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Simulated knee flexion contracture effect on postural stability in elderly people

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Abstract

Background: Postural instability is one of the common problems of aging. However, with increased age many systems of body such as musculoskeletal system are affected and changed. One of these changes is knee flexion contracture. The study aimed to investigate the simulated knee flexion contracture effects on postural stability in elderly.

Materials and Methods: 15 elderly subjects (11 men, 4 women) participated in this study. Postural stability at 0 and 30 degree of knee joints was evaluated utilizing of two rehabilitation knee braces (adaptable knee range of motion control brace). In 0 degree, braces did not cause any constraint whereas for knee joint in 30 degree, contracture was simulated so knee joints were in 30 degree flexion and extension not allowed. Postural stability in standing position with eyes open and closed were assessed by a force platform . COP data were analyzed to describe the stability of elderly persons.

Results: Result of this study showed that COP parameters in eyes closed condition were significantly increased (P<0.05).

In addition, these results showed that in 0 degree with eyes open, postural sway was in minimum range; and in 30 degree simulated knee flexion contracture (KFC) with closed eyes, postural sway was maximum.

Conclusion: This study concluded that postural stability of elderly people was affected by knee flexion contracture, a condition which stability was diminished and defected.

Key words: postural stability, COP, aging, simulated knee flexion contracture

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Introduction

The ability to maintain a stable standing posture is known to decrease with age. The effect of aging potential mechanism on postural control is due to reduced sensory function of one or more sensory systems that affect the stance stability. The three main sensory systems used to provide proper feedback for control of upright standing balance are visual, vestibular, and proprioceptive systems.

An important aspect of this sensory integration is the ability of the postural control system to adapt to external perturbations by adjusting the relative weight placed on the information obtained from various sensory systems(1). Postural instability increases due to dysfunctions in sensorimotor system in elderly people (2). Older adults demonstrated increased amounts of postural sway which may lead to more falls (3). With increasing age, the musculoskeletal system will undergo a series of changes. One of these changes is the joint contractures. Knee flexion contractures are one of the most common types of contracture (4). Severe knee osteoarthritis often causes knee flexion contracture (5). Many patients will get problem in extending the knee due to degenerative changes of the knee (6). In the knee joint contracture, joints alignment and consequently its proprioception and also the spine alignment will be affected; therefore, correct and proper data are not transmitted from the muscles and ligament of the knee joints to the upper centers, and as a result, the efficiency of the postural control declines, and balance maintaining will become difficult.

The incidence of falls in elderly, and its medical and social impacts caused to lead many investigations on postural stability (7). Studies are showing that 25-35 % of people over the age of 65 years of age fall at least once a year and this number rising to 50% for people over the 80 years (2). The previous studies investigated the effect of the knee joint contracture on the balance of the elderly and the knee kinetics and the trunk kinematics. For example, Harato *et al.* studied the effect of the simulated knee flexion contracture on the knee kinetics both in affected and contralateral limbs during gait. They found that the knee flexion greater than 15 degrees led to mechanical overloads in both limbs (8). They also studied changes in trunk kinematics with simulated knee flexion contracture in the elderly women during walking and standing. They observed that the knee flexion contracture in both conditions has significant effects on three-dimensional kinematics of the trunk, and therefore will lead to spinal imbalance (9). In another study, Potter et al., studied the standing balance in simulated unilateral and bilateral knee flexion contracture, of 15 and 30 degrees braces. They found that with 30 degrees bilateral flexion contracture the COP moved anteriorly. Also it was concluded that with a unilateral flexion contracture of 30 degrees, the COP shifted toward the unflexed side (10).

The present information shows the importance of the postural stability also, the knee flexion contracture in the elderly people. According to the acquired information, there was only one similar study that investigated the effect of simulated knee flexion contracture on the postural stability (10). However, in this study the simulating was not on the elderly subjects. Also in this similar study, only COP displacement was used while in the present study more parameters of COP excursion were chosen and evaluated. In general, the aim of present study was to investigate simulated bilateral knee flexion contracture on the postural stability in the elderly.

