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Effects of Taekwondo and Walking Exercises on the Double-Leg Balance Control of Elderly Females

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ABSTRACT

The purpose of this study was to compare and analyze the effect of twelve-week Taekwondo and walking exercises on the double-leg balance control by dividing elderly females into Taekwondo, walking exercise and control groups. In total, 30 elderly females were randomly divided into Taekwondo, walking exercise, and control groups, with 10 subjects in each group. Subjects participating in this study were 10(age 69.4±5.8 years), 10(age 71.4±7.6 years) and 10(age 70.6±4.8 years) in the three groups, respectively. Although the AP measures were not significantly different among the groups and times, the ML RMS distance and ML velocity, among the ML measures showed a significant difference among the groups and times. Average velocity and 95% confidence ellipse area were also significantly different among the groups and times. Twelve-week Taekwondo and walking exercises were found to be effective in improving static balance control. Future studies on the development of a Taekwondo intervention program tailored for the elderly with many subjects conducted by using a long-term training program are expected.

Keywords : Taekwondo, Walking, Center of Pressure, Static Balance Control, Fall

Ⅰ. Introduction

Physical changes related with aging include an overall decrease of physical strength and sensory function following degeneration of physiological function(Shumway-Cook & Woollacott, 2000; Winter, 1990); changes of the central nervous system and the musculoskeletal system also influence the balance control system(Maki & Mcllroy, 1996; Masani et al., 2007). This deterioration of the musculoskeletal system causes a reduction in the control of posture and movement and increases the risk of falling(Shumway-Cook & et al., 2000; Maki & et al., 1996; Masani et al., 2007).

A fall is when a part of a body reaches the ground via losing stability due to an unintentional posture change occurring accidentally in daily life(Fuller, 2000). Experience of fall limits activities of the elderly and hinders their independent life, and fear of falls provokes a serious problem on their mental and social well-being. The experience rate of falls has been reported to be higher in older persons and in females(Fuller, 2000; Unsworth, 2003).

Among the elderly aged over 65 years in the U.S., 60% experienced falls and it was the first cause of mortality of those aged over 65 years. Moreover, the medical costs related to falling was found to be around 5 trillion won(Centers for Disease Control and Prevention, 2005). In Korea, 48.2% of the elderly aged over 65 years experienced falls and hospitalization due to lumbar vertebral fracture, and pelvic bone fracture associated with falls ranked seventh among total diseases of the elderly aged over 65 years(National Health Insurance Corporation, 2006). Like this, falling is a major cause of growing injury, disorder, and mortality of the elderly, so the attention of researchers and clinicians to this

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problem has increased(Lin, Seol, Nussbaum, & Madigan, 2008). Therefore, many researchers have investigated balance control of specific groups with neurological or orthopedic disorders or degeneration associated with aging as well as athletes and healthy persons to develop intervention programs for the enhancement of balance control and to determine risk factors of falling(Dolye, Hsiao-Wecksler, Ragan, & Rosengren, 2007).

Center of pressure(COP) analysis was performed to quantify physical sway(Winter, 1995). COP trajectory is an important factor for a complex system, requiring an appropriate ability of the nervous system and the musculoskeletal system to integrate sensory information, such as visual, somatic, and vestibular senses and to produce strength for the control of orientation and position of the body segments(Massion, 1994).

Balance control, which is essential for daily activities and exercise performance, is enhanced by a planned training referred to above, and it can be achieved by increasing the muscle strength needed for balance control. This improvement of muscle strength and muscular endurance positively affects balance maintenance and the prevention of falls(Adlerton et al., 2003; Lipsitz, 1991; Lord, Ward, & Williams, 1996; Wolfson, Judge, Whipple, & King, 1995). Sport training has been reported to be effective in improving balance control by strengthening somatic sense and the ability to use otolith information through repetition of specific movements(Bringoux, 2000; Paillard, et al., 2006). Previous studies reported that tai chi and dance sports programs improved balance control of subjects experiencing falls(Gatts & Woollacott, 2007; Judge, 2003; Schmit, Regis, & Riley, 2005).

Taekwondo is a martial sport with competitive characteristics. Since it was selected as a demonstration sport in the 1988 Seoul Olympics and as an official one in the 2000 Sydney Olympics, its popularity has skyrocketed(Kang & Lee, 2002; Jang, You, Kim, & Byeon, 2007). For these reasons, Taekwondo programs for various persons are necessary and the possibility of its use as an intervention program to improve the health and quality of life of elderly females and to reduce their risk of falling needs to be evaluated.

