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Does the arm swing exercise benefit spatio-temporal parameters for female elderly?

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KEYWORDS
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Stance Phase;
Swing Phase;
Stride Length.

ABSTRACT
Shuai Shou Gong (SSG) is a simple form of arm swing exercise that has been developed and applied in China for over a thousand years. It has a profound impact on maintaining physical health, especially for older people. While the spatio-temporal parameters (STP) of gait worsen in most elderly and lead to the risk of falls, the beneficial effects of SSG on these parameters of gait have not yet been verified. This study investigated the effects of SSG on the STP of gait in elderly females. Fifty-six elderly females who lived in urban communities in Khon Kaen province were recruited. They were randomly allocated into either an exercise group (EG) or a control group (CG). The EG took part in the SSG training program for eight weeks (40 minutes per day and three days per week). The CG maintained their daily life without any exercise during the same period. ANCOVA analysis revealed that SSG produced significant improvements in stance phase (left value and right value), swing phase (left value and right value), first double support phase (left value and right value), single support phase (left value), and stride length (left value and right value) in the EG compared to the CG (p-value < 0.05). Therefore, SSG could improve some temporal and spatial parameters of gait in elderly females.

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Introduction

Human gait relies on a complex interplay of crucial parts of the nervous, musculoskeletal, and cardiopulmonary systems. Spatio-temporal parameters control a person's mode of ambulation or locomotion, which involves movements of the whole body; a particular kind of gait is a specific way of walking[1]. The gait of the elderly is characterized by the strength of the back-foot decreasing as they walk, leading to a shorter step length, which relates to a lower walking speed[2]. These phenomena lead to more gait problems when the elderly are walking. The strength of the back foot in the beginning is less, which leads to a shorter step size. Shorter steps lead to a slower pace and longer feet support time. Shorter steps lead to more steps on the same road[3].

Among the elderly, the stride length decreases, the cycle time increases, and the walking base increases; the duration of the stance phase increases as a percentage of the gait cycle; stride length divided by cycle time almost always decreases[4]. The fear of falling affects the gait spatial-temporal parameters of the elderly; the gait will be slower, the stride length will be shorter, so the standing support time of the limbs is prolonged[5].

Kinematic gait analysis involves the description of gait components. It deals with motion, not dynamics, which studies the forces acting on objects. Therefore, we can use distance (space) and time parameters to analyze the STP of gait[5]. When scholars describe the kinematic characteristics of gait of the elderly, they usually include gait period, support phase, step length, stride length, gait cycle duration, and walking speed. Among scholars, the walking speed index has been widely used[6]. Older adults appear to have poor gait performance due to general muscle weakness, joint stiffness, and poor dynamic balance. The prevalence of gait abnormalities is 35% among people 70 years and older who live in the community[7]. Compared with younger adults, older adults walk slower, with a reduced stride length and an increased stance width[8]. A faster pace can be found in some elderly peoples' walk, because they might take more steps on the same path. Not only age itself, but also pathological conditions can affect gait in the elderly. Osteoarthritis and Parkinson's disease become more commonly found with age, which results in a shorter stride length. Typically, age-related gait changes occur between the ages of 60 and 70, where the stride length decreases, the cycle time increases, and the walking base increases[5].

The gait of older adults is characterized by the upper torso swinging back and forth and the body tilting slightly forward. Standing sway increases with age, after which the postural reflexes become sluggish. It could be that older people are more dependent on accurate feedback data to keep their balance. In addition, it has been observed that older adults decrease in the strength of the hindfoot during walking, resulting in a shorter stride length[9]. Therefore, any exercise mode that improves muscle strength of the leg and trunk might lead to improvement of gait parameters and to less risk of falls.

Shuai Shou Gong (SSG) is a simple form of arm swinging exercise that has been developed and applied by Chinese people. It is easy to practice individually and as a group exercise in a community. Typically, SSG is done by swinging the arms rhythmically in a standing position with straight legs alternating with knee bending. Based on the principles of training, SSG could result in increased muscle strength and balance control of lower limbs and trunk simultaneously. Several studies have found positive effects of SSG, including increased range of shoulder motion and reduced forward head posture in adults[10], improved exercise capacity and peak oxygen consumption in the overweight and normal weight sedentary young adults[11], glycaemic control of type 2 diabetes subjects[12], cognitive performance in older women with mild cognitive impairment[13], cardiac autonomic function in patients with chronic obstructive pulmonary disease[14], and reduced waist circumference with obesity participants[15]. However, the effects of SSG on the STP of elderly females in the community have not been verified. Since these components of physical capabilities could contribute to normal gait in humans, it is therefore hypothesized that SSG would have a positive effect on STP gait parameters.

Materials and methods

An experimental design was conducted in a subdistrict of Khon Kaen province, Thailand. The researcher selected two communities in Khon Kaen province based on similar age group and Barthel activities of daily living index (BADLI). Then the two communities were randomly assigned to an exercise group and a control group. This study was approved by the Research Ethics Committee of Khon Kaen University, Thailand (HE612355). The study is registered with the Clinical Trials Registry of Thailand (TCTR20200709001).