Materials and Methods

15 elderly persons (11 men and 4 women) with the mean ± SD of age, weight, height, and body mass index of 62.06± 2.15 years, 72.13±10.76 kg, 166.47±6.42 cm and 25.76±3.69 respectively were chosen among the elderly people referring to the retired center of Medical Sciences University and Shahid Chamran University of Ahvaz. A simple random sampling method was applied and after case history and clinical examination of the knee, the appropriated elderly people were contributed in the study.

The participants signed the informed consent form approved by the Ethical Committee of the Ahvaz Jundishapur University of Medical Sciences and entered the study. The inclusion criteria for this study were age of 60 years or older (2, 7 and11-12), ability to stand for 60 seconds (11), ability to walk independently without assistant of any devices (2-3), having no record of falling even for once in the last year (7 and 13-14), and having a normal or minimum corrected vision (1-2 and 11). Exclusion criteria were acute or sub-acute neuromuscular or orthopedic diseases (2-3 and 14-19), contracture in both limbs (8, 9), and history of surgery in limbs or limbs joint replacement (2, 5 and 8-9). Getting the score equal or less than24 in mini mental status examination (2, 11-12 and 16), recent history of fraction or twisting in limbs (16), and vestibular dysfunctions like vertigo (3, 4 and 16).

Instrument:

To study the postural stability, the tests were carried out in applied biomechanics laboratory of the Rehabilitation School of the Ahvaz Jundishapur University of Medical Sciences. In rehabilitation studies, the COP data were used frequently to declare the quality of the postural stability. The study of the COP sway shows the contrast between neural and the biomechanical systems for the balance control. The COP parameter has different variables; in this study, some of variables were used. The COP data was collected at a sampling rate of 100 Hz using a Bertec force platform (Series 9090, MIE, UK). Time duration for recording data for each test was 50 seconds. The COP data were filtered with a bidirectional 4th order low pass Butterworth filter with 10Hz cut off frequency. The COP parameters including path length, area, and mean COP displacements and velocities in anterior-posterior and medial-lateral directions were extracted from filtered data.

A simulation of knee joint contracture:

To simulate the knee joints flexion contracture, adoptable knee braces were used. To investigate the stability in this study, six positions were designed which included: upright stance, no brace, once with open eyes, and once with closed eyes; upright stance with a zero degree braces once with open eyes, and once with closed eyes; and upright stance with a 30 degrees braces once with opened eyes, and once with closed eyes. In the zero degree, both the braces put on the knees in the way that the knees were straight and did not cause any constraint for the subject. For a simulation of the 30 degrees, the braces put on 30 degrees so the same as real contracture, knees would stay in 30 degrees and they could not be extended. After getting ready in the desired position, the subjects stood with bare feet on the force platform so the arms were relaxed at the side of the body, and the head erected upright. In open- eyes condition, subjects instructed to look straight ahead and focus on a scenic picture on a wall approximately 2 m in front of them. In closed eyes condition, subjects were instructed to stand quietly with their eyes closed for the duration of the trial. Each test lasted for 50 seconds with a two minutes rest interval. The tests were taken randomly and each test repeated three times and the average data of three trials were analyzed.

Statistical methods:

Statistical analysis was conducted using SPSS.16. K-S statistical test was used for examining normal distribution of data. To compare the variations in different positions 2-way repeated measure ANOVA was used. Significance level was set at 0.05.

Results

Tables 1 and 2 show the summary of results. The results showed that significant differences exist between the mean velocity, and mean velocity in anterior-posterior direction. According to the results, significant differences exist between the open and closed eyes conditions in the parameters of the path length, mean velocity, area (area of a 95% confidence ellipse), and mean velocity in anterior-posterior and medial-lateral direction. In closed eyes condition, the subjects showed more sway. In addition, the maximum stability was found in the parameters of the path length, the mean velocity, the area, and the mean velocity in anterior-posterior in the simulated zero degree contracture with opened eyes; and the minimum stability was found in the simulated 30 degrees contracture with closed eyes.

Discussion

In this study, the effect of simulated knee flexion contracture on postural stability in elderly people was investigated, and three positions including, standing without brace, with zero degree braces, and 30 degrees braces were compared to each other. Results showed that subjects had better postural stability when they were standing with zero degree brace compared to other positions. In fact, in most measured parameters of the COP, the use of zero degree braces decreased the postural sway. It also indicated that postural stability in the zero degree brace condition with open eyes was increased to the maximum rate.