Walking is a consecutive and repeated movement using the nervous system and the musculoskeletal system comprehensively and it requires a high-level of cooperation(Perry, 1992). Walking exercise is a moderate-intensity physical activity to enhance health and physical strength(Murphy & Hardman, 1998), and its potential as an intervention program for the prevention of falls in the elderly is thought to be high, but studies on this potential have not been sufficient.

Therefore, this study was conducted to investigate the effects of Twelve-week Taekwondo and walking exercises on the variables of the double-leg balance control by dividing elderly females into Taekwondo, walking exercise, and control groups.

Ⅱ. Methods

1. Subjects

This study recruited 30 elderly females who had no problem in daily activities and no endocrine, neurological, or orthopedic disorders for the last six months, and they were randomly divided into Taekwondo, walking exercise, and control groups with 10 subjects, in each group. The females participating in this study were 10(age 69.4±5.8 years), 10(age 71.4±7.6 years) and 10(age 70.6±4.8 years) in the three groups, respectively<Table 1>. The females of the Taekwondo and walking exercise groups did not participate in any other program except their assigned exercise and those of the control group did not perform in any other physical program and only performed actions required for daily activity. An informed consent form was given to all of the subjects.

Table 1. Comparison of the subject's characteristics between the three groups(n=30)

		Taekwondo(n=10)	Walking(n=10)	Control(n=10)	P^a
Age (years)	pre	69.4±5.8	71.4±7.6	70.6±4.8	-
	post	69.4±5.8	71.4±7.6	70.6±4.8	-
Height (cm)	pre	153.1±6.0	152.5±2.6	151.2±5.5	-
	post	153.3±6.4	152.4±2.9	150.9±5.0	-
Weight (kg)	pre	61.1±7.5	61.0±8.9	55.1±8.1	-
	post	60.7±8.4	60.9±8.4	55.2±7.7	-
BMI (kg/m2)	pre	26.0±2.5	26.2±3.8	24.1±3.5	-
	post	25.4±2.8	26.3±3.8	24.3±3.5	-

Values are mean±SD : BMI = weight/height (kg/m^2) : a is the result of one-way ANOVA between three groups : - means none significant

2. Intervention protocol

The Taekwondo exercise consisted a 10-minute warm up that included walking and stretching, a 40-minute main exercise of Taekwondo basic movements, such as Stance, Defense, Punch, Hit, Pivot, Kick, Block, and Poomsae 1 Jang, and a 10-minute cool down; this was conducted for about 60 minutes at a time, three times per week for 12 weeks. the exercise intensity according to the subjects was 40~50% HRmax and 9-11 RPE in weeks 1~4 and 50~60% HRmax and 9-13 RPE in weeks 5~12. The walking exercise consisted of a 10-minute warm up that included walking and stretching, a 40-minute walking exercise, and a 10-minute cool down and it was performed for about 60 minutes per at a time for three times per week for 12 weeks. The exercise intensity according to the subjects was 40~50% HRmax and 9-11 RPE in weeks 1~4 and 50~60% HRmax and 9-13 RPE in weeks 5~12. To maintain the intensity level, a Polar heart rate checker(Polar Electro OY, Finland) was used.

3. Laboratory measurements

1) Body composition

Height(cm) and body weight(kg) were measured with barefeet at the Sports Science Laboratory of University by an established bioelectrical impedance method using a Venus 5.5 body composition analyzer(Jawon Medical, Gyeongsan, Korea).

2) Experimental procedures and equipment

The subjects maintained an upright stance on the force platform(AMTI OR6-7, Watertown, MA, US) with feet together, arms lowered naturally and open eyes toward a 15° upward target for 70 seconds.

Data were sampled at 100 Hz and filtered using a fourth order Butterworth, zero-phase low-pass filter at a 10 Hz cut-off frequency. To eliminate an initial sway which could occur in an experimental environment, the data collected in five to sixty seconds after the starting sign were analyzed(Dolye et al., 2007; Raymakers, Samson, & Verharr, 2005).

