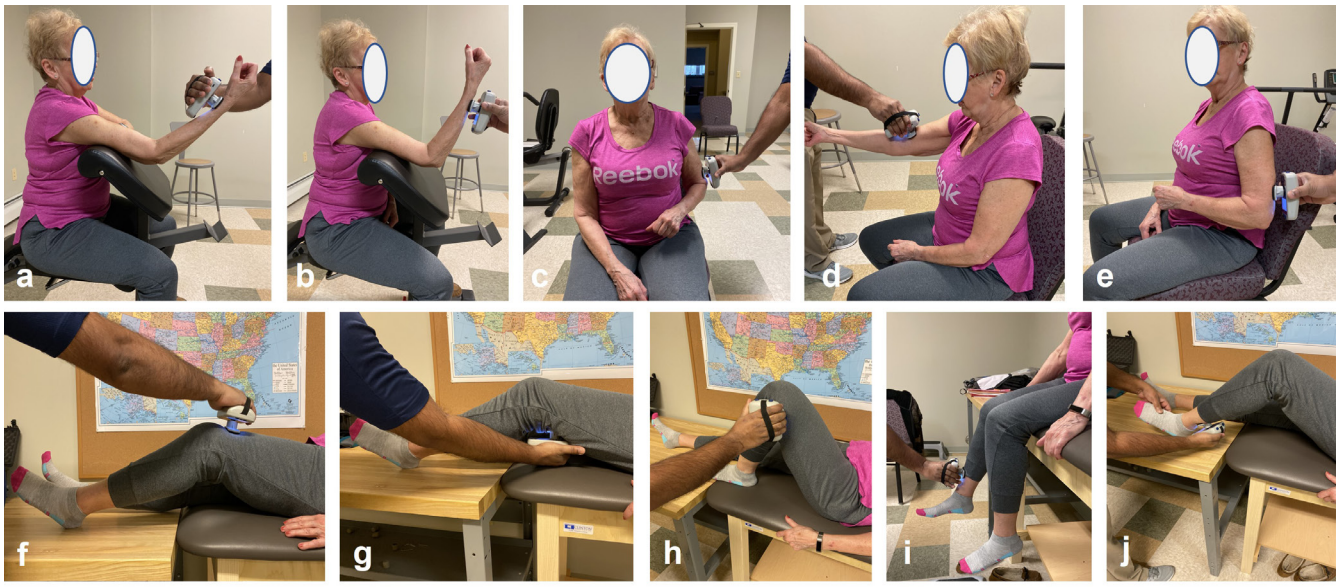

Figure 2. Participants performing maximal voluntary isometric contraction (MVIC) while researcher holding Dynamometer on the elbow flexors **(a)**, elbow extensors **(b)**, shoulder flexors **(c)**, shoulder abductors **(d)**, shoulder extensors **(e)**, hip flexors **(f)**, hip extensors **(g)**, hip abductors **(h)**, knee flexors **(i)** and knee extensors **(j)**.

Chair yoga (CY) and tai chi (TC)

The CY and TC sessions were conducted as a group activity under the care of a certified instructor for about 35-40 min. The participants started with breathing exercises. The TC session was conducted for about 10-15 mins, followed by 5 mins rest period, then the CY poses were performed for about 15-20 mins. A total duration of 30-40 mins was spent on CY and TC training days. Participants performed cat/cow, forward fold, seated twist, chest opener, chair pigeon/hip opener, dancer, downward-facing dog, eagle, extended side angle, knee to chest, lunge, and tree CY poses using yoga chairs (24, 25, 28, 33, 34) (**figure 3**).

Subjective assessments

- A: ADL difficulty scale: participants were asked to perform the following activities and their pain responses were recorded. The pain scale ranged from 0 (no pain) to 10 (worst pain). The activities were: a) combing hair, b) pulling a heavy object, c) using arm to rise from a chair, d) carrying an object above the shoulder, e) putting on shirt/coat, f) washing opposite armpit and back, g) getting in and out of the car, h) walking on the flat ground, i) ascending stairs, j) descending stairs, k) getting in and out of bed, l) bending to pick up from the floor (41).
- B: Visual Analog Scale (VAS). The participants were asked to mark the level of perceived soreness on the plain paper (0 to 10 points; 0 indicated "no pain" and 10 indicated "extreme

Figure 3. (a) Participants performing chair yoga (CY) poses. **(b)** Participants performing tai chi (TC) session.

pain") when the mid-belly of the selected ten muscle groups was palpated in a circular motion by the investigator (39).
- C: the delayed onset of muscle soreness (DOMS) was assessed by asking the participants to perform the movements at the shoulder, elbow, hip and, knee joints (flexion for extensors, extensors for flexors, and adduction for abductors), and pain level was recorded based on their verbal responses (39).

