Biomedical
Communication

Biosci. Biotech. Res. Comm. 9(4): 689-693 (2016)

BBRC
Bioscience Biotechnology
Research Communications

# Effectiveness of constrained time of visual data on angular velocity during sit-to-stand movement in three planes

Mozhgan Faraji Aylar*, Faramarz Firouzi and Mandana Rahnama Araghi

*Faculty of Engineering, Electrical Engineering Department, Imam Reza International University, Mashhad, Iran*

*Faculty of engineering, Department of Biomedical Engineering, Mashhad Branch, Islamic Azad University, Iran*

*Faculty of Physical Education & Sport Sciences, Ferdowsi University of Mashhad, Iran*

## ABSTRACT

The purpose of this study investigation was to assess whether time of constrain of visual information influences the angular velocities of sit to stand (STS) task in children or not. Five girls with congenital blindness (CB) and ten girls with no visual impairments were divided into two groups of five, control or treatment. The participants in the treatment group were asked to close their eyes (EC) for 20 minutes before the STS test; whereas the ones in the control group kept their eyes open (EO). The performance of the participants in all three groups was measured using a motion capture system and two force plates. The results showed that the constrained duration of visual information did not affect the angular velocities of lower extremity joints in three planes (sagittal, frontal and transverse). These finding suggest that vision is not the major influence factor on the STS kinematics.

**KEY WORDS:** VISUAL INFORMATION, SIT TO STAND, ANGULAR VELOCITIES, ANATOMICAL PLANES

## INTRODUCTION

Sit-to-stand (STS) motion is a demanding activity of everyday living that is on average performed four times in an hour (Coghlin & McFadyen, 1994; Music, Kamnik, & Munih, 2008), and is accepted as being a prerequisite for gait (Kerr, White, Barr, & Mollan, 1997). Some studies demonstrated that the hip and knee joints required highly forces during STS performance greater than gait and stair ascent (Kerr et al 1994).

Dark adaptation for the visual system is the process of adjusting to total darkness or to lower levels

ARTICLE INFORMATION:

*Corresponding Author: m.faraji@imamreza.ac.ir
Received 26th Oct, 2016
Accepted after revision 2nd Dec, 2016
BBRC Print ISSN: 0974-6455
Online ISSN: 2321-4007
Thomson Reuters ISI ESC and Crossref Indexed Journal
NAAS Journal Score 2015: 3.48 Cosmos IF : 4.006

Online Contents Available at: http//www.bbrc.in/

of illumination (Held, 1988). The time of the rod intercept reported is less than or equal to 20 min, usually 8.2 (±1.4) min (Jackson & Edwards, 2008) and 12.5 min (Holfort et al 2010), in young and elderly people, respectively. Therefore, in this study, the time of the eyes being closed was set to be 20 minutes to ensure occurrence of rod intercept.

Congenitally blind children usually suffer from falls that result in injury (Jackson, et al 1999) and contusion. The STS movement is one of the safest tasks for blind children to perform. The STS movement requires the coordination of all body segments (Manckoundia et al. 2006) and balance (Treasurer et al 2007). The STS task is a common activity in daily life (Galli et al 2008), so it is completely familiar with central nervous system (CNS). In addition, the study of visual adaptation is important for a variety of practical reasons as well as for obtaining an understanding of the effects of the visual information in performance of the motor tasks. The specific objective of the present study was to characterize the kinematics of STS performance in short- and long-durations dark adaptation tasks. The fundamental aim of this study was to develop knowledge about the visual memory during the STS performance.

## METHODS

### PARTICIPANTS

The total participants in this study were 15 girls who were randomly selected. Five of the girls suffered from congenital blindness (CB) (mean (±standard deviation), age: 94.6 (±5.58) mo, mass: 25.74 (±2.12) kg, height: 126.82 (±0.05) cm, leg length: 36.62 (±1.58) cm, anterior superior iliac spines (ASIS) width: 17.76 (±1.23) cm) and the remaining ten were healthy and did not have any visual impairments. These ten healthy girls were divided into two groups.

The subjects in one group (treatment group) closed their eyes (EC) (age: 93.8 (±5.88) mo, mass: 24.16 (±1.36) kg, height: 124.24 (±0.044) cm, leg length: 34.56 (±1.13) cm, ASIS width: 15.84 (±0.64) cm) for 20 minutes before the STS test was carried out ; whereas the other group (control group) kept their eyes open (EO) (age: 95.8 (±5.53) mo, mass: 26.06 (±5.21) kg, height: 126.66 (±0.05) cm, leg length: 36.16 (±1.56) cm, ASIS width: 16.46 (±0.95) cm). During the practice and trial phases, the subjects in the EC group had their eyes closed to prevent any learning taking place through receiving visual information. The healthy girls had no musculoskeletal or neuromuscular problems and were considered normally active. Moreover, blind children were physically active in daily life and merely suffered from blindness. An informed oral consent was obtained from each subject and their parents after they were provided with detailed information about the study. In addition, a local ethic committee confirmed the human studies.