Sample

The sample size was calculated by the following formula[16].

$$\text{n/group} = \frac{2\sigma^2(z_\alpha + z_\beta)^2\,(1-\rho^2)}{(\mu 1 - \mu 2)^2}$$

Since the current study was a part of the main study that verifies the effects of SSG on standing posture, the sample size calculation was based on data from a previous study using occiput-wall distance as a major outcome measure. Thus, $\mu 1$ = 6.0 cm.; $\mu 2$ = 7.88 cm.; α = 0.05 ($Z_{0.05}$ = 1.645) and β power was set to 80%, ß=0.2 ($Z_{0.2}$ = 0.842)[17]. The dropout rate was set at 20%, because the intervention period was eight weeks, which is a relatively long time. The sample size was 28 per group, and the total sample size of this experiment was 56.

The inclusion criteria for participants were being older women, between 60 and 80 years old, who lived in Khon Kaen province during the study period and who could communicate in Thai. The participants' mental state scores, tested by the Thai version of the Mini-Mental State Examination, were between 10-24 points[18]. Moreover, the participants had to be able to walk independently and as indicated by the Barthel Activity Daily Living Index, BADL, with a score of 75 or more [19]. The exclusion criteria were people who had a history of recent severe joint pain or injury, history of related diseases affecting the movement system, history of significant injury due to a fall in the last year, were smokers or drinkers and had regular physical exercise during the past six months. The termination criteria were as follows: (1) death, (2) one or more missing interventions, (3) experienced unexpected conditions during the intervention, such as severe illness or injury, (4) unable to complete data measurement or comply with the requirements, and (5) required to withdraw.

Data collection

Participants were recruited through a public announcement. Ninety-two elderly females were recruited in this study, but 56 passed the criteria. The flow diagram of this study is shown in Figure 1. All participants gave written informed consent prior to participation. The STP were measured at baseline, day 1, week 4 and week 8.

Intervention

The fifty-six participants were randomly allocated into a Shuai Shou Gong exercise group (EG) and a control group (CG). The participants in the EG attended a supervised SSG training for eight weeks. The training frequency was three days per week, while each training session was 40 minutes per day[20]. Two trainers and six volunteers took part in every training program. The participants' heart rate of the EG was controlled at 40-50% of their age adjusted maximum heart rate. The metronome and music were used to control the rhythm of the movement of arm swing during the exercise. The participants could stop for a while if they felt uncomfortable during the exercise, after which they could resume the exercise program when they were recovered.

During SSG steps, the participants stood with their feet a shoulder width apart. The arms were actively raised to shoulder height with comfortably straightened fingers. While their trunk and neck were kept upright, their arms swung back and forth naturally following the preset tempo of the metronome, to follow the gradual principle of training. The metronome and music were set so that participants performed 15 arm swings per minute during the first two weeks of SSG training, 20 arm swings per minute during weeks 3 to 4, and 25 arm swings per minute

during weeks 5 to 8. There was a two-minute break halfway through the 30 minutes of the SSG. The participants were asked to breathe through their noses; they breathed in during the upswing and breathed out on the downswing. Each set of SSG consisted of five arm swings. The action of the 1st to 4th swing were performed with knee straight, followed by knee bending and dipping down twice at the 5th swing[10] (Figure 2).

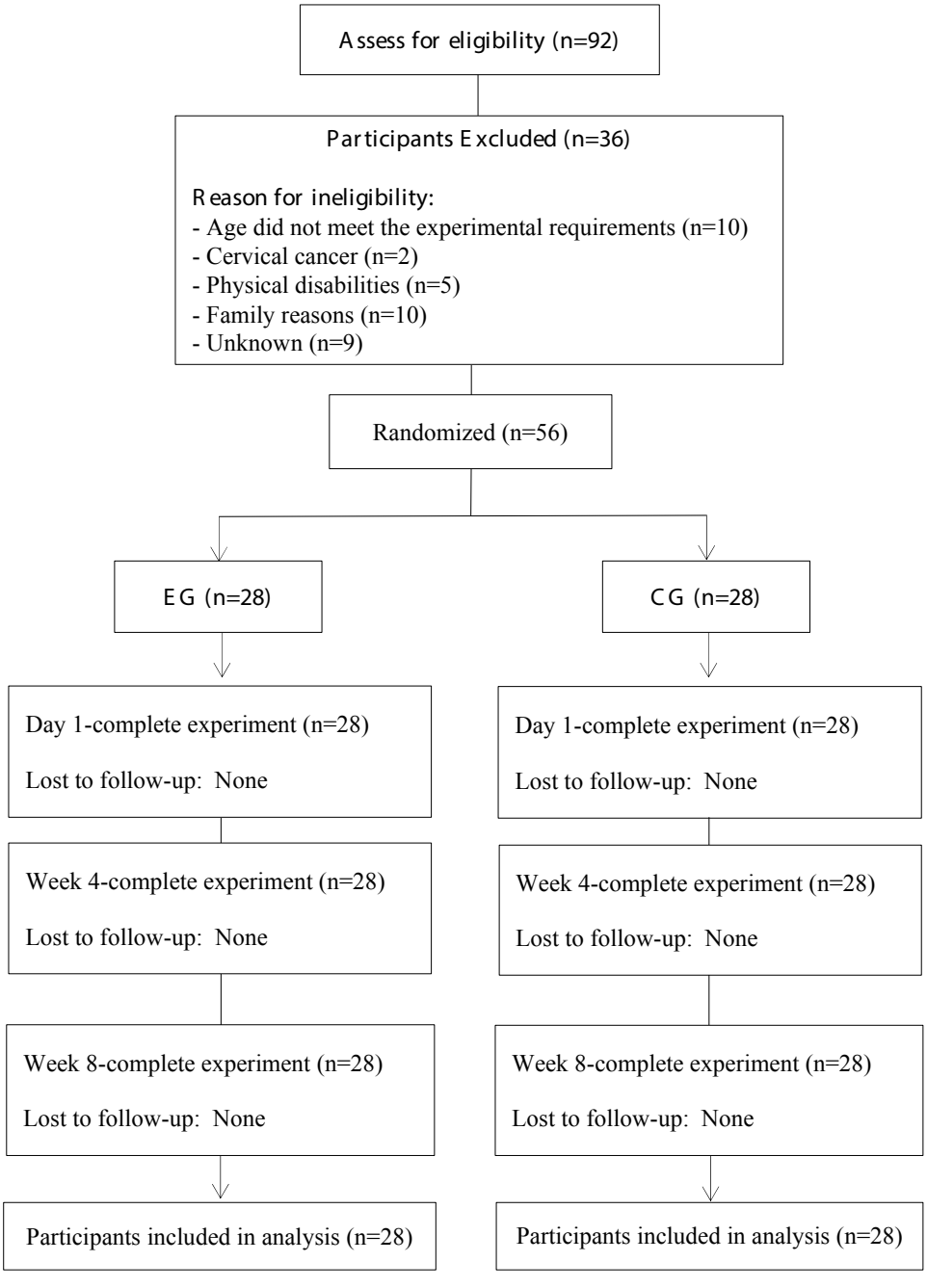

Figure 1 Flow diagram of the study
Note: EG, exercise group; CG, control group.

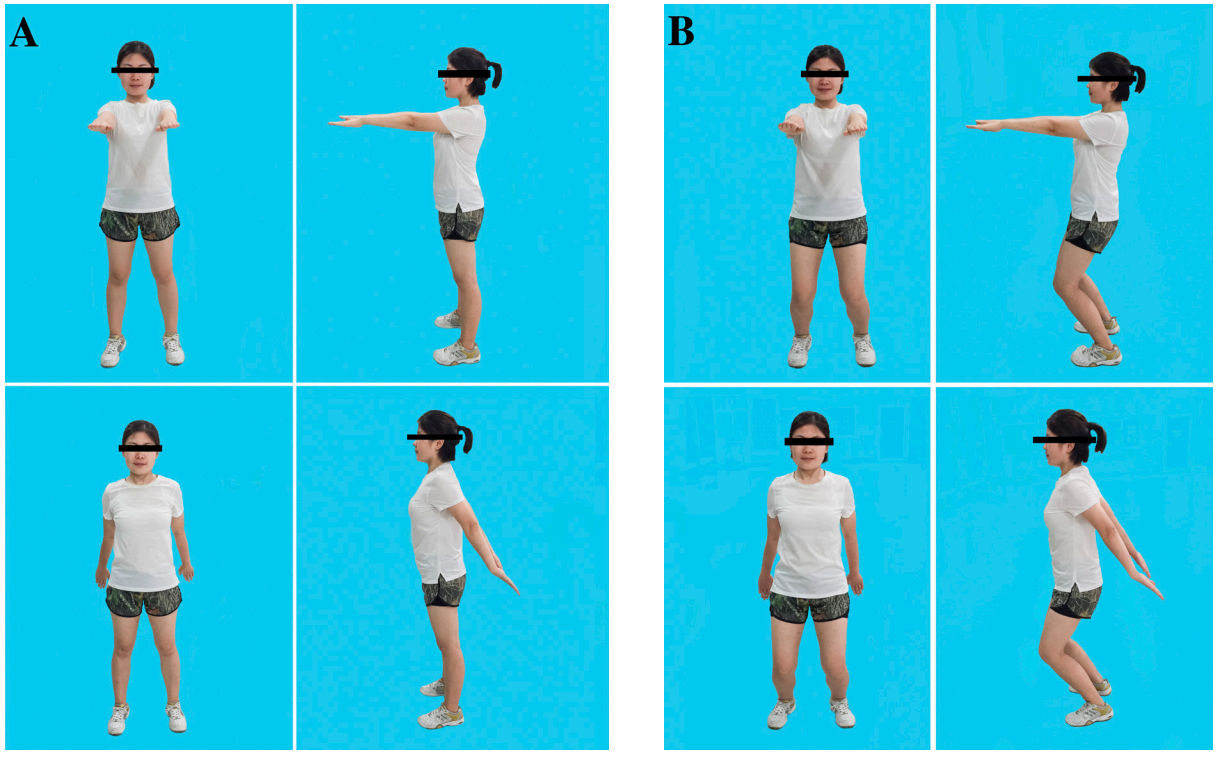

Figure 2 The movement postures of the Shuai Shou Gong exercise (SSG). A single set of SSG performance consists of the first four swings with knees extended (A) in the standing position and the fifth swing (B) with slightly bent knees.