Objective assessment
- D: Pressure Pain Threshold (PPT): PPT is the minimum amount of force applied to induce pain and measured using an electronic algometer (baseline 60-pound Dolorimeter/ Algometer pain threshold meter, pro-health care, USA) on the mid-belly of the selected ten muscle groups (39).

ECC exercise protocol

Participants performed ECC exercises (4 × 10 or 2 × 20 repetitions) on the selected ten muscle groups with an intensity of 20% or 30% MVIC using Ultimately Fit Adjustable Ankle Weights (Hayneedle Company, USA) (39, 40, 42) (**figures 1, 4**).

Week 9

Medical post-protocol assessment: the health screening, functional limitations, MMT, Tinetti balance and gait, MVIC, and general endurance assessments were carried out on the participants like the medical pre-protocol assessment (week 1) **table III**.

Statistical analysis

Statistical analysis was carried out using GraphPad Prism software (version 8.2.0), San Diego, CA. The paired-sample t-test and repeated measures one-way ANOVA with Tukey's multiple comparison tests were carried out and the difference between medical pre-protocol, study protocol, and medical post-protocol subjective and objective assessments were compared. The subjective and objective assessment results were also compared between the weeks. Statistical significance was set at an alpha level at $p \leq 0.05$.

RESULTS

A total of 9 sedentary older adults (6 women and 3 men) with chronic condition(s) participated and completed all the interventions in this study (**figure 1**). The characteristics of the participants are shown in the **table II**. There were no significant differences between women and men in terms of age, BMI, HR, and BP and were within the normal values throughout the study period. But there were significant differences between women and men in terms of their height and body weight **table II**.

The effect of CY and TC performance prior to ECC exercise (results of subjective and objective assessments) is presented in the Consort flow diagram (**figure 5**). The exercise induced DOMS, pain and functional limitations were carefully assessed and differentiated from the participants preexisting chronic condition(s) pain. Our results show that functional limitations, DOMS, VAS, and PPT levels were improved in the CY and TC performed weeks 2, 4, 6, and 8 compared to ECC exercise weeks 3 and 7. Participants did not perform any kind of exercises in the weeks 1, 5 and 9 to have the pain assessment result. The mean DOMS, VAS, and PPT results are shown in **figure 6**. In the ECC exercise week 3, DOMS, VAS, and PPT results showed moderate pain on shoulder abductors ($p = 0.009$), elbow extensors ($p = 0.012$),

Figure 4. Participants performing eccentric contraction (ECC) exercises using ankle weights on the elbow flexors **(a),** elbow extensors **(b)**, shoulder flexors **(c)**, shoulder abductors **(d)**, shoulder extensors **(e)**, hip flexors **(f)**, hip extensors **(g)**, hip abductors **(h)**, knee flexors **(i)** and knee extensors **(j)**.

hip abductors (p = 0.008) and hip extensors (p = 0.013) and were statistically significant different. In the ECC exercise week 7, VAS, and PPT assessments showed moderate pain on the shoulder abductors (p = 0.028), and elbow extensors (p = 0.042) and were statistically significant different. The DOMS and pain were felt only on weak muscle groups (weeks 3 and 7) of the participants. Our results show that CY and TC performance improved DOMS and pain that are induced by the ECC exercise weeks 4 and 8. There were no significant differences between women and men, and type(s) of chronic disease in terms of the functional limitations, DOMS, VAS, and PPT results.

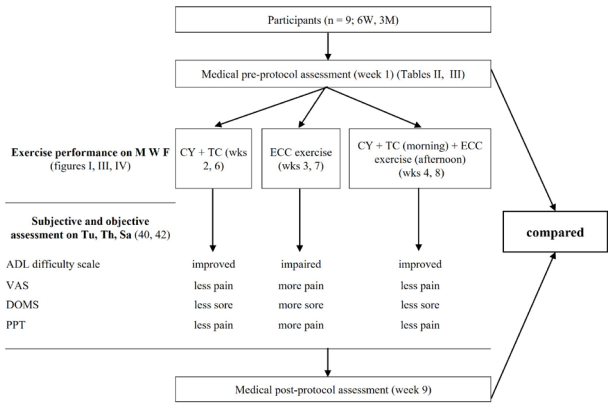

Figure 5. The Consort flow diagram shows the summary of assessment results.
M: Monday; Tu: Tuesday; W: Wednesday; Th: Thursday; F: Friday; Sa: Saturday.

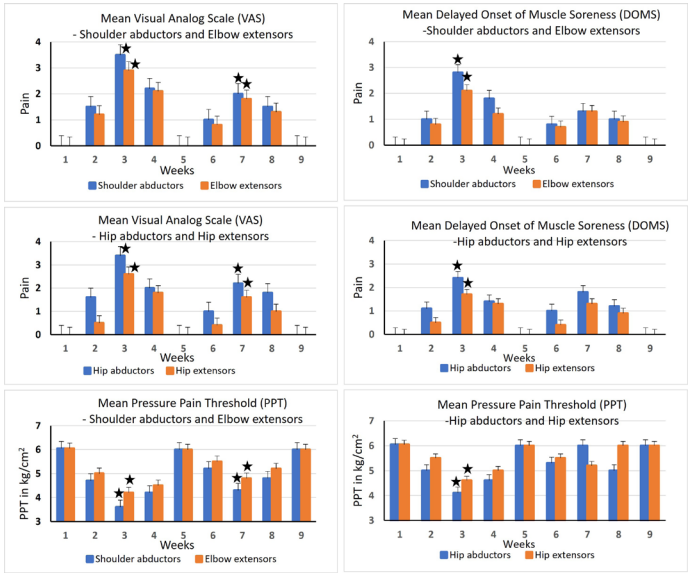

Figure 6. Mean delayed onset of muscle soreness (DOMS), visual analog scale (VAS), pain pressure threshold (PPT) assessment results.
*: significance.

The participants' medical pre-protocol results (week 1) were compared with medical post-protocol results (week 9) using paired t test (**figure 5**). The mean MMT, AROM, and MVIC results (week 1 and 9) were compared and presented in the **table IV**. In general, MMT, AROM, and MVIC improved in the selected ten muscle groups and their joints. MMT showed significant differences in the shoulder extensors, and abductors, elbow extensors and hip extensors and abductors. AROM showed significant differences in the shoulder flexors, and abductors, and hip extensors and abductors. MVIC showed significant differences in the selected ten muscle groups. The overall percentage of increased MVIC value at the medical post-protocol was between 13.04% and 26.31%. The MMT, AROM, and MVIC were improved and showed significant differences on the weak muscle groups **table IV**. The Tinetti balance and gait score, general endurance (2-min walk test distance) and functional limitations were also improved in the participants (**table V**). The mean Tinetti balance and gait score showed significant difference whereas the general endurance score did not show significant difference. There was no perceived exertion noted after the 2-min walk test and did not show significant difference (**table V**). There were no significant differences between medical pre-protocol and medical post-protocol results in terms of genders and type(s) of chronic disease. Our results show that CY and TC performance prior to ECC exercise improved the balance, gait, AROM, muscle strength, flexibility, and functional limitations of the participants by minimizing the ECC induced DOMS, and muscle pain and preexisting chronic condition(s) pain (**figure 7**).

DISCUSSION

The number of older adults continues to increase in the world, the prevention of physical disability is an important public health priority. Physical activity and mobility will help sedentary older adults to be independent for long time and delay the occurrence of disability in the future (1-3). Research works on older adults support that physical activity is effective for both preventing and controlling chronic conditions associated with multiple comorbidities such as, obesity, high BP, cardiovascular diseases, and type 2 diabetes (8, 9).
A big challenge is designing a suitable exercise program for sedentary older adults with chronic conditions and making them participate in the exercise program regularly. Due to age related physical and mental health issues it is a big challenge for them to participate consistently in routine physical activity. Also, performing vigorous high intensity exercises will be difficult for the sedentary older adults with chronic conditions as it requires more energy and muscle strength.