### DATA COLLECTION

Retro-reflective markers were placed over bony landmarks including: vertex, seventh cervical vertebra (C7), spinous process of the twelfth thoracic vertebrae, right and left of lateral border of the acromion process, right and left of head of humerus, right and left of olecranon process of the ulna, right and left of head of styloid process of the ulna, right and left of ASIS, right and left of posterior superior iliac spines (PSIS), right and left of greater trochanter, right and left of lateral femoral epicondyles, right and left of lateral malleoli, right and left of 5th distal metatarsal heads, right and left of calcaneal tuberosity.

Before performing the test, the equipment and the instruments were introduced verbally to the participants in the EO group; whereas this was done through sense of touch for the EC and CB groups. The Subjects were barefoot and were seated on a firm chair with no armrest, back support or wheels. The height of the chairs was adjusted in a way that corresponded with 100% of the subject's leg length, the distance from the lateral femoral condyle to the ground. During the STS test, the participants had one foot on each force plate for 3 to 4 s (Kerr, et al. 1994), the arms were folded across the chest and wore tight shorts.

The subjects sat with their bodies and extremities (thighs, legs and feet) symmetrically placed relative to the chair and the width of the feet was determined from the ASIS width. The subjects in EO group were told to place their feet within the outer limits of the two force plates, one foot on each plate. In addition, the subjects were requested to use a self-selected movement strategy. The widths of the ASIS for the EC and CB groups were determined using a thick stick on the force plates. They were instructed to raise their entire body from the chair at a self-selected velocity, and keep standing until reaching the upright position for 3 to 4 s ( Kerr et al., 1994). Each subject was requested to perform five STS trials with 30 s rests between the trials and had three practices before the actual test. Lower limb dominance was determined by the foot used to kick a ball (Burnett et al. 2011).

Two adjusted force plates (9260AA6, Kistler, Switzerland) with a sampling frequency of 1000 Hz, were used to record the ground reaction forces during the performance of the STS task. An eight camera video-based opto-electronic system (Qualisys AB, Sweden, sampling, 100 Hz) was used for 3D motion capture. The Force plates and the motion data were filtered using a fourth order Butterworth filter (cutoff frequency of 10 Hz) ( Huffman et al 2015).

| Table 1: Phase durations of sit-to-stand (STS) motion | | | |
|---|---|---|---|
| | Congenital blindness | Eyes closed | Eyes open |
| Phase I (preparation phase) | 0.48 ± 0.30 | 0.614 ± 0.36 | 0.492 ± 0.09 |
| Phase II (rising phase) | 0.888 ± 0.53 | 1.22 ± 0.55 | 0.568 ± 0.12 |
| Total duration of STS motion | 1.308 ± 0.51 | 1.834 ± 0.39 | 1.06 ± 0.13 |
| Values are in second: mean ± SD. | | | |

## DATA PROCESSING

Upper extremity markers were used to define STS events. Markers of olecranon process of the ulna and head of styloid process of the ulna were used to control folded arms across the chest because all participants were children in the investigation. Markers of ASIS, PSIS and greater trochanter were used to define hip joint center. Segment of head-arm-trunk (HAT), thigh, leg and foot were defined by the head of humerus to the hip center, the hip center to the lateral femoral epicondyle, the lateral femoral epicondyle to the lateral malleoli, the lateral malleoli to the 5th distal metatarsal heads, respectively. Flexion, abduction, and internal rotation occurred at the initiation of movement, when STS entered its final points, was beginning extension, adduction, and external rotation at sagittal, frontal, and transverse planes, respectively.

## STATISTICAL ANALYSIS

Descriptive values (means, standard deviations) across trials were first obtained. Data distribution was tested for homoscedasticity using the Levene's test. A one-way repeated measures analysis of variance (ANOVA) was performed to test for the effects of vision on angular velocities of the lower extremity joints (the hip, knee and ankle). A two-way repeated measure ANOVA was performed to test the effects of interaction of a visual-motor adaptation memory and phases of STS motion on (1) phase durations and (2) differences between phase durations. If equal variance was found between groups, Bonferroni's post hoc test was used for pair-wise comparison of means. If unequal variance was determined between groups, Tamhane's was used for pair-wise comparison (Highsmith et al., 2011). These analyses were performed separately for dominant and non-dominant sides. Differences were considered significant at $p < 0.05$. Statistical analysis was performed using the SPSS 19.0® software.

## RESULTS

The CB group had the lowest value and the EC group got the highest value among the groups during the preparation phase. Also, the EO group had the lowest value and the EC group got the highest value among the groups during the standing phase and total duration of the STS performance (Table 1).

