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A Comparison of Gait Characteristics in the Elderly People, People with Knee Pain, and People Who Are Walker Dependent People

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Abstract. [Purpose] The purpose of this study was to compare the gait parameters of age-matched people with a normal gait (≥ 65 years), age-matched people with knee pain, and age-matched people with walker dependent gait at a self-selected gait speed. [Methods] Subjects walked on even ground in bare feet and were allowed a natural arm swing on a 6-m walkway. Walker-dependent participants walked on a walkway without a walker. [Results] The kinematic and spatiotemporal gait characteristics were used to investigate the difference among the each group. Hip flexion, knee flexion, and stride width parameters were not different. The gait speed, stride length and time, hip and knee extension, and ankle flexion and extension parameters were significantly different. [Conclusion] A comparision of kinematic and spatiotemporal gait characteristics during gait may provide an insight into the gait pattern of normal elderly people, those with knee pain, and the walker-dependent elderly.
Key words: Elderly people, Gait characteristics, Walker dependent

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INTRODUCTION

An integrated neuromotor system with a sufficient motor drive and adequate sensory feedback is required for efficient locomotion[1)]. Gait adaptations in elderly people may be associated with a decrease in muscle strength due to the loss of motor neurons, muscle fibers, and aerobic capacity[2–4)]. A decline in mobility due to gait adaptation in the elderly limits their activities of daily living. Researchers studying age-related differences in gait have shown that older adults have a reduced gait speed[5–8)], less hip and knee extension, reduced ankle dorsiflexion angle at heel-strike[5–7, 9, 10)], decreased step and stride length, and altered step width[5–7, 11–13)]. Additional, increases in double-support time, stance time, and quadriceps energy absorption and a reduction in power during toe-off also have been reported in older adults[5–14)]. Ishikura (2001) described that the gait speed of walker-dependent participants decreased to about 70% of the normal gait speed[15, 16)].

In general, there have been no studies that have investigated the difference in gait characteristics for elderly people, age-matched people with knee pain, and people dependent in a walker over 2 years. We theorized that people who are walked dependent and walk with knee pain may be slow and show a distorted gait pattern. The purpose of this study was to describe the differences in gait characteristics among a normal group, age-matched control group with knee pain, and age-matched control group with walker.

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SUBJECTS AND METHODS

Subjects

To compare the gait characteristics of each group, twenty-one participants were recruited. The study group consisted of: ten normal elderly people, six people with knee pain in an early stage of knee arthrosis (<VAS 4), and five people dependent on a walker for at least 2 years. All people participated in a multivariate comparison study of gait variability at self-selected walking speeds, and their knee joints were not limited in terms of range of motion. Participants enrolled in this study after providing informed consent in accordance with the ethical standards of the Declaration of Helsinki. Diagnosis of osteoarthritis (OA) was based on the American College of Rheumatology criteria for OA of the knee.

Methods

Subjects walked on even ground with bare feet and were allowed a natural arm swing. First, a self-selected walking speed was determined. Second, subjects completed 5 walking trials at the self-selected speed. Third, walker-dependent gait participants walked on the walkway without a walker after researchers confirmed whether they could walk 10 m without falling down and turn around. When they walked without their walker, one researcher supervised them from 1 m away, and put cushions around the walkway to prevent injuries resulting from falls. These subjects rested at least 2 min between trials. Subjects were instructed to look ahead and to avoid extraneous movements while walking.

Table 1. General characteristics of subjects (n=19)

Group	N	Age (years)	Height (cm)	Foot length (mm)	Gender ratio (male/female)
Normal	10	70.67±2.67	159.65±8.91*	239.03±6.28*	5/5
Knee pain	6	72.07±4.06	159.34±8.94*	240.46±7.51*	2/4
Walker dependent	3	72.11±2.20	157.65±8.91*	238.34±7.69*	1/2

*p>0.05

Table 2. Comparison of spatiotemporal gait characteristics

Gait characteristics	Group	N	Mean±SD	95% Confidence intervals
Gait speed(m/s)*	Normal	10	106.55±9.48[b]	99.76–113.33
	Knee pain	6	94.03±13.29[b]	80.09–107.97
	Walker dependent	3	46.50±2.78[a]	39.58–53.41
Stride length (cm)*	Normal	10	110.20±8.90[b]	103.83–116.56
	Knee pain	6	98.24±11.93[b]	85.71–110.76
	Walker dependent	3	67.13±1.19[a]	64.17–70.10
Stride width (cm)	Normal	10	10.16±2.39	8.44–11.87
	Knee pain	6	11.58±2.27	9.21–13.96
	Walker dependent	3	11.43±1.57	7.53–15.33
Stance phase of gait cycle (%)*	Normal	10	63.40±1.87[a]	62.06–64.73
	Knee pain	6	62.97±0.92[a]	62.01–63.94
	Walker dependent	3	68.95±2.28 [b]	63.28–74.61
Stride time (m/s)*	Normal	10	1.02±0.02[a]	1.00–1.04
	Knee pain	6	1.03±0.07[a]	0.96–1.11
	Walker dependent	3	1.49±0.03[b]	1.39–1.59

$^{a<b}$ p<0.05, * Larger than effect size 0.7 (p<0.01)

Two subjects who anterior walkers were discarded because they could not walk without an anterior walker or had a high risk of falling. A gait analysis was performed using a VICON system (Oxford Metrics, UK). The kinematics of thirty-one 14-mm markers was measured using a 6-camera VICON 612 system. Five markers were placed on the pelvis, anterior superior iliac spine (ASIS) and a four-marker cluster on the sacrum; a four mark cluster was placed on the left thigh and on the lateral epicondyle of the left femur; a four mark cluster on the left shank, one on the left lateral malleolus; and five makers on the feet (the head of the second phalanx, the head of the fifth metatarsal, and the calcaneus). All statistics were calculated using PASW version 18.0. Descriptive statistics were calculated (frequency, mean and standard deviation, and range). The spatiotemporal and kinematic gait characteristics were used to calculate for the means, standard deviations, and 95% confidential intervals in each group. Table 1 shows the eleven gait characteristics that were adopted by this study. The Kruskal-Wallis test was used to compare the gait characteristics in each group. The Bonferroni collections method was used to compare the difference invalues within each group. p<0.05 was adopted as the criterion for statistical significance.

RESULTS

An independent samples t-test demonstrated no significant difference among the normal group, knee pain group, and walker-dependent group for height and foot length. The mean ages of each enrolled group were 70.6, 72.2, and 88.3 years (Table 1).

The normal group and knee pain group had faster gait speed and longer stride times and stride lengths than the walker-dependent group (p<0.05). The stance phase rate of the walker-dependent group was higher the than those of normal group and the knee pain groups (p<0.05). Stride width was similar among the group (p<0.05) (Table 2).

With regard to peak knee extension, peak ankle flexion, and stance phase rate, the walker-dependent group had a greater gait variability than the normal group (p<0.05). With regard to peak ankle extension, the values of the walker-dependent and knee pain groups were greater than that of the normal group (p<0.05). The hip flexion and knee flexion kinematic parameters were not significantly different among the group (p>0.05) (Table 3).

In addition, the effect size for the difference in spatiotemporal gait characteristics was large (p<0.01, η^2=0.75–0.94) except for stride width (p>0.05, η^2=0.09). The effect size for the difference in kinematic gait characteristics was medium (p<0.05, η^2=0.41–0.64) except for hip and knee

Table 3. The comparison of kinematic gait characteristics

Gait characteristics	Group	N	Mean±SD	95% Confidence intervals
Hip flexion (°)	Normal	10	32.49±7.32	27.25–37.73
	Knee pain	6	34.64±5.72	28.63–40.64
	Walker dependent	3	43.55±5.04	31.04–56.07
Hip Extension (°)*	Normal	10	−10.38±8.40[a]	−16.40–4.38
	Knee pain	6	−3.80±8.77	−13.02–5.40
	Walker dependent	3	10.53±14.79[b]	−26.20–47.26
Knee flexion (°)	Normal	10	64.00±5.85	59.81–68.18
	Knee pain	3	61.78±3.84	57.75–65.80
	Walker dependent	3	61.11±3.63	52.09–70.13
Knee extension (°)*	Normal	10	6.20±3.79[a]	3.49–8.91
	Knee pain	3	10.33±4.51	−0.87–21.53
	Walker dependent	3	14.33±1.53[b]	10.54–18.13
Ankle flexion (°)*	Normal	10	13.87±3.29[a]	11.51–16.22
	Knee pain	3	15.01±5.10[a]	9.65–20.37
	Walker dependent	3	22.95±3.08[b]	15.29–18.04
Ankle extension (°)*	Normal	10	−11.78±3.99[a]	−14.64–8.93
	Knee pain	3	−3.74±3.57 [b]	−7.49–0.01
	Walker dependent	3	−1.51±0.91[b]	−3.76–0.74

$^{a<b}$p<0.05, *Effect size range 0.41–0.65 (p<0.01)

flexion ($p>0.05$, $\eta^2=0.29$ and 0.07).

DISCUSSION

The findings of this comparison for gait among normal participants, those with knee pain, and those who were walker dependent indicated that walker-dependent participants walked in a manner in which the hip, knee, and ankle were slightly bent. Hip flexion, hip extension, knee flexion, and step width were not different among the group. The gait speed of the walker-dependent participants was also slower than that of the normal control group and knee pain group. The stride time and stride length of the walker-dependent group were shorter and longer than those of the normal group and knee pain group. The rate of stance phase for the walker dependent group was lower than that of the normal group and knee pain group.

In the spatiotemporal parameters, gait velocity was slower in the walker-dependent gait group. The overall stance phase of the gait cycle was longer in the walker-dependent gait group. The stride length and time of the walker-dependent gait group were shorter and slower than those of the other groups. One possible reason for this was that an adaptive mechanism may have occurred to reduce the risk of falls by decreasing postural stability. A walker-dependent gait causes subjects to limit their activity level, which results in decreased mobility and balance and an overall reduction in flexibility. The effect size of the spatiotemporal parameters was large. Although the number of subjects was small, the subjects of this study were sufficient for investigation of the realistic difference in gait variability.

The results of this study showed that kinematic parameters (such as hip extension, knee extension, ankle flexion, and ankle extension) of the knee pain group and walker-dependent gait group were less than those of the normal group in this study. The reason for this may be an increased stiffness of soft tissue structures in the knee, more knee flexion throughout the gait cycle to unconsciously lower their center of gravity, and an unconscious precaution against tripping. In our study, the hip and knee flexion kinematic parameters were not different among the groups. There was a difference in hip extension between elderly participants and walker dependent participants. The reason for this may be that the gait pattern for walker-dependent participants showed a lack of appropriate use of hip extension power or ground reaction force. Hip extension is an important parameter for firing of the central pattern generator neurons that are responsible for consistent stepping during gait[17–19]. Therefore, the lack of hip extension in walker-dependent people may indicate that the signal needed for a central pattern generator to generate stepping in each group is regular. A previous study reported that an experimentally altered step width was a significant contributor to the energy cost of walking in adults[20, 21]. In the present study, the consistent step width values in the groups indicate that the energy cost of walking was not increased due to knee pain or walker-dependent gait. The range of effect size for kinematic gait variability was medium or less medium. Thus, future studies are needed to investigate the realistic difference in kinematic gait variability among the groups with a larger group of subjects.

Previous research comparing younger and older people have explained that a possible mechanism for kinematic gait variability may be that push-off torque in older people was more reduced than that in younger people[22]. This study showed similar results in participants with a weaker knee and a larger knee extension angle. The reason for this may be the intention to increase limb stability.

The ankle flexion and extension parameters of the walker-dependent gait group were significantly lower than that those of normal group and knee pain group. The reason for this may be that it is part of an adaptive mechanism to reduce energy cost by decreasing push-off torque by decreasing the ankle moments or tight dorsiflexors.

In the future, a gait analysis of older people who have knee pain and are walker dependent might more clearly define the characteristic results of our study. Intention studies could be conducted to determine whether improving knee extension, stride length, or walking velocity in people with knee pain and people who are walker-dependent improves functional gait. This study should be repeated with a large sample size that would make a normal distribution of subjects more likely.

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