3) Variables

Variables were anteropoterior(AP) and mediolateral(ML) COP, root mean square(RMS) distance, AP and ML velocity, AP and ML 50% power frequency, AP and ML 95% power frequency, AP and ML total power frequency, average velocity and 95% confidence ellipse area(Dolye et al., 2007; Prieto et al., 1996).

4. Statistical Analysis

The mean and standard deviation of each variable were calculated with SPSS 14.0 statistics program(SPSS, Chicago, IL, USA). To investigate a reciprocal effect among the three groups and time, two-way repeated measure ANOVA was performed. When significance was observed, paired sample t-test and one-way ANOVA were conducted to examine the difference between pre- and post-training levels and the difference in means of the three groups, respectively.

The Duncan test was used as post hoc test and $p<0.05$ meant a statistical significance.

Ⅲ. Results

1. Body composition

Physical characteristics of the females in Taekwondo, walking exercise, and control groups are presented in Table 1. Age, height, weight, and body mass index(BMI) of the three groups that were gauged before and after training were not significantly different.

2. AP and ML factors

There was no reciprocal effect among the groups and times on the AP RMS distance, AP velocity, AP 50% power frequency, and AP total power frequency with regard to upright stance. Although the AP 95% power frequency showed a reciprocal effect among the groups and times($p<0.05$), no significant difference was observed according to the groups and times(Table 2, Figure 1).While ML 50% power frequency, ML 95% power frequency, and ML total power frequency on the upright stance had no reciprocal effect among the groups and times, the ML RMS distance and ML velocity did have such an effect($p<0.05$). The ML RMS distance of the Taekwondo and walking exercise groups showed a significant difference between pre- and post-training ($p<0.05$), and with regards to post-training, the levels of the three groups were also significantly different($p<0.05$). The post-hoc test revealed the order of walking exercise, Taekwondo, and then control group(W, T<C). The ML velocities of Taekwondo and walking exercise groups showed significant differences between pre- and post-training($p<0.05$) and with regards to post-training, the levels of the three groups were also significantly different($p<0.05$). According to the post-hoc test, the order was walking exercise, Taekwondo, and then control group(W, T<C).

3. Average velocity and 95% confidence ellipse area

The average velocity and 95% confidence ellipse area were found to have a reciprocal effect among the groups and times($p<0.05$). The Taekwondo and walking exercise groups showed significantly different average velocities between pre- and post-training($p<0.05$) and with regards to post-training, the levels of the three groups were also

Table 2. Variables of COP trajectories

		Taekwondo(n=10)	Walking(n=10)	Control(n=10)	*Duncan*
AP RMS distance (cm)	pre	0.70±0.17	0.80±0.18	0.83±0.28	-
	post	0.62±0.12	0.64±0.20	0.77±0.10	-
AP velocity (cm/s)	pre	1.68±0.70	1.51±0.30	1.71±0.49	-
	post	1.44±0.60	1.34±0.30	1.65±0.34	-
AP 50% power frequency (Hz)	pre	0.16±0.09	0.08±0.03	0.20±0.15	-
	post	0.11±0.10	0.08±0.05	0.10±0.08	-
AP 95% power frequency (Hz)	pre	1.02±0.54	0.75±0.26	1.10±0.38	-
	post	0.84±0.39	0.94±0.33	0.83±0.20#	-
AP total power frequency (Hz)	pre	0.55±0.25	0.62±0.20	0.49±0.19	-
	post	0.45±0.23	0.44±0.43	0.53±0.23	-
ML RMS distance (cm)	pre	0.68±0.18	0.75±0.14	0.62±0.12	-
	post	0.41±0.16¶	0.31±0.12¶	0.74±0.11*#	W, T<C
ML velocity (cm/s)	pre	1.60±0.66	1.58±0.32	1.38±0.40	-
	post	0.65±0.23¶	0.64±0.06¶	1.74±0.60*#	W, T<C
ML 50% power frequency (Hz)	pre	0.24±0.20	0.09±0.08	0.20±0.16	-
	post	0.13±0.13	0.14±0.22	0.12±0.13	-
ML 95% power frequency (Hz)	pre	1.09±0.31	0.98±0.22	1.15±0.47	-
	post	0.84±0.32	0.89±0.25	0.83±0.28	-
ML total power frequency (Hz)	pre	0.44±0.23	0.56±0.18	0.53±0.19	-
	post	0.15±0.15	0.09±0.06	0.20±0.18	-
Average velocity (cm/s)	pre	2.33±0.92	2.43±0.44	2.43±0.67	-
	post	1.60±0.59¶	1.62±0.30¶	2.66±0.73*#	T, W<C
95% confidence ellipse area (cm^2)	pre	7.66±3.34	7.58±3.00	7.98±3.57	-
	post	3.11±1.74¶	3.83±1.16¶	8.40±1.80*#	T, W<C

AP means anteroposterior, MP means mediolateral : ¶ is the result of a paired sample t-test and *p*<.05 : * is the one-way ANOVA between three groups and *p*<.05 : # is the two-way repeated measure ANOVA between time×three groups

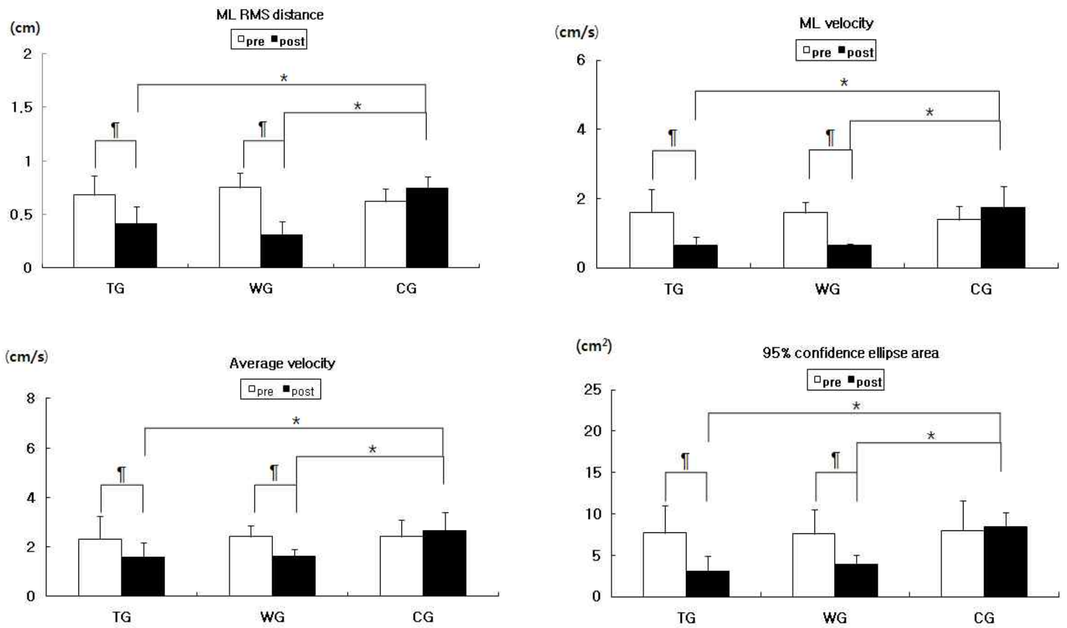

Figure 1. ML RMS distance, ML velocity, Average velocity, & 95% confidence area(*mean±SD*) of the 12 weeks of training of the pre and post measurements : TG- Taekwondo group, WG- Walking group, CG- Control group, AP-Anteroposterior, MP- Mediolateral : ¶ is the result of the paired sample t-test and *p*<.05; * is the one-way ANOVA between the three groups and *p*<.05.

significantly different(p<0.05). The post-hoc test revealed the order of Taekwondo, walking exercise, and then control group(T, W<C). The Taekwondo and walking exercise groups also had significantly different 95% confidence ellipse area between pre-and post-training(p<0.05) and with regards to post-training, the levels of the three groups were also significantly different(p<0.05). The post-hoc test showed the order of Taekwondo, walking exercise, and then control group(T, W<C).

Ⅳ. Discussion

This study investigated the effect of twelve-week Taekwondo and walking exercises on the variables of the double-leg balance control by dividing elderly females into Taekwondo, walking exercise, and control groups.

Among the elderly, loss of the ability to perform daily activities and decreased response to external changes reduce stability(Shumway-Cook & et al., 2000; Winter, 1990). The lower stability caused by this deterioration of physical function can be improved by deliberate training and it can not only decline the degree of the negative change, but it can also maintain and enhance stability(Choi, Jeon, & Choi, 2000).

According to the results of this study, although AP measures were not significantly different among the groups and times, ML RMS distance and ML velocity out of the ML measures were found to be significantly different among the groups and times.