Twenty-eight participants in the CG were asked to maintain their regular life and did not participate in the SSG training and other exercise classes. All participants in this group were offered the SSG training at the end of the experiment. The SSG program for CG was performed with a similar duration and frequency as EG carried out.

Outcome measurements

In the RCT, the immediate and longer-term benefits of SSG were studied. The following gait parameters were measured: stance phase, swing phase, first double support phase, single support phase, stride length, % stride length, and step length for both groups at baseline (seven days before the first session of SSG), immediately after the first session of SSG or no SSG (of the CG) on day 1, after 4 weeks and after 8 weeks. The CG also maintained the same measurement period, but they did not undergo SSG training during the 8-week intervention cycle. STP was measured and recorded by the G-walk (BTS Bioengineering Corporation, Quincy, Massachusetts, USA) gait analysis system. The G-walk is a wearable device embedded with an accelerometer and a gyrometer attached to a special belt around the pelvis at the sacrum level. It has been found reliable for measurement of the spatial-temporal gait parameters with excellent concurrent validity (ICC values ranging from 0.85 to 0.99)[21]. The participants kept a preferred walking speed on a 20-meter track. The movement information was collected by the sensor and sent to a computer via Bluetooth. At the end of each measurement, G-walk software displayed an automatic report which contained all the parameters recorded during the walk.

Statistical analysis

The continuous variables were reported as mean ± standard deviation (SD). To compare the differences for each variable between the two groups, the analysis of covariance (ANCOVA) was applied. One-Way Repeated-Measures ANOVA was used for within group comparison. The differences

between EG and CG in the 95% confidence interval were calculated. The researcher used the Statistical Package for the Social Sciences Software for statistical analysis (version 26.0 IBM, Armonk, NY, USA licensed for Khon Kaen University), *p*-value < 0.05 was considered statistically significant.

Results

Demographic information of participants Ninety-two participants were screened for eligibility in this study. There were 56 participants who met the criteria. The participants' characteristic data included average age, body mass index (BMI), blood pressure, Barthel activities of daily living index (BADLI), and Rosenberg self-esteem scale (RSES) as shown in Table 1. There was no significant difference in participants' characteristic data between the EG and the CG.

Table 1 Baseline demographic information for participants in the exercise group (EG) and control group (CG)

Characteristics	EG (n=28) (Mean ± SD)	CG (n=28) (Mean ± SD)	Total (n=56) (Mean ± SD)
Age (years)	68.3 ± 5.6	69.4 ± 4.4	68.8 ± 5.0
BMI (kg/m^2)	26.1 ± 3.8	25.1 ± 2.6	25.6 ± 3.2
Blood Pressure			
Systolic blood pressure (mmHg)	122.1 ± 22.6	134.6 ± 14.4	128.4 ± 18.5
Diastolic blood pressure (mmHg)	67.6 ± 12.6	66.9 ± 9.1	67.3 ± 10.9
BADLI (score)	96.00 ± 3.8	96.79 ± 2.8	96.39 ± 3.3
RSES (score)	25.43 ± 2.8	24.89 ± 2.3	25.01 ± 5.2

Note: EG, exercise group; CG, control group; BADLI, Barthel activities of daily living index; RSES, Rosenberg self-esteem scale.

The results for gait spatial-temporal parameters (STP) in the EG and the CG are presented in Tables 2 and 3, and Figure 2. Two-way repeated ANOVA results showed that first double support phase left value (DSLV), first double support phase right value (DSRV), single support phase left value (SSLV), stride length left value (SLLV), and stride length right value (SLRV) changed significantly for within-group comparison in the EG (Table 2).

For the between-group comparison (Table 3), ANCOVA revealed that STPLV and STPRV decreased significantly in the EG relative to the CG after completion of the 8-week SSG training. On the contrary, SWPLV and SWPRV were significantly increased in the EG relative to the CG after completion of the 8-week activity.

DSLV and DSRV decreased significantly in the EG relative to the CG after completion of the eight weeks of SSG. SSLV and SSRV were significantly decreased in EG relative to CG. However, there was no between-group difference for %SLLV, %SLRV, SLHLV and SLHRV parameters.

