THE EFFECT OF 12 WEEKS CIRCUIT-TRAINING ON HEEL CONTACT VELOCITY AND REACTION TIME IN ELDERLY WOMEN

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The purpose of this study was to determine the effects of circuit-training on heel contact velocity (HCV) during walking and reaction time (RT) in community-dwelling elderly women. Subjects were 20 healthy independent elderly women who participated in circuit-training which consisted of posture control, strength training and walking training for 12 weeks. Study outcomes included gait test, reaction time test, and 30-s chair stand test. RT and HCV were decreased significantly. The times of the 30-s chair stand test was increased significantly after training. These findings suggest that 12 weeks of circuit-training may attenuate the risks of slips and slip-initiated falls during walking in community-dwelling elderly women.

KEY WORDS: circuit-training, slip, heel contact velocity, reaction time, elderly

INTRODUCTION: Falling is an important health problem for many elderly. Thirty percent of the community-dwelling people over 65 years of age fall at least once a year (Tinetti et al., 1988). These falls may lead to a decrease of activity resulting in social isolation, to serious injuries, such as fractures of the wrist and hip, and even to death (Tinetti et al., 1988). Avoiding a slip-initiated fall requires reduction in likelihood of slipping, and a quick and effective corrective response for regaining balance after slips during walking. A high anterior-posterior heel contact velocity (HCV) in the swing phase is thought to increase the risk of slipping (Lockhart et al., 2003; Winter, 1991). The HCV during the heel contact (HC) was significantly higher for older individuals than for younger individuals (Mills & Barrett, 2001; Winter, 1991) and higher for fallers than non-fallers (Lockhart et al., 2003), even though the walking velocity of older participants and fallers were slower. We believed that one of the effective countermeasures against slip-initiated fall for elderly is to decrease HCV. During late swing, activation of the hamstrings group causes a flexion moment at the knee, and an extension moment at the hip, both of which contribute to the reduction of HCV prior to HC, thus delayed and reduced hamstring muscle activation is associated with this increased HCV (Winter, 1991). In addition, Lord et al., (1996) has demonstrated that training program (aerobic, balance and strengthening) have proven successful at translating lower extremity muscle strength increases to improvement in gait in older adults. Therefore, we hypothesized that circuit-training is an effective intervention in decrease HCV in elderly people. To the authors' knowledge, however, no study has considered the effect of circuit-training on HCV in elderly. There is considerable evidence that reaction time (RT) involving movements of the lower limb and the whole body increase with age (Lord et al., 2001). Previous research has shown that older adults have slower and smaller postural muscle response after the slip (Tang et al., 1998). In addition, it has been shown that decreased response time can substantially improve mobility of older adults who have the risk of falling (van den Bogert et al., 2002). Previous studies (Rooks et al., 1997; Whitehurst, 1991) have assessed the effects of resistant training and aerobic training on RT of elderly people, but the findings of those studies are inconsistent. Moreover, few data is available on the effects of circuit-training on RT. Thus, the purpose of this study is to examine HCV and RT changes after 12 week circuit-training in community-dwelling elderly women.

METHODS: Twenty healthy elderly women (age range, 65-79 yrs), who were independent in their activities of daily living without walking aids, were recruited to participate in this study from Health Promoting Center. This study was approved by the local ethics committee. These subjects affirmed their health diagnoses, anamnesis. The training program contained aerobic trainings, activities of balance, and strength training. In detail, it included stretching, balance ball, step, body-bar exercise, mini-hurdle walking, zigzag footwork, walk in pool, walking, and sit-and-stand up. The subjects participated in approximately two-hour training

sessions twice weekly for 12 weeks. The trainings were divided into five sections: a 5-to 10-minute warm-up period, a 15-minute stretching period, a 70-minute circuit-training period (included a 30-minute balance ball training period or a 30-minute walking in pool period) and a 10-minute relaxation (cool down) period. One-to 5-minute rest periods were taken between training sections. Lower extremity muscle strength was determined via the 30-second Chair Stand Test (CS-30 test) which has been shown to be safe and effective measure of lower extremity muscle strength in older adults (Jones et al., 1999). Each subject stood on mat switch of whole body reaction measuring equipment (TKK-126b, TAKEI Japan) and was asked to jump upright as quickly as possible in response to flashing. RT that average value of the results (five timed trials) except each maximum and minimum was recorded.
Gait analysis: Subjects wore sports shoes walked across a 10 m walkway, while sagittal kinematic data of the left lower extremity were collected using a high-speed (125 f/s) camera (HSV-500C3, NAC Japan). The markers were placed on the left side of the subject at the following bony landmarks: the heel, the fifth metatarsal head, the lateral malleolus, the femoral epicondyle, the greater trochanter and the acromion. Subjects were asked to walk on the walkway at a self-selected pace after several practice trials. During the practice session, each subject established a self-selected comfortable walking pace. The markers of every subject were digitized using the video-based WINanalyze 5 motion measurement system (Mikromak, Berlin, Germany). The raw data of the markers were filtered with Savitizky-Golay filter. The HCV were calculated utilizing heel velocity in the horizontal direction at heel displacement of 2/125 s and 1/125 s($\triangle$t) before and after the HC phase using the formula: HCV = V_i = [-2X(i-2)- X(i-1)+ X(i+1)+2 X(i+2)]/10$\triangle$t. Where, X(i) = heel displacement in the horizontal direction and i = frame number at the HC phase. The index of HCV/V was calculated by dividing the HCV by gait velocity (V).
Statistical analysis: All data analyses were performed with the Statview statistical package (Abacus Concepts J-4.5). Standard statistical methods were used to calculate mean and SD. To test changes in outcome measure between pre- and post-training data, a student's paired t-test was performed. Statistical significance was preset at the $p < 0.05$ level.

RESULTS: Table1 shows the changes in outcome measures between baseline and 12 week measures. RT decreased 6.4% after circuit-training (p<.05). The times of CS-30 test increased 13.5% (p<. 001), and this indicated a gain in muscle strength. After 12 week circuit-training, the stride, cadence, and velocity are not a significantly different. However, HCV and HCV/V decreased 31.6% (p<. 001) and 22.2% (p<. 01) respectively.

Table 1 Changes in outcome measures between baseline and 12 week measures.

	Baseline (n = 20)	12 week measures (n = 20)	Change
Gait velocity (m/s)	1.5 ± 0.4	1.3± 0.3	0.20
Stride (m)	1.5 ± 0.4	1.3 ± 0.2	0.20
Cadence (steps/s)	122.5 ± 11.1	119.4 ± 12.1	3.10
HCV (m/s)	1.3 ± 0.3	0.9 ± 0.3	0.4***
HCV/V	0.9 ± 0.2	0.7 ± 0.2	0.2 **
RT (msec)	481.3 ± 73.2	450.5 ± 66.3	30.2*
CS-30 test (times)	14.8 ± 4.0	16.8± 3.4	2.0 ***

Values represent mean ± SD, * p < .05, ** p < .01, *** p < .001
HCV/V = (the anterior-posterior velocity of heel contact) ÷ (gait velocity)

DISCUSSION: RT is a physiological entity that has been studied extensively in the research literature and has been linked as a causal factor in the incidence of falls in the elderly population. The findings of previous studies regarding the effect of training on RT are inconsistent. Whitehurst (1991) has reported that there was no effect of aerobic training (8 weeks for 3 35- to 40-min. sessions per week) on RT of elderly women. However, Rooks et al (1997) have reported that not only resistance-training but also walking training for 10

months have an improvement on RT respectively. Differences in the mode and intensity of the training, particularly differences in the mode between two studies may also explain the inconsistencies. Whitehurst (1991) used stationary bicycle training, compared to Rooks et al used climbed-stairs and walking training. While the mode in our study was different with the study by Rooks et al (1997), there is a similar improvement in both studies. Our findings suggest that RT is modifiable by circuit-training because a decrease 6.4% over 12 week training period. Furthermore, the increase of the times CS-30 test in this study seems to be an improvement in lower limb muscular strength.
Balance and characteristics of gait change with advancing age appear to be important predictors in determining the likelihood of an older adult falling. It has been shown that the two critical points in the gait cycle from a falls perspective are minimum toe clearance and HC, which occur during the swing phase and the swing to stance transition, respectively (Winter, 1991). The majority of slips occur in the phases following HC and a high HCV has been proposed as a risk factor for slip induced falls (Lockhart et al., 2003; Winter, 1991). In addition, HCV has been reported to be greater in elderly than young (Mill & Barrett, 2001; Winter, 1991) and was independent of gait velocity (Mill & Barrett, 2001). Therefore, the greater HCV of the elderly may provide an explanation as to why slips are the primary cause of falls in elderly men (Berg et al., 1997). A significant decrease (31.6%) in HCV was observed over 12 week training period in the present study. Furthermore, the index of HCV/V has also shown a similar decrease. Mills & Barrett (2001) have showed that the greater HCV of elderly was independent of gait velocity. Thus, improvement of HCV in our study was interpreted as a contribution of training rather than as a change in gait velocity.

CONCLUSION: Circuit-training for 12 weeks effectively improved HCV and RT. Our results suggest that circuit-training may attenuate the risk of slip-initiated falls during walking.

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