On both sides (D and ND) in the sagittal plane, the EO group at the ankle joint had the lowest value and

| Table 2: Means for ankle, knee, and hip angular velocity for congenital blindness, eyes closed, and eyes open groups at dominant and non-dominant sides during sit-to-stand in sagittal, frontal, and transverse planes. | | | | | | |
|---|---|---|---|---|---|---|
| | Sagittal plane | | | | | |
| | Congenital blindness | | Eyes closed | | Eyes open | |
| | Dominant | Non-Dominant | Dominant | Non-Dominant | Dominant | Non-Dominant |
| Ankle | 7.02 ± 3.71 | 10.72 ± 6.94 | 7.35 ± 5.77 | 5.53 ± 3.51 | 2.58 ± 4.01 | 1.24 ± 7.38 |
| Knee | 59.49 ± 24.04 | 60.39 ± 26.22 | 43.63 ± 14.05 | 41.08 ± 11.19 | 58.43 ± 9.71 | 58.56 ± 14.81 |
| Hip | 54.35 ± 24.96 | 52.26 ± 24.27 | 36.50 ± 9.46 | 34.60 ± 6.43 | 57.48 ± 7.51 | 56.06 ± 7.00 |
| | Frontal plane | | | | | |
| Ankle | 8.77 ± 6.38 | 9.62 ± 13.98 | 7.76 ± 6.92 | 4.35 ± 5.40 | 10.84 ± 7.77 | -4.19 ± 7.28 |
| Knee | 20.23 ± 10.13 | 5.91 ± 7.48 | 10.81 ± 6.89 | 10.96 ± 6.58 | 11.87 ± 12.01 | 12.57 ± 12.32 |
| Hip | 11.13 ± 7.27 | 6.79 ± 3.85 | -.72 ± 17.40 | 5.32 ± 8.29 | 7.94 ± 6.80 | 12.58 ± 12.18 |
| | Transverse plane | | | | | |
| Ankle | 25.21 ± 17.92 | 21.73 ± 34.28 | 8.37 ± 13.16 | 17.35 ± 13.05 | 7.15 ± 17.58 | -14.62 ± 45.71 |
| Knee | 8.74 ± 13.56 | 24.53 ± 38.77 | 49.11 ± 44.41 | 24.95 ± 32.80 | -7.66 ± 8.31 | -21. 01 ± 51.32 |
| Hip | -12.54 ± 11.90 | 16.17 ± 39.44 | 14.36 ± 30.48 | -.32 ± 10.56 | -.25 ± 24.38 | -29. 10 ± 22.48 |
| Values are in degree/second: mean ± SD. | | | | | | |

at the hip joint reached the highest value among the groups. In addition, the EC group at the knee and hip joints obtained the lowest value among the groups. Furthermore, the CB group got the highest angular velocity among the groups in both sides of the lower extremity except at the D side of the ankle joint. In frontal plane, the EC group at the hip joints reached the lowest value among the groups. In vertical plan, the EO group at the ankle and the knee joints obtained the lowest value and the CB group had the highest value among the groups (Table 2). However, no significant difference was observed among the groups at three plans.

## DISCUSSION

The fundamental aim of this study was to investigate how short (EC group) and long (CB group) terms restricted visual memory affect the angular velocities of the lower extremity joints during the STS movements. The results of this study were consistent with those of some previously conducted studies (Hennington et al., 2004; Santos et al. 2013; Yasin et al. 2008). In this study, the longest time of STS performance was dedicated to standing phase among the all participants (Table 1). The EC group had the highest time of the STS movement. This result exhibits that blind people hurry to rise from chair (i.e. seat-off point), although they had a little patience in the standing phase.

Hennington and others have reported at 0.583 (±0.117), 0.661 (±0.288), and 1.242 (±0.117) seconds for before seat-off, after seat-off and total duration of STS motion, respectively between 4.3 to 11.8 years old. In the present study, the duration of preparation phase was 0.48(±.30), 0.614(±.36), and 0.492(±.09) seconds for the CB, EC and EO groups, respectively (Hennington et al., 2004). In the preparation phase, the present study was similar to the result of Hennington's study, but for the EC group a little difference has been observed in the standing phase and the total duration of the STS movement.

In Seven's study, total duration of STS motion was reported at 1.34 (±0.31) for 9.6 (±1.2) years old, our finding in the EC group was slightly different from the value (Yasin et al 2008). In Santos's study, the total duration of the STS movement was reported at 1.34 (±0.15) and 1.48 (±0.19) seconds for the dominant and non-dominant sides, respectively (Santos et al 2013). In the EO and CB group the value were less than Santos's data. In Santos's study age of participants' age were different from this study, and then maybe this difference is related to the age. Because, it approved that young children (12 to 18 months old) with an increase in their age, there is an inclination toward a rise in the number of successful trