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Would Static-Stretching Exercises Acutely Affect the Gait Parameters in the Older Adults or not?

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ABSTRACT

Introduction: Falling is one of the most important health issues among the elderly that can lead to irreparable injuries. Previous studies suggest that exaggerated hip muscle tightness is a common characteristic of the fallers. The present research aimed to analyze the effects of one stretching session on the falling risk of older adults.

Methods: Fifteen healthy elderly men voluntarily participated in this research. They randomly divided into two control and experimental group with equivalent physical characteristics (n=25 in each group). The participants were excluded if they had problems that may affect their walking ability. This study was quasi-experimental research. Kinematic gait analysis was executed by motion analysis system previous (PRE) and instantly following (POST) a set of characteristic static-stretching training for the hip flexor muscles on both limbs. Statistical analysis was performed using SPSS version 22.

Results: The results of our study demonstrated a significant increase in walking speed and step length ($P < 0.05$) following one session of static-stretching training. Also, there was a significant decrease in double support time during the stance phase of walking ($P < 0.05$), proposing developed stability and mobility. The anterior-posterior pelvis tilt was also increased significantly in post-test in comparison with pre-test ($P < 0.05$). Some of the other gait parameters like toe clearance inhabited unchanged ($P > 0.05$) and the stable pattern of segmental angular velocities was suggested to analyze the stability of the unaltered gait parameters.

Conclusion: The findings propose that stretching training, applied on a systematic basis (e.g. daily exercises), result in gait adaptations which can be considered as indicative of decreased the risk of fall.

Introduction

Falling is one of the most important health issues among the elderly that can lead to injuries and even death. It is suggested that approximately 30% of the elderly over the age of 65 years (1) and 50% of the elderly over the age of 80 years have been affected by it annually. Although the minimal percentage of fallings result in hip fractures, maximal percentage of hip fractures follow on as the impact of falling. Furthermore, the injuries caused by falling in older adults commonly require long-term admissions and can severely decrease their mobility and reduce their physical activity following rehabilitation (1). These variables ultimately affect the social activities of the elderly and cause the need for care assistance and dependency (1, 2). There are many internal and external risk factors that affect the human movement and may lead to lots of hip fractures and fall in people. External factors, such as slippery surface and icy surfaces are related to environmental hazards, but internal factors are related to the individual which are the best predictors of the fall risk for the older adults (3). One of the major causes of falling is muscle weakness due to aging (4). Basically decreased physicalactivity and impaired mobility measurements such as body sway and walking gait are extremely associated with the risk of fall. It has been indicated that there is a positive and significant relationship between fall occurrence and range of motion (ROM) reduction which is the result of the muscle-tendon unit and surrounding connective tissue stiffness (5). The decrease in the ROM particularly around the hip and ankle joints can lead to falling because the hip rigidity affects the dynamics of the lower extremity during walking (6). Kang et al. (2008) offered that a decline in lower limb joints mobility is one of the significant age-related variables affecting the pattern of walking gait. It has been demonstrated that regardless of the walking speed, both older adult fallers and non-fallers have lower maximum hip extension during walking than younger adults. Since the tightness of the antagonistic muscles has a major influence on the maximum hip extension, special hip flexor stretching exercises are expected to be a marvelous way to improve walking ability in the older adults and decrease the fall risk(7). In the research done by Kerrigan et al. (2001), it has been suggested that exaggerated hip tightness is the common characteristic of the fallers. In another study (2003) they reported an increase in the maximum hip extension during walking, following a 10-week unsupervised training program, but the increase was not significant. These results may be due to the lack of adequate adherence and control over the exercise. Actually, it has been demonstrated that home practiced (unsupervised) exercises are less effective than controlled, center-based ones. The effect of correctly performed stretching exercise on gait parameters has remained unclear. If it is assumed that the result of long-lasting exercises is accumulative feedback of consecutive training sessions, examining the temporary effect created by one session can found an interesting option to comprehend the long-lasting consequences of stretching exercise programs. Actually it has been shown that stretching exercises can construct acute alternations in joint ROM (8-11). Aging can be characterized via additional amplitude at the hip joint and or several changes in gait pattern (e.g., increase step length) that have been provided by the acute effects of stretching exercises. Consequently, the current research focused on the investigation of the acute effects of a single session of static stretching training for the hip flexor muscle complex over the walking gait and some of the factors that have been correlated with the falling risk in the older adults.

Methods

Participants

Fifteen healthy elderly men voluntarily participated in this research. All of the participants signed the written consent form, after apprising of the inherent risks and benefits. The participants were excluded if they had problems that may affect their walking ability (e.g. a history of surgery or fractures in the lower extremity, low back pain, arthritis, etc.), were unable to carry out their regular daily activities with no assistance, had a history of falling over the past 12 months or were involved in a regular physical activity program in the last six months. Female participants were not included, because of physiological differences between the two genders. This study was approved in the Ethics Committee at Kerman University of Medical Sciences (IR.KMU.REC.1394.598).