Table IV. Manual muscle testing (MMT), active range of motion (AROM), maximal voluntary isometric contraction (MVIC) comparison before (medical pre-protocol assessment; week 1) and after (medical post-protocol assessment; week 9) the study protocol.

	MMT (O-no contraction palpable, 5-normal strength)			AROM (in degrees)			MVIC (in lbs)		
	Week 1	Week 9	MD (P-value; significance)	Week 1	Week 9	MD (P-value; significance)	Week 1	Week 9	MD (P-value; significance)
	Mean (SD)	Mean (SD)		Mean (SD)	Mean (SD)		Mean (SD)	Mean (SD)	
Shoulder flexion	4.4 (0.4)	4.8 (0.31)	0.4 (0.096; ns)	138 (16)	165 (10)	27 (0.004; ***)	30 (5)	39 (6.1)	9 (0.006; ***)
Shoulder extension	4.1 (0.42)	4.7 (0.38)	0.6 (0.032; **)	45 (4.6)	51 (3.8)	6 (0.164; ns)	37 (3.5)	43 (5)	6 (0.04; **)
Shoulder abduction	3.5 (0.61)	4.6 (0.37)	1.1 (0.009; ***)	130 (18)	162 (12)	32 (0.003; ***)	26 (3)	33 (4.8)	7 (0.033; ***)
Elbow flexion	4.5 (0.38)	4.9 (0.21)	0.4 (0.106; ns)	158 (6)	164 (4.6)	6 (0.236; ns)	42 (3.2)	48 (2.5)	6 (0.046; *)
Elbow extension	4 (0.44)	4.7 (0.37)	0.7 (0.008; ***)	165 (6.2)	170 (4.2)	5 (0.314; ns)	25 (2)	30.5 (3.3)	5.5 (0.047; *)
Hip flexion	4.5 (0.36)	4.8 (0.26)	0.3 (0.12; ns)	85 (5.8)	94 (54)	9 (0.113; ns)	32 (3.8)	39 (4.1)	7 (0.027; **)
Hip extension	3.6 (0.465)	4.5 (0.38)	0.9 (0.014; **)	11 (4)	19 (3.7)	8 (0.009; **)	35 (3.5)	43.5 (3.8)	8.5 (0.018; **)
Hip abduction	3.5 (0.71)	4.7 (0.31)	1.2 (0.007; ***)	32 (5.6)	49 (3.9)	17 (0.004; ***)	28 (3.2)	38 (4.2)	10 (0.008; ***)
Knee flexion	4.3 (0.41)	4.7 (0.365)	0.4 (0.11; ns)	98 (12)	106 (8)	8 (0.136; ns)	38 (4.4)	45 (4.7)	7 (0.039; *)
Knee extension	4.5 (0.32)	4.8 (0.24)	0.3 (0.131; ns)	175 (8.2)	176 (7.8)	1 (0.435; ns)	46 (4.5)	55 (5.4)	9 (0.013; **)

MD: mean difference; ns: not significance; *: significance; SD: standard deviation.

Table V. Tinetti balance and gait, general endurance, and functional limitations comparison before (medical pre-protocol assessment; week 1 and after medical post-protocol assessment; week 9 the study protocol).

		Week 1	Week 9	MD (P-value; significance)
		Mean (SD)	Mean (SD)	
1	Tinetti balance and gait (max. score 28)	23.89 (1.90)	26.55 (0.73)	2.66 (0.0001; ***)
2	General endurance (2-min walk test in sq. ft)	437 (34.68)	489.33 (35)	52 (6.35; ns)
3	Rating of perceived exertion (RPE); O-no exertion, 10-maximal exertion	0.444 (0.726)	0 (0)	0.444 (0.103; ns)
4	Functional limitations	Week 1	Week 9	
	1 (W)	Arthritis in hands and right hip, difficulty in lifting things, hearing aids	Felt better in arthritis (free movements), persistence of mild difficulty in lifting things	
	2 (W)	Mild weakness on the right side of the body with hand tremor for the past 25 years	Overall activities improved, still having mild weakness	

	Week 1	Week 9	MD (P-value; significance)
	Mean (SD)	Mean (SD)	
3 (W)	Difficulty in performing fine hand functions, arthritic and mild stiff hands	Hand functions were improved	
4 (M)	Stiff shoulders, hearing aids	Shoulder(s) movements were improved	
5 (W)	History of left hip replacement surgery and stiffness	Improved hip stiffness	
6 (M)	Osteoarthritic knees with pain, hearing aids	Knee pain has improved	
7 (W)	Knee pain	Knee pain has improved	
8 (W)	Shoulder pain, hearing aids	Shoulder pain has improved	
9 (M)	Stiff shoulders	Improved stiff shoulders	

MD: mean difference; ns: not significance; *: significance; SD: standard deviation; W: women; M: men.

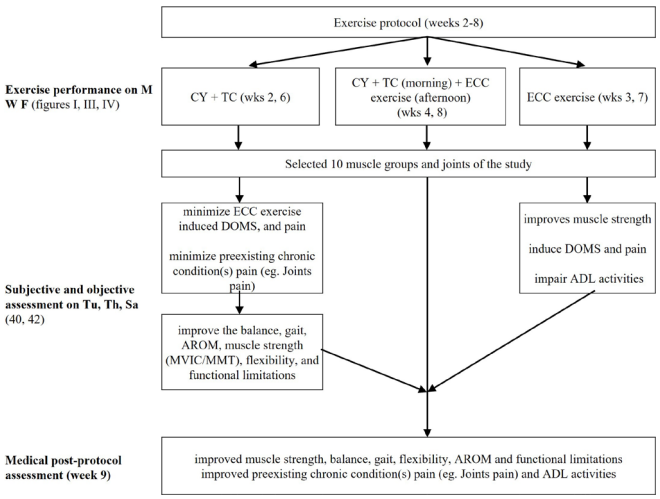

Figure 7. The Consort flow diagram shows the effect of chair yoga (CY), tai chi (TC) and eccentric contraction (ECC) exercise performance on the sedentary older adults.

M: Monday; Tu: Tuesday; W: Wednesday; Th: Thursday; F: Friday; Sa: Saturday.

High intensity ECC exercise induce DOMS, muscle pain and functional limitations that may not be possible and liked by older adults with chronic conditions. So, we designed a pilot study that involved low to moderate intensity ECC exercise protocol, suited well for this population group. Our exercise protocol included CY, TC and ECC exercises that were comfortable to perform, required less energy and muscle strength, and shown to have many health benefits. We observed trends of improvements in pain symptoms, functional limitations, muscle strength, balance, and gait functions in the post-protocol assessment (week 9) compared to pre-protocol assessment (week 1). The most important outcome of the study was, CY, TC performance prior to ECC exercise improved muscle strength, balance, gait, AROM and ADL activities of participated all sedentary older adults. CY and TC performance minimized the ECC induced DOMS, and pain and preexisting chronic condition(s) pain especially preexisting joint pain and mobility (**figure 7**). The selected participants completed entire study period successfully. There were no dropouts from the participants. All participants were enthusiastic, and co-operative throughout the study period. The exercise protocol showed health benefits to all women and men participated in this study and did not show significant differences between them. Past studies have confirmed that ECC exercise training improves muscle strength, aerobic capacity, and functional physical fitness in older adults better than CON exercise training (10-13). ECC exercise induces more pain and DOMS than CON exercise (14, 43). Mild to moderate intensity ECC exercises performance showed less DOMS and pain in sedentary older adults (16, 18). The eccentric exercise training of the knee extensors improved physical function and health parameters of older adults better than concentric training and suggested to focus on eccentric contractions in exercise medicine (44). ECC exercise can be combined with other therapies, which might be a feasible, cost-effective, and successful tool in the treatment of well-known pain conditions (45). The ECC endurance exercise is a potential training modality that can be applied to older adults for improving muscle strength, aerobic capacity, and functional ability (19-21). The study participants felt moderate DOMS and pain on the shoulder abductors, elbow extensors, hip abductors, and hip extensors in the weeks 3 and 7. This due to weak and less used upper and lower extremity muscle groups than the flexors of the upper extremity and extensors

of the lower extremity. In the weeks 3 and 7, due to sole performance of ECC exercise, participants experienced DOMS, pain, and functional limitations and there were no complementary therapeutic exercises like CY and TC. Research evidence supports that yoga and TC are valid complementary or alternative therapeutic exercises (25, 31). In the weeks 4 and 8, our participants performed mild to moderate ECC exercise and felt mild to moderate DOMS, pain, and functional limitations those were taken care by performing CY and TC. Our study results concur with previous studies outcome (14, 16, 18, 44). The magnitude of the preservation of ECC exercise strength in older adults ranged from 2% to 48% when compared to CON exercise strength. This ECC exercise strength might be clinically relevant, especially to initiate resistance training and rehabilitation programs in individuals with low levels of strength (37, 38, 48). In our study, the medical post-protocol MVIC (week 9) showed a higher muscle strength compared to medical pre-protocol MVIC (week 1). The overall percentage of increased MVIC value at the medical post-protocol was between 13.04% and 26.31%.

Research show that yoga and TC are described as meditation in motion that promotes serenity through gentle, slow, and focused movements coupled with deep breathing (23). The review of literature showed sufficient evidence to support yoga and TC performances have tremendous health benefits like relief pain, improve flexibility and balance, and muscle strength (22-29). There are no yoga and TC intervention-related serious adverse events that have been reported (24). Approximately, eight to ten weeks of exercise protocol can reduce the pain in chronic clinical conditions (46, 47). CY and TC are appropriate for older adults who cannot participate in traditional yoga or exercise and shown to be associated with decreased pain and, improved physical function (28, 31-35). A traditional Srichiangmai dance like TC significantly improved balance and mobility among older adults and prevent age-related fall risk (49). In a study, yoga combined with back school program intervention lowered anxiety, kinesiophobia and disability, and improved the quality of life in people affected by non-specific chronic low back pain (50).

This study results concurred with previous reports for promoting CY and TC in physical activity guidelines for sedentary older adults. In our study, CY and TC performance improved pain, balance, gait, flexibility, and functional activities. Although this pilot study was not designed to assess underlying mechanisms through which CY and TC ease pain, improve flexibility, muscle strength, balance and joint stability will need to be clarified in future studies.

We designed the study first time in the combination of CY, TC and ECC exercises (upper and lower extremity muscles) involving sedentary older adults. The outcome of the study showed benefits for all participants. Participants performed manual ECC exercises using adjustable ankle weights and dumbbells. There were a lot of physical works for the researchers while assisting ECC exercise for the selected nine participants. There is a need of performing the study with more participants (larger sample size). Within a short duration (9 weeks), participants received significant health benefits from the exercise protocol. We could not track and evaluate the long-term outcomes for the participants. At least, 6 to 12 months follow-up is necessary.

Suggestions for further research study

Participants were advised to continue to perform tai chi and yoga along with regular exercises with care. The study involved 10 upper and lower extremity muscle groups in total. Structure and function of the muscle vary in each region and their responses to ECC exercise, yoga and TC might vary. So, future research can be focused on various muscles groups and their responses can be tracked at the muscle cell and molecular level that might be measurable parameters.

CONCLUSIONS

Our results show that ECC exercises improved muscle strength and induced DOMS and muscle pain. CY and TC performance improved the balance, gait, AROM, muscle strength, flexibility, and functional limitations of the participants by minimizing the ECC induced DOMS, and muscle pain and preexisting chronic condition(s) pain. This pilot study also demonstrated the feasibility and acceptability of conducting CY, and TC prior to ECC exercise improved muscle strength, balance, gait, AROM and ADL activities in the sedentary older adults with chronic conditions. This can potentially prevent age-related mobility and balance decline as well as its related fall risk. The data collected and the challenges encountered will be useful for a future larger clinical trial in the older adult population. Our findings have important implications for clinical exercise prescription as low perceived training intensity (CY and TC), and exercise type (ECC) are well suited to the needs of older adults with chronic conditions.

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DATA AVAILABILITY

Data are available to the following repository link: https://www.dropbox.com/sh/b6vw07khq09c8xu/AAAFcS0_grD0qRgry9W6tq6Xa?dl=0.

CONTRIBUTIONS

CMS: data collection, writing of the manuscript, data analysis and revision of the manuscript.

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CONFLICT OF INTERESTS

The author declares that he has no conflict of interests.

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