Table 2 Within-group comparison using two-way repeated ANOVA of outcome measures at all assessment time points

Outcome	Group (EG=28) (CG=28)	Baseline (Mean ± SD)	Day 1 (Mean ± SD)	Week 4 (Mean ± SD)	Week 8 (Mean ± SD)
STPLV (Cycle %)	EG	62.17 ± 2.11	61.44 ± 1.84	62.02 ± 1.85	61.78 ± 1.99
	CG	60.91 ± 2.17	60.68 ± 1.97	61.67 ± 1.60	62.73 ± 1.91*
STPRV (Cycle %)	EG	60.93 ± 1.81	61.07 ± 1.55	61.02 ± 2.22	60.99 ± 2.37
	CG	60.65 ± 1.62	61.39 ± 1.48	61.39 ± 1.34	62.65 ± 2.12*
SWPLV (Cycle %)	EG	37.83 ± 2.11	38.42 ± 1.76	37.92 ± 1.43	38.19 ± 1.97
	CG	39.19 ± 2.25	38.50 ± 1.41	37.77 ± 2.01	37.74 ± 1.69
SWPRV (Cycle %)	EG	39.07 ± 1.81	38.72 ± 2.25	38.04 ± 2.20	39.11 ± 2.07
	CG	39.06 ± 1.62	38.24 ± 1.91	38.36 ± 1.60	37.71 ± 2.19*
DSLV (Cycle %)	EG	11.49 ± 2.85	11.54 ± 1.86	12.16 ± 1.72	12.91 ± 1.37*
	CG	11.40 ± 1.91	11.22 ± 2.34	11.69 ± 2.96	10.80 ± 1.50
DSRV (Cycle %)	EG	10.65 ± 1.67	10.70 ± 1.34	12.14 ± 1.30	12.63 ± 1.50*
	CG	11.73 ± 1.58	11.57 ± 1.55	11.46 ± 2.84	11.72 ± 1.67
SSLV (Cycle %)	EG	39.06 ± 1.55	38.00 ± 2.08	38.20 ± 1.75*	37.53 ± 2.27*
	CG	39.07 ± 1.82	38.62 ± 2.21	38.82 ± 2.62	38.81 ± 1.84
SSRV (Cycle %)	EG	38.95 ± 2.22	39.09 ± 2.06	37.27 ± 2.17*	37.99 ± 1.87
	CG	37.79 ± 2.07	38.45 ± 1.93	37.91 ± 1.79	38.10 ± 1.90
SLLV (m)	EG	1.12 ± 0.13	1.12 ± 0.13	1.16 ± 0.14	1.27 ± 0.14*
	CG	1.12 ± 0.09	1.12 ± 0.10	1.11 ± 0.10	1.10 ± 0.10
SLRV (m)	EG	1.09 ± 0.11	1.10 ± 0.13	1.11 ± 0.13	1.25 ± 0.16*
	CG	1.12 ± 0.09	1.12 ± 0.10	1.11 ± 0.10	1.12 ± 0.11
%SLLV (% height)	EG	74.85 ± 9.68	73.15 ± 8.48	72.36 ± 8.33	72.87 ± 8.83
	CG	73.96 ± 5.30	73.88 ± 5.28	73.75 ± 5.39	73.79 ± 5.97
%SLRV (% height)	EG	74.25 ± 9.04	73.11 ± 8.25	72.24 ± 8.43	72.60 ± 9.16
	CG	73.96 ± 5.30	73.90 ± 5.28	73.29 ± 5.44	73.66 ± 6.13
SLHLV (% str height)	EG	49.89 ± 2.32	49.29 ± 2.21	49.51 ± 2.62	49.83 ± 2.55
	CG	49.47 ± 2.28	49.63 ± 2.62	49.54 ± 2.11	49.12 ± 2.09
SLHRV (% str height)	EG	50.48 ± 1.91	50.72 ± 2.21	50.49 ± 2.62	50.25 ± 2.51
	CG	49.47 ± 2.28	50.37 ± 2.62	50.21 ± 2.27	50.88 ± 2.09

Note: EG, exercise group; CG, control group; ANCOVA, Analysis of Covariance; STPLV, stance phase left value; STPRV, stance phase right value; SWPLV, swing phase left value; SWPRV, swing phase right value; DSLV, first double support phase left value; DSRV, first double support phase right value; SSLV, single support phase left value; SSRV, single support phase right value; SLLV, stride length left value; SLRV, stride length right value; %SLLV, % stride length left value; %SLRV, % stride length right value; SLHLV, step length left value; SLHRV, step length right value. * Indicates statistically significant difference within the groups (p-value < 0.05).

Table 3 Between-group comparison of adjusted mean and 95% CI of outcome measures (adjusted for baseline using ANCOVA) at each of the assessment time points

Outcome	Group (EG=28) (CG=28)	Adjusted Baseline (Mean)	Mean	Day 1 Difference (95%CI)	Mean	Week 4 Difference (95% CI)	Mean	Week 8 Difference (95% CI)
STPLV (Cycle %)	EG	61.54	61.20	0.28 (95%CI -0.69 to 1.26)	61.85	0.01 (95%CI -0.91 to 0.93)	61.56	-1.39 (95%CI -2.41 to -0.38)*
	CG	61.54	60.92		61.84		62.95	
STPRV (Cycle %)	EG	60.79	61.01	-0.44 (95%CI -1.18 to 0.30)	60.97	-0.46 (95%CI -1.41 to 0.49)	60.93	-1.79 (95%CI -2.93 to -0.65)*
	CG	60.79	61.45		61.43		62.72	
SWPLV (Cycle %)	EG	38.51	38.68	0.43 (95%CI -0.34 to 1.20)	38.22	0.75 (95%CI -0.08 to 1.57)	38.38	0.83 (95%CI -0.15 to 1.81)*
	CG	38.51	38.24		37.48		37.55	
SWPRV (Cycle %)	EG	39.07	38.72	0.47 (95%CI -0.53 to 1.47)	38.04	-0.32 (95%CI -1.24 to 0.60)	39.11	1.40 (95%CI 0.32 to 2.48)*
	CG	39.07	38.25		38.36		37.71	
DSLV (Cycle %)	EG	11.45	11.54	0.31 (95%CI -0.82 to 1.44)	12.15	0.45 (95%CI -0.84 to 1.74)	12.90	2.09 (95%CI 1.35 to 2.83)*
	CG	11.45	11.23		11.70		10.81	
DSRV (Cycle %)	EG	11.19	10.88	-0.52 (95%CI -1.29 to 0.26)	12.27	0.93 (95%CI -0.31 to 2.17)	12.73	1.11 (95%CI 0.22 to 2.0)*
	CG	11.19	11.39		11.34		11.62	
SSLV (Cycle %)	EG	39.06	38.00	-0.61 (95%CI -1.70 to 0.47)	38.20	-0.61 (95%CI -1.57 to 0.35)	37.53	-1.27 (95%CI -2.33 to -0.21)*
	CG	39.06	38.62		38.81		38.81	
SSRV (Cycle %)	EG	38.37	38.86	0.19 (95%CI -0.83 to 1.20)	36.95	-1.29 (95%CI -2.18 to -0.40)*	37.84	-0.42 (95%CI -1.43 to 0.59)
	CG	38.37	38.68		38.23		38.25	
SLLV (m)	EG	1.12	1.12	0.01 (95%CI -0.04 to 0.43)	1.16	0.05 (95%CI 0.00 to 0.10)	1.28	0.17 (95%CI 0.10 to 0.23)*
	CG	1.12	1.12		1.12		1.11	
SLRV (m)	EG	1.10	1.12	0.01 (95%CI -0.03 to 0.05)	1.12	0.02 (95%CI -0.03 to 0.07)	1.26	0.13 (95%CI 0.06 to 0.21)*
	CG	1.10	1.11		1.10		1.13	
%SLLV (% height)	EG	74.40	72.88	-1.28 (95%CI -4.05 to1.49)	72.11	-1.90 (95%CI -4.82 to 1.03)	72.60	-1.46 (95%CI -4.65 to 1.73)
	CG	74.40	74.15		74.00		74.06	
%SLRV (% height)	EG	74.11	73.01	-0.99 (95%CI -3.71 to 1.74)	72.15	-1.24 (95%CI -4.06 to 1.58)	72.51	-1.26 (95%CI -4.44 to 1.92)
	CG	74.11	74.00		73.39		73.77	
SLHLV (% str height)	EG	49.68	49.13	-0.65 (95%CI -1.57 to 0.27)	48.82	-0.91 (95%CI -2.20 to 0.38)	49.67	0.40 (95%CI -0.47 to 1.27)
	CG	49.68	49.78		49.73		49.28	
SLHRV (% str height)	EG	49.97	50.81	0.52 (95%CI -0.81 to 1.85)	50.44	0.19 (95%CI -1.17 to1.55)	50.23	-0.66 (95%CI -1.94 to 0.63)
	CG	49.97	50.29		50.25		50.89	

Note: EG, exercise group; CG, control group; ANCOVA, Analysis of Covariance; STPLV, stance phase left value; STPRV, stance phase right value; SWPLV, swing phase left value; SWPRV, swing phase right value; DSLV, first double support phase left value; DSRV, first double support phase right value; SSLV, single support phase left value; SSRV, single support phase right value; SLLV, stride length left value; SLRV, stride length right value; %SLLV, % stride length left value; %SLRV, % stride length right value; SLHLV, step length left value; SLHRV, step length right value. * Indicates statistically significant difference between the groups (p-value < 0.05).

Discussion

The study aimed to verify the effects of SSG on spatio-temporal parameters of gait in healthy elderly females. The main findings of the study using ANCOVA revealed the 8-week SSG training could significantly change STPLV, STPRV, SWPLV, SWPRV, DSLV, DSRV, SSLV, SLLV, and SLRV in the EG compared to the CG for between-group comparison. The improved STP demonstrated by the exercisers at the completion of the trial indicated the SSG training program could improve the age-related decline in the functional gait of older women. Therefore, the SSG training program might have an appropriate nature, adequate duration, and exercise intensity sufficient to produce considerable STP improvements.

The participants in the EG group showed a significant decrease in the STPLV and STPRV, but not those in the CG group. The increment of the stance phase accompanied a decrease of SWPLV and SWPRV, indicating that the CG participants walked slower, as is normal with reduced stability following aging. On the contrary, the decreased STPLV and STPRV in combination with increased SWPLV and SWPRL in the EG after completion of the 8-week SSG training suggest that they walked faster, which could be due to improved muscle strength and joint mobility[22]. The SSG exercise may also reflect a coordinated movement involving the hamstrings and quadriceps, which may increase the strength and stability of these muscles. These results are consistent with the report by Shigematsu et al. that a combination of aerobic dance and balance exercises can improve lower limb muscle strength, one-leg balance, and functional stretching in adults[23]. A meta-analysis also reported that therapeutic exercise generally improves habitual gait markers in older adults in a community study and found that progressive resistance training improves strength and balance. Quadriceps muscle strength plays a vital role in standing, walking, squatting, and other functional activities. The simple task of standing from a sitting position was affected by quadriceps strength such that active older adults need less time to complete activities from sit to stand[24]. The combination of aerobic dance and balance training is also very effective for improving muscle strength, as it always involves movements similar to those in SSG such as standing on one leg, squatting, and walking with heel contact[25].

The SSG increases in the first double support phase, but not in the single support phase because these changes may represent an adaptation to changes in the sensory or motor system to produce a safer and more stable gait pattern[26]. Individuals with greater stability should have longer first double support phase and single support phase. This improvement is always accompanied by a reduction in stance duration and increase of swing time. During SSG, the body was in a straight line, head and shoulders back, chest forward, feet shoulder width apart, and this position allowed the entire body to be activated; it may improve the elderly core muscle control, lower limb muscle strength, effectively promoting their core strength, core endurance, flexibility, and mobilizing the spinal joints[27].

The body's trunk is at its lowest vertical position, and its highest forward speed during the double support phase; forward speed is also at its highest in the first half of the single support phase. The trunk is lifted by the supporting legs, converting some kinetic energy into potential energy when it slows down. During the later single support phase, the trunk drops again in front of the supporting leg, and with the lower altitude simultaneously speeds up again[5]. The first double support phase is kept as a stable interval, which can promote the body's speed moving forward, and the trunk can generate more forward kinetic energy.

It has been seen that the 8-week SSG training increases participant's stride length significantly in the present study. The average range of stride length in normal healthy older adults is 1.22-1.84m (50-64 years) and 1.11-1.71m (65-80 years)[5]. Increased stride length is associated with improved hip extension strength and hip flexion strength[28]. Heels rise less during front swing and at the initial contact, the posture of the foot is closer to the horizontal direction. Both changes are associated with a decrease in stride length. The angle of the toe out in the elderly also

increases, and the posture and movements of the arms change [29].

There was no significant change in % stride length and step length. This might be due to the SSG training being performed in a standing posture rather than as a walking exercise. Therefore, it is apparently a non-specific training for the gait spatio-temporal parameters. In addition, the measurement of gait parameters in this study indicates that the participants must walk comfortably. Although their legs are strengthened, they still walk with the same speed and pattern (conservation of energy). The changes of spatio-temporal parameters might be seen if the participants are asked to walk as fast as they can. This could be due to SSG being performed in a standing position which was a non-specific training for walking[30]. No specific walking training was included in the study; therefore, it is not surprising that SSG did not show significant changes in some other STP. Should a study want to get excellent spatio-temporal parameters of gait, gait-specific training may be included. Lastly, regarding participants' characteristics, most of them were relatively healthy with a normal range of BMI and BP. The SSG could produce limited effects to them such that some STP parameters could not be significantly changed. Even for those with statistical significance, the magnitude of changes was less than 5%.

There are some limitations of the study which should be acknowledged. There was no blinded assessment in this study. This could be prone to giving bias, since the assessor could have a trend to favor positive results in either known groups. For future study, a single blind (blind the assessor) could reduce the potential bias. The results of this study could not be applied to elderly males because all the participants were females. Physiological and psychological responses could be different between the two genders. Further research could be done on the male population. Lastly, this study did not either confirm muscle strength change or muscle activity during exercise. Therefore, it is recommended to monitor muscle strength as well as perform electromyography during the SSG in a future study.

Conclusion

SSG produced significant but modest improvements in stance phase, swing phase, first double support phase, single support phase, and stride length in the EG compared to the CG. Therefore, SSG could improve some but not all spatial-temporal parameters of gait in elderly females. Further study should explore the physiological mechanism of muscle activation during SSG.

Take home messages

The Shuai Shou Gong could modestly improve some of the spatio-temporal parameters of gait in elderly females. It has provided older women with a simple and practical daily exercise for improvement of gait.

Conflicts of interest

The authors declare no conflict of interest.

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References

1. Hausdorff JM. Gait variability: methods, modeling and meaning. J Neuroeng Rehabilitation 2005; 2(1): 1-9.
2. Pirker W, Katzenschlager R. Gait disorders in adults and the elderly. Wien Klin 2017; 129(3): 81-95.
3. Meurisse GM, Bastien GJ, Schepens B. Effect of age and speed on the step-to-step transition phase during walking. J Biomech 2019; 83: 253-9.

4. Espy DD, Yang F, Bhatt T, Pai YC. Independent influence of gait speed and step length on stability and fall risk. Gait & posture 2010; 32(3): 378-82.
5. Whittle MW. Gait analysis: an introduction. Butterworth-Heinemann; 2014.
6. Hirose D, Ishida K, Nagano Y, Takahashi T, Yamamoto H. Posture of the trunk in the sagittal plane is associated with gait in community-dwelling elderly population. Clin Biomech 2004; 19(1): 57-63.
7. Alexander NB. Gait disorders in older adults. J Am Geriatr Soc 1996; 44 (4): 434-51.
8 Winter DA, Patla AE, Frank JS, Walt SE. Biomechanical walking pattern changes in the fit and healthy elderly. Phys Ther 1990; 70 (6): 340-7.
9. Cesari M, Kritchevsky SB, Penninx BWHJ, Nicklas BJ, Simonsick EM, Newman AB, et al. Prognostic value of usual gait speed in well-functioning older people-results from the Health, Aging and Body Composition Study. J Am Geriatr Soc 2005; 53(10): 1675-80.
10. Xiao Z, Eungpinichpong W, Wang X, Chatchawan U, Hu Y. Immediate effects of Arm Swing Exercise therapy on shoulder range of motion and forward head posture: A Pilot study in young adults. Int J GEOMATE 2020; 18(67): 188-94.
11. Prasertsri P, Boonla O, Phoemsapthawee J, Leelayuwat N. Arm swing exercise improves exercise capacity and oxygen consumption in overweight and normal weight sedentary young adults. J Exerc Physiol 2017; 20(1): 111-22.
12. Leelayuwat N, Tunkumnerdthai O, Donsom M, Punyaek N, Manimanakorn A, Kukongviriyapan U, et al. An alternative exercise and its beneficial effects on glycaemic control and oxidative stress in subjects with type 2 diabetes. Diabetes Res Clin Pract 2008; 82(2): e5-e8.
13. Phoemsapthawee J, Ammawat W, Leelayuwat N. The benefit of arm swing exercise on cognitive performance in older women with mild cognitive impairment. J Exerc Physiol 2016; 19-6.
14. Tunkamnerdthai O, Auvichayapat P, Punjaruk W. Modified arm swing exercise improves oxidative stress and heart rate variability in patients with chronic obstructive pulmonary disease: a randomized controlled trial. J Exerc Physiol 2018; 21(4): 41-52.
15. Songsaengrit B, Benjapornlert P, Pisprasert V, Aneknan P, Kanpettha Y, Sespheng A, et al. Effects of traditional and modified arm swing exercise on abdominal obesity, hemodynamics and quality of life in patients with metabolic syndrome. J Exerc Physiol 2016; 20(6): 83-93.
16. Borm GF, Fransen J, Lemmens WA. A simple sample size formula for analysis of covariance in randomized clinical trials. J Clin Epidemiol 2007; 60(12): 1234-8.
17. Benedetti MG, Berti L, Presti C, Frizziero A, Giannini S. Effects of an adapted physical activity program in a group of elderly subjects with flexed posture: clinical and instrumental assessment. J Neuroeng Rehabil 2008; 5(1): 1-11
18. Cockrell JR, Folstein MF. Mini-mental state examination. Principles and practice of geriatric psychiatry, 2002: 140-1.
19. Hsueh IP, Lee MM, Hsieh CL. Psychometric characteristics of the Barthel activities of daily living index in stroke patients. J Formos 2001; 100(8): 526-32.
20. American College of Sports Medicine. ACSM's guidelines for exercise testing and prescription. Lippincott Williams & Wilkins; 2013.
21. Magnan A, McFadyen BJ, St-Vincent G, Lord SR, Murray SM, Chapman K, et al. Sit-to-stand performance depends on sensation, speed, balance, and psychological status in addition to strength in older people. J Gerontol A Biol 2002; 57(8): 539-43.
22. Allet L, Armand S, De Bie RA. The gait and balance of patients with diabetes can be improved: a randomised controlled trial. Diabetologia 2010; 53(3): 458-66.

23. Shigematsu R, Chang M, Yabushita N, Sakai T, Nakagaichi M, Nho H, et al. Dance based aerobic exercise may improve indices of falling risk in older women. Age Ageing 2002; 31(4): 261-6.
24. King MB, Whipple RH, Gruman CA, Judge JO, Schmidt JA, Wolfson LI. The Performance Enhancement Project: improving physical performance in older persons. Arch Phys Med Rehabil 2002; 83(8): 1060-9.
25. Magnan A, McFadyen BJ, St-Vincent G, Lord SR, Murray SM, Chapman K, et al. Sit-to-stand performance depends on sensation, speed, balance, and psychological status in addition to strength in older people. J Gerontol A Biol 2002; 57(8): 539-43.
26. Salzman B. Gait and balance disorders in older adults. AFP 2010; 82(1): 61-8.
27. Saelao K, Kanungsukkasem V. Effects of arm swing exercise, walking and walking exercise combined with arm swing exercise on health-related physical fitness of the elderly women. J Sport Health Sci J 2012; 13(1): 92-103.
28. Lord S R, Lloyd DG, Nirui M. The effect of exercise on gait patterns in older women: a randomized controlled trial. J Gerontol A Biol Sci Med Sci 1996; 51(2): 64-70.
29. rince F, Corriveau H, Hébert R. Gait in the elderly. Gait & posture 1997; 5(2): 128-35.
30. Wassom DJ, Lyons KE, Pahwa R, Liu W. Qigong exercise may improve sleep quality and gait performance in Parkinson's disease: a pilot study. Int J Neurosci 2015; 125(8): 578-84.