In the static and dynamic balance test as well as the clinical balance test, methodologies and variables vary, but ML stability measures are predictors of the risk of falling(Maki, Holliday, & Topper, 1994; McIlroy et al., 1996) and the sway of ML measures was reported to increase in subjects with degeneration as well as, neurological and orthopedic disorders associated with aging(Rocchi, Chiari, & Cappello, 2004). In particular, ML RMS distance and ML velocity are some of the best predictors for the risk of falling(Piirtola & Era, 2006). Therefore, to prevent falling the static stability of the ML measures should be improved and this study revealed their improvement.

A variable, 50% power frequency was used to differentiate a group without a significant difference or difference according to the existence of visual information, and a 95% power frequency was used to examine the difference according to the existence of visual information in the elderly as well as difference related with aging(Prieto et al., 1996). However, this study showed no significant difference in the frequency domain of the AP and ML measures.

According to the results of this study, the average velocity was significantly different among groups and times. Average velocity is a variable which can examine changes following aging regardless of visual information and is the most beneficial in various balance tests(Prieto et al., 1996; Raymakers et al., 2005). In addition, the International Society of Posturography(ISP) recommended the use of the average velocity and RMS distance measures on postural control evaluation using a force plate(Kapteyn et al., 1983).

Currently, studies using the 95% confidence ellipse area have been conducted(Dolye et al., 2007; Prieto et al., 1996; Rocchi et al. 2004) and in them, the 95% confidence ellipse area was also observed to be significantly different among the groups and times.

Therefore, the Twelve-week Taekwondo and walking exercise was considered to the improve static balance control of the elderly females in this study. The improvement of physical function through the walking exercise was thought to enhance the static balance control of the elderly females and this was similar with the findings of a previous study that studied the enhancement of muscle strength of the lower limbs through walking exercise that resulted in the improved static balance control of the elderly(Raymakers et al., 2005). Moreover, this study found that the improvement of static balance control following Taekwondo and walking exercises was similar. One of key factors influencing the performance of Taekwondo athletes is muscle strength, and improved muscle strength promotes better balance control(Jang et al., 2007). Another study revealed that training through the Taekwondo Poomsae program produced positive effects on aerobic exercise performance and muscle strength(Park & Kim, 2003). Therefore, the Taekwondo program was also considered to be effective in improving the static balance control of elderly females.

According to previous studies, a 12-week resistance exercise program, a 12-week low-intensity exercise program, and a 12-week low-intensity aerobic dance program increased the muscle strength of the elderly(Judge, Underwood, & Gennosa, 1993), improved muscle strength, flexibility, balance, walking and muscle endurance of the elderly(Brown & Holloszy, 1991), and enhanced the health-related physical strength of elderly females(Hopkins, Murrah, Hoeger, & Rhodes, 1990); the enhancement of the aerobic exercise performance and muscle strength caused by these effects positively influenced the static stability and prevention of falling in the elderly(Adlerton et al., 2003; Lipsitz, 1991; Lord, et al., 1996; Wolfson et al., 1995). In addition, with regards to the maintenance of balance of the elderly, the input of proprioception from the lower limbs was very important and its effect became larger if vision was blocked(Raymakers et al., 2005). The reports referred to above were considered to be similar with the findings of this study.

In summary, as intervention programs to improve double-leg balance control of elderly females, Taekwondo and walking exercises are considered to be effective. Like previous studies reporting that tai chi and dance sports programs enhanced the balance control of persons experiencing falls(Schmit et al., 2005, Hopkins et al., 1990), more research on Taekwondo programs should be performed to identify whether or not it is a program for better balance control.

Ⅴ. Conclusion

This study analyzed the effect of twelve-weeks of Taekwondo and walking exercises on the variables of the double-leg balance control by dividing elderly females into Taekwondo, walking exercise, and control groups and it drew following conclusions.

Although AP measures were not significantly different among the groups and times, the ML RMS distance and ML velocity, among the ML measures, showed significant differences among the groups and times. The average velocity and 95% confidence ellipse area were also significantly different among the groups and times.

In conclusion, the twelve-week Taekwondo and walking exercise were found to be effective in improving the static balance control of elderly females. Further studies developing a Taekwondo intervention program customized for the elderly and applying long-term training with many subjects are expected.

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