To the authors' best knowledge, no study has yet investigated the effect of the brace on postural stability in elderly. In some studies the effect of wearing the neoprene sleeve braces, prophylactic, and functional brace on different groups such as patients with knee osteoarthritis, rugby players, and patients with anterior cruciate ligament rupture were investigated. Results showed that using these braces improves the proprioception and significantly increases the postural control in these groups (20-22). The results of using the zero degree brace in present study is consistent with the results of those studies and it was revealed that the use of zero degree brace improved the proprioception and provided a better mechanical stability for the knee joint. Therefore, the subjects showed the minimum sway and the maximum stability in a zero degree brace with open eyes.

The results also showed that when the knee contractures were simulated with 30 degrees braces, the subjects showed more postural sway. When a person's knees are put in a 30 degrees flexion, the joint and the surrounding soft tissues will not be in their normal position which causes defect in transported sensory data to upper centers. These findings were the same for the study of Potter *et al.*, which was proved that in knee contractures of 30 degrees, the postural stability of the subjects was affected, and the standing balance was disturbed and defected (10).

When the elderly people are placed in difficult postural conditions like the closed eyes condition in which vision data is not available, or when the surface under their foot changes, or like the present study, when changes occur in their normal musculoskeletal system, they show increased sway and postural instability. In fact with aging, processing of information in the central nervous system become slower (16). In absence of visual data, the boundary of stability in the elderly people will be decreased and the COP sway will be increased; therefore, maintain a stable posture becomes difficult (23). Besides, with decreased stability boundary in the elderly, they tend to have both a shorter time to lose balance in the standing position and functionally related problems of taking more time to reacquire stability (24). However, it is worth to note that a series of disagreements exist on the brace and its effects. Birmingham *et al*., investigated the effect of functional brace on knee flexion and extension muscular strength of patients after anterior cruciate ligament reconstruction. With the study of the torque produced by knee flexion and extension muscles, they found that the effect of the brace depends on the knee muscular strength. They mentioned that a brace may inhibit knee flexion strength of stronger individuals, yet result in no change or even improvement in knee flexion strength of weaker patients (25).

Our results also revealed that the elderly people showed poorer postural balance based on most of the COP parameters, in closed eyes condition. In fact, with absence of vision data the subjects encountered difficulty to maintain stability. The results of the earlier studies also showed that the visual factors significantly affect the postural stability of the elderly (12, 19, and 26). Therefore, for the elderly people, maintaining the postural stability in the closed eyes condition was more difficult compared to the open eyes condition. Results also indicated that the sway of the COP in anterior-posterior direction was higher than medial-lateral direction in both mean displacement and velocity variables. These results are in agreement with the results of Mackey's (27) and Du Pasquier (28) studies that investigated the effect of vision on postural stability of the elderly people. In general, for maintaining postural stability, individual needs three sensory systems including somatosensory, visual, and vestibular. When a person is standing on a flat stable surface, he or she needs a proper weighting between these information. Vestibular information may play a limited role in the quiet standing and visual and somatosensory information become more important to control the posture. Therefore, the absence of vision in closed eyes condition was predicted to make the task more challenging for the subjects, leading to an increase in body sway (29).

Other limits of the study included a lack of investigation about the more difficult postures like changes in the under feet surface (using foam) or a lack of investigation about the walking of the elderly people with the simulated contracture which did not carried out due to being too old people and to make the conditions safe. The real contracture did not studied because the people with real contracture were not active people in the available society and even if we found them, the degree of the contracture differed among the people and there was not opportunity for a careful study.

And in this study, postural stability was investigated in the static position. Lastly, we suggest that the effect of the stimulated knee-joint kinetic contracture be studied in dynamic situations to offer more proper preventive and treating plans upon more data for the elderly people.

Table 1. Descriptive statistics (mean ± SD) for the COP parameters in six test positions

Test position / Parameter	Without Simulation open eyes	Without Simulation closed eyes	0 degree Simulation open eyes	0 degree Simulation closed eyes	30 degree Simulation open eyes	30 degree Simulation closed eyes
Path length	128.24±14.23	131.94±16.90	125.92±14.85	131.95±16.23	129.03±13.20	137.64±21.20
Mean velocity	2.57±0.28	2.62±0.33	2.51±0.29	2.63±0.32	2.58±0.26	2.74±0.42
Area	3.95±2.63	3.81±2.71	3.61±2.28	4.46±3.53	4.43±2.58	4.62±2.54
Mean displacement A-P	0.78±0.24	0.81±0.33	0.86±0.31	0.90±0.33	0.91±0.25	0.98±0.34
Mean displacement M-L	0.70±0.36	0.61±0.23	0.58±0.21	0.64±0.32	0.66±0.24	0.66±0.23
Mean velocity A-P	1.01±0.28	1.21±0.30	0.99±0.21	1.21±0.25	1.04±0.20	1.25±0.48
Mean velocity M-L	1.01±0.13	1.02±0.16	0.97±0.14	1.009±0.16	1.008±0.13	1.07±0.15

*A-P: anterior-posterior
*M-L: medial-lateral
Significance level P<0.05 and confidence coefficient 95%

Table0. The values of indicators of the mean difference in the different parameters of the center of pressure compared with the test modes

Test position \ Parameters (i-j		Path length	Area	Mean **velocity**	Mean velocity A-P	Mean velocity M-L	Mean displacement A-P	Mean displaceme nt M-L
without Simulation open eye (i)	Without Simulation closed eyes(i)	-2.65	0.13	-0.05	*-0.11	-0.003	-0.02	0.08
	0 degree Simulation open eye (j)	+2.99	0.33	*0.06	0.02	*0.04	-0.07	0.11
	0 degree Simulation closed eye (j)	-3.03	-0.51	-0.06	-0.11	0.01	*-0.11	0.05
	30 degree Simulation open eye (j)	-o.1	-0.48	-0.002	-0.03	0.01	*-0.13	0.03
	30 degree Simulation closed eye (j)	*-8.45	-0.67	*-0.17	*-0.24	-0.05	*-0.19	0.03
without Simulation closed eye (i)	0 degree Simulation open eye (j)	*5.56	0.19	*0.11	*0.13	*0.04	-0.04	0.03
	0 degree Simulation closed eye (j)	-0.46	-0.64	-0.009	-0.002	0.01	-0.08	-0.02
	30 degree Simulation open eye (j)	2.46	-0.62	0.04	0.07	0.01	-0.10	-0.04
	30 degree Simulation closed eye (j)	-5.97	-0.81	-0.11	*-0.13	-0.04	*-0.16	-0.04
0 degree Simulation open eye (i)	0 degree Simulation closed eye(j)	*-6.03	*-0.84	*-0.12	*-0.13	-0.02	-0.04	-0.06
	30 degree Simulation open eye (j)	*-3.10	*-0.81	*-0.06	*-0.05	-0.02	-0.05	-0.08
	30 degree Simulation closed eye (j)	*-11.53	*-1.01	*-0.23	*-0.26	*-0.09	*-0.12	-0.08
0 degree Simulation closed eye (i)	30 degree Simulation open eye (j)	*2.92	0.02	*0.05	*0.07	0.001	-0.01	-0.02
	30 degree Simulation closed eye (j)	-5.50	-0.16	-0.11	-0.13	*-0.06	-0.07	0.01
30 degree Simulation open eye (i)	30 degree Simulation closed eye (j)	*-8.43	-0.19	*-0.16	*-0.21	*-0.06	0.06	0.003

Significance level P<0.05 and confidence coefficient 95%

Figure 1: Standing position without simulated knee flexion contracture

Figure 2: Standing position with zero degree simulated knee flexion contracture

Figure 3: Standing position with 30 degrees simulated knee flexion contracture

In Conclusion Finally, it can be included that in simulating the contracture in a position which knees are not bended and the brace is in the zero degree, findings conformed the results of the earlier studies and lead to improve the stability; but when the 30 degrees knee flexion contracture was simulated, the postural stability diminished and affected. Therefore, the contracture of the knees in elderly people can be a threat for their balance to increase the fall risk.

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