Different of Saccadic Eye Movement and Vergence Eye Movement Compare with Fixed gaze on Postural Control in Healthy Elderly

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Abstract

Introduction: Thailand is becoming a complete elderly society. The senility affects every system of human body. The sensory that relates to the postural control of human is the integration of a vestibular, a somatosensory and a visual system. A vision is also deteriorated in the elderly which leading to the falling problem in the elderly. The aim of this study was to investigate the difference between saccadic and vergence eye movement on postural sway in healthy elderly.

Methods: Seven healthy elderly were invited to participate in the study. All participants were assigned to perform 3 conditions which compose of fixed gaze, saccadic eye movement and vergence eye movement. The participants performed 3 times for each condition and 70 seconds in each time. The center of pressure (COP) was measured by forced platform and the Kinovea program was used for detecting the anteroposterior (AP) sway.

Results: COP area, length and velocity were different in each condition. There was a significant difference between saccadic eye movement and fix gaze condition but there was no significant difference between vergence eye movement and fix gaze condition.

Conclusions: Saccadic eye movement may affect the postural control in healthy elderly.

Keyword: Elderly, Falling, saccadic eye movement, vergence eye movement, Postural control, Postural sway

Introduction

Older population is increasing in Thailand [1] Falling in the elderly is a major public health problem. The falling rate in elderly was approximate 35-40% per year in Thailand [1]. The maintaining of the postural control is decreased due to the risk factors of falling. Both intrinsic factor (physiological adaptation in elderly such as neurological adaptation, visual adaptation) and extrinsic factors (unsatisfying environment such as slip floor) effect the postural control [2]. The visual system is usually deteriorate when we aged such as cataract, macular degeneration and presbyopia which lead to the visual impairment. The postural control is the integration of various systems of the body. They are composed of the musculoskeletal systems, neuromuscular synergies, individual sensory systems, sensory strategies, internal representations, adaptive mechanisms, anticipatory mechanisms and sensory strategies including somatosensory, vestibular and visual system. The voluntary eye movement systems are divided into the vergence eye movement (seeing near and far objects) and the conjugate eye movement (seeing with same direction) that is saccadic eye movement, smooth-pursuit eye movement, optokinetic movement and vestibule-ocular reflex [5]. The saccadic and pursuit eye movement were able to reduce the postural sway when compared to fix gaze [4]. However, there was no study related to the comparison of the saccadic and vergence eye movement on the postural control in the elderly. The purpose of this study was to investigate the effect of saccadic and vergence eye movement while standing compared with fix gaze in healthy elderly.

Materials and Method

The healthy elderly participants were recruited from the community and blinded to the purposes of the experiment. The inclusion criteria were the elderly aged between 60-74 years old, able to communicate and understand Thai, normal vision (able to wear a glasses while testing) tested by a snellen chart. The exclusion criteria were an abnormality in balance (Berg Balance Score < 41 points), Impaired cognition (Mini-Cog test <3 points), a history of the lower limb surgery within 10 years, the body mass index (BMI) is over 30 kg/m^2, a color blindness (the Ishihara test <17 points), a history of falling within a year, a neurological disorder including central nervous system damage or disorders that control the balance in the inner ear, a musculoskeletal system disorder including bone fractures and severe arthritis, a history of practicing balance exercise for more than 3 times per week within 6 months and using gait aid when walking and standing. Seven healthy elderly were random into 3 conditions which are fixed gaze, saccadic eye movement and vergence eye movement. Prior to performing the selected condition, all participants were standing barefoot on the force platform placed 1 meter away from the wall and watch directly to the eye training pad. The postural sway was measured by attached a reflective markers to the head of fibula and lateral malleolus. The camera was hold at the front of participants to confirm correct eye movement and another camera was placed at the side to record the body sway in anteroposterior direction. Each participant stood on the force platform for 10 seconds prior to a selected conditions. For fixed gaze, the 37.5 x 30 cm^2 white paper was marked with a red dot (a diameter was 2 cm) on the center of the paper. In this condition, the participants were instructed to watch the red dot continuously and then rest for 10 seconds. The saccadic eye movement was done by 5 Percon Saccade. Participants were instructed to watch the underlined numbers and read aloud the number to confirm correct eye movements in order of

left to right and from top to bottom. The watching velocity depended on the rhythm of the metronome at 1.1 Hz (77 beats per minute), then rest for 10 second. The vergence eye movement was performed by using Brock string and the velocity depended on the rhythm of the metronome at 1.1 Hz (77 times / min). The camera was located at the side of body and measured the body sway. The video was processed in the kinovea program. The center of pressure (COP) sway parameters were measured by the force platform (Zebris FDM version 1.12). The independent paired t-test was used for analysing the different of COP sway and sway distance in AP direction while perform fixed gaze, saccadic eye movement and vergence eye movement. The p-value < 0.05 was considered statistically significant. All statistical analyses were performed with SPSS version 20.0

Result

Seven healthy elderly age between 60-74 years old with body mass index (BMI) 22.99 (±3.15) kg/m^2 were participated in this study. (show in table1). The independent paired t-test indicated that there was no significant difference of center of pressure between saccadic eye movement and fixed gaze. The sway distance in anteroposterior (AP) direction was significant difference ($p<0.05$) and the different of center of pressure and sway distance in AP direction of vergence eye movement compared with fixed gaze were no significant difference see in table 2 and table 3

Table1: Characteristics of the participants (n=7).

Characteristics	Participants (Mean±SD)
Sex Male: Female (%)	3:4 (42.86: 57.14)
Age (years)	68.43±5.13
Weight (kg)	54.17±10.75
Height (cm)	152.72±8.50
BMI (kg/m^2)	22.99±3.15
Dominant hand Right: Left (%)	7: 0 (100:0)

Table 2: The comparison of the center of pressure parameters and sway distance in AP direction of the saccadic eye movement to the fixed gaze.

Outcomes	Fix gaze	Saccadic	Mean difference	p-value	95% confidence

COP area (mm^2)	215.09±58.63	283.66±127.92	-68.57	0.22	-184.45 to 47.31
COP length (mm)	572.27±200.18	683.95±214.27	-111.67	0.35	-353.16 to 129.81
COP velocity (mm/sec)	8.27±2.62	9.84±2.86	-1.57	0.30	-4.78 to 1.64
AP sway (cm)	4.85±1.79	2.49±0.77	2.36	0.012*	0.67 to4.05

* $p<0.05$

Table 3: The comparison of the center of pressure parameters and sway distance in AP direction of the vergence eye movement to the fixed gaze.

Outcomes	Fix gaze	Vergence	Mean difference	p-value	95 % confidence
COP area (mm^2)	215.09±58.63	220.71±98.23	-5.62	0.90	-99.82 to 88.59
COP length (mm)	572.27±200.18	511.86±120.43	60.42	0.51	-131.97 to 252.81
COP velocity (mm/sec)	8.27±2.62	7.27±1.70	1.00	0.42	-1.58 to 3.57
AP sway (cm)	4.85±1.79	3.22±2.12	1.63	0.15	-0.65 to 3.91

Discussion

From the present study, we found that the sway distance in AP direction of the healthy elderly were significantly decrease while performing the saccadic eye movement when compared with fixed gaze. The postural control is composed of 7 components which are musculoskeletal components, neuromuscular synergies, adaptive mechanisms, anticipatory mechanisms, internal representation, sensory strategies and individual sensory systems [10]. The three sensory systems are consist of the somatosensory system, vestibular system and visual system. The movement of the eye affect the visual system. The first eye movement, the vergence eye movement, occur when a bilateral medial rectus muscle converge and diverge for accommodation which is controlled by the nucleus in the brainstem but this pathway is still unclear [9]. Another eye movement, the saccadic eye movement, influence on postural control in older adults due to neural adaptation from visual stimulation. The pathway of saccadic eye movement begin with the frontal eye field send the signal to the superior colliculus,

which is the vertical gaze center and the horizontal gaze center, then the signal will arrive at the trochlear and abducens nerves and initiate the saccadic eye movement and some signal is sent a feedback to the other part of the body for control balance [8]. The capability of visual system was declined in older adults which lead to the falling incident. Rodrigues et al. found that there was a significant decrease of sway in AP direction when performed the saccadic and smooth pursuit eye movement with frequency 0.5 Hz and 1.1 Hz in the elderly [5]. From Bae's study, He showed that the saccadic eye movement affected the postural control in elderly by neural adaptation (ใส่อ้างอิงของ Youngsuk Bae 2016)

The visual information receive from retina send the signal to primary visual cortex , V1 and V2 cortex and descending two pathway for parietal lobe and temporal lobe .The temporal lobe send signal through dorsal stream which associate and analyse information the visual, touch and proprioception. This area is center of signal to motor response.The concentric and eccentric of muscle that importance to postural control. The postural control occur when control of ankle joint by musculoskeleton system. The contraction of muscle around ankle joint to stability by hip knee and ankle strategy. For keep center of mass within base of support of body. The compare of COP area length and velocity during closed eye after experiment in both group showed no significant because during closed eye that interrupt visual sensory which abnormal factor effect to impair of postural control.

The COP parameters was not significantly different when compare between saccadic eye movement and fix gaze, but the COP parameters was increased in the saccadic eye movement condition. This may due to dual task activity of performing the eye movement together with speaking that affect the postural sway. From Coelho et al, they measured the balance when the community-dwelling elderly perform the standing while speaking animal names and found that the balance was disturbed during the activity [7]. Regarding the capacity theory, a neural system have a capability for processing various information. However, the brain must divided its ability to process information, so the working capacity decreases while perform a dual or multiple task [8]

In this study, COP sway parameters from the forceplate showed the mean value between AP and mediolateral (ML) direction and sway distance by kinovea showed only in AP direction, so the result is conflict to the previous study. Training saccadic eye movement at least 5 minute for 21 consecutive days was able to improve balance in healthy female elderly [3]

Conclusion

The difference between saccadic and vergence eye movement compared with fixed gaze show that the sway distance in AP direction of saccadic eye movement was significant different. However, the COP sway parameters of saccadic and vergence eye movement and sway distance in AP direction of vergence eye movement was different but not statistical significant. Thus, the postural control is affected by the movement of the eye.

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