Data collection

Participants were requested to walk in the laboratory area, less than the 30s following the static-stretching procedures to record their gait kinematics. They walked specified pathway 4-6 times, to be familiar with the protocol. The walking procedure was performed barefoot at the participant's self-selected speed. Three-dimensional kinematics of the lower extremities were recorded with 3D Motion Analysis System (Digital Real-Time System, Raptor-H, with 6 infrared optoelectronic cameras). Passive markers were placed on the landmarks bilaterally which include: 1. Anterior superior iliac crest (ASIC), 2. The most prominent protuberance of the greater trochanter (TROC), 3. Lateral femoral epicondyle (KNEE), 4. Lateral malleolus (MALL) and 5. he fifth metatarsal joint (META). The right side of the lower limb kinematic was analyzed. The two-dimensional analysis in sagittal and frontal planes of the pelvis and lower extremities were performed. Other researches have used unilateral analysis (7, 12, 13) and have reported a symmetrical profile between segments in healthy individuals(14). First three valid trials from ten gait cycles for each participant in both experimental conditions (PRE and POST), were selected to further analysis. The period between two consecutive heel contacts of the right foot was considered as the gait cycle. Each participant's movement pattern had been represented by these three cycles which were normalized to the gait cycle (first heel contact corresponded to 0% and the second heel contact corresponded to 100%) and averaged (ensemble averaged). individual's angles in normal standing posture were obtained to normalize angular parameters in the sagittal plane. Table 1 presents the variables used to describe the gait in the present study.

Static-stretching protocol

A set of characteristic static-stretching training for the hip flexor muscles on both limbs was performed. Since satisfactory results of static-stretching training have been proved in groups of older adults, we used that type of exercises (15, 16). The exercises were performed when the participants were lying on their back with both lower limbs hanging from the edge of a padded table. One of the experienced experimenters exerted stretching by flexing the thigh toward the trunk at approximately 45 degrees to the horizon, while another experimenter moved the contralateral thigh downwards to make hip hyperextension. Then the experimenter flexed the knee of the stretched leg and sustained it in a position which participants reported the first symptoms of muscle discomfort for the 60s. Four alternate exercises were repeated in each leg (240 seconds per each limb).

Statistical analysis

A one-way ANOVA showed no significant differences in terms of variability ($P > 0.05$). Kolmogorov-Smirnov (K-S) test was used to confirm data normality. A number of *t*-tests have been used for dependent gait variables to determine significant differences between the two experimental conditions (PRE and POST). Statistical analyses were performed with Statistical software package, version 7.0 and the significance level was set at ($P < 0.05$). Bonferroni's correction was applied to adjust the significance of the coefficient level.

Results

Fifteen healthy elderly men with mean age of 65.50 ± 3.841, height 168.10 ± 5.215 weight 70.865 ± 7.775 and body mass index 24.781 ± 2.483 voluntarily participated in this research. The demographic characteristics of all participants have been reported in Table 1. As shown in table 1 there were no significant differences in baseline characteristics of participants in both groups and they were comparable. The results of the present research are provided in Table 2. A one-way ANOVA was performed to compare within-subject differences after a single session static stretching training. A one-way ANOVA showed no significant differences in terms of variability ($P > 0.05$). The findings of this study showed significant differences between the walking gait variables previous and following stretching. The results of our study demonstrated a significant increase in walking speed and step length ($P < 0.05$) following one session of static-stretching training. Also, there was a significant decrease in double support time during the stance phase of walking ($P < 0.05$), proposing developed stability and mobility. The anterior-posterior pelvis tilt was also increased significantly in post-test in comparison with pre-test ($P < 0.05$). Some of the other gait parameters like toe clearance inhabited unchanged ($P > 0.05$) and to analyze the stability of the unaltered gait parameters.

Table 1. Descriptive statistics of participants' characteristics

Groups	n	Age	Height	Mass	BMI
Experimental group (Mean ± SD)	15	65.502±3.481	168.101±5.215	70.865±7.775	24.781±2.483
Control group (Mean ± SD)	15	67.324±3.762	168.315±4.357	71.237±5.500	24.984±1.902

Table 2. Walking gait parameters

Parameters(unit)	Pre test	Post test	d	v
Cadence (step/min)	59.11±3.24	60.48±3.81	0.64	0.01
Step length (m)	0.55±0.43	0.58±0.73	6.00*	0.21
Toe clearance (m)	0.017±0.004	0.019±0.003	13.45	0.39
Gait speed (m/s)	1.03±0.11	1.07±0.06	5.33*	0.02
Flexion/Extension of hip (˚)	23.78±4.39	26.11±3.23	4.74	0.12
Flexion/Extension of knee (˚)	48. 31±5.23	51.76±4.71	3.21	0.08
Dorsi flexion/Plantar flexion of ankle (˚)	23.43±2.34	24.93±2.10	5.50	0.09
Gait cycle duration (s)	1.00±0.04	0.09±0.07	-0.5	0.01
Swing duration (%)	39.76±1.31	40.00±0.01	4.20*	0.11
Stance duration (%)	60.24±2.45	60.00±0.12	-1.92*	0.02
Double support duration (s)	0.17±0.02	0.16±0.01	-4.68*	0.04
Anterior/Posterior tilt of pelvis (˚)	14.77±3.12	16.54±4.35	19.62*	0.15
Rotation of pelvic (˚)	6.04±4.34	7.55±1.86	20.57*	0.18
Heel contact velocity (m/s)	1.19±0.11	1.21±0.09	4.91	0.12

Mean ± standard deviation previous (PRE-test) and following (POST-test) static-stretching exercises, the mean difference (d) and variability within subject trials (V). * indicate significant differences ($P \leq 0.05$.

All participants were able to reach a 6.6 percent greater walking speed reached by greater step length with no adjust in cadence after stretching. The increase in step length was generally reached by the integrity of greater movement about the pelvis with growth in both anterior tilt and rotation in the horizontal plane. The walking gait pattern also reveal alters in the temporal pattern. The increased walking gait speed following stretching was occurred by a reduction in the stance time, a lower proportion of time in double support and, a greater swing duration. These indicated temporal alternations are suggestive of enhanced balance.

Discussion

The purpose of this study was to investigate the acute effect of static stretching exercises on gait parameters. It was hypothesized that static stretching exercises would acutely change the desired variables and would decrease the risk of falls in the elderly (7, 12, 13, 17-22). The dynamic spatiotemporal features that have been observed immediately after stretching were similar to those reported in previous studies (23, 24). Therefore, it can be claimed that the sample used in this study is sufficient to show the population of healthy elderly men living in the community. We used the stretching protocol that previous studies had demonstrated its effect on the range of motion (25). Since the study by Nakamura et al. (2011) showed that stretching had still significant effects on the muscle-tendon elastic properties after five minutes, in the present study, the effects of static stretching exercises were analyzed after a 30 seconds interruption, which seems to be an adequate time to maintain the effects of stretching (26). It has been suggested that gait speed is the foremost independent fall-related predictor (27). So that the people who are at risk of falling have a lower gait velocity in comparison to those who are not at risk of falling (28). Hence, the increased gait speed resulting from the application of stretching exercises in the present study, suggests that these exercises have been effective in improving mobility and some of the important functional effects of aging. So, stretching exercises provide an important strategy that reduces the risk of fall during walking. Although walking speed is finally defined by step length and cadence (29), but in the present study, due to the fact that cadence remained unchanged, greater walking speed cannot be associated with it. Therefore, increasing the speed of walking after stretching can be considered as a result of increased pelvic rotation and tilting range of motion, which ultimately increased the step length. The heel of the swinging leg would strike farther in front of the body if the range of motion around the pelvis increases (30). It is believed that increasing the rotation of pelvic have a substantial effect on gait dynamics via flattening the climax of the center of the mass path, which makes body movement smoother and also by creating smother alteration in the center of mass, enables the elderly to attenuate the ground impact forces (30). Consequently, it may be conjectured that decreasing the contact forces at heel strike can help to minimize head acceleration through progression and provide a facilitated balance of the visional platform (31) and lesser disruption over the vestibular equipment. One of the other offered predictors of fallings in the elderly is increased double support time (32). The shorter double support time, the more stability during gait; that can display a scale of mobility. Accordingly, it is necessary to increase the duration of double support time to increase stability during progression for the next step (32). The idea that stretching exercises can be an impressive way to ameliorate gait performance in the elderly, is reinforced through this evidence. Among other factors that are associated with risk of fall, anteroposterior heel contact velocity and the toe clearance can be pointed out (33). The anteroposterior heel contact velocity obtained in this study is alike to that explained in previous studies (34). The angular velocities of the thigh, shank, and foot of the swinging leg largely determine the desired variable. The unchanged anteroposterior heel contact velocity and clearance in this study can be explained by the stability of the segmental angular velocities. Our results may be affected by aging-related conditions (e.g., balance problems, osteoarthritis), that make changes in gait pattern.

Conclusion

It can be concluded that stretching exercises lead to significant corrections in gait characteristics of elderly which makes their movement patterns similar to healthy adults. These results indicate that improved and/or reduced negative influence of aging over a number of functional characteristics associated with fall risk during gait is achieved through the attractive strategy resulting from these exercises. It is essential to keep in mind that stretching training is a principal part of physical activity programs and should be illustrated as one of the effective parameters on walking gait performance. It is required to conduct studies to examine the long-term effects of stretching exercises to find out whether the temporary effects displayed in this study appear as a result of a methodical training program. Furthermore, it is necessary to confirm these assumptions experimentally by longitudinal studies regarding stretching and the fall risk. And in the end, the authors declared no conflicts of interest.

Ethical disclosure

In this study, tests that threatened the health of individuals were not used.

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Author contributions

All the authors have accepted responsibility for the entire content of this submitted manuscript and approved submission.

Conflict of interest

The authors declare that they have no conflict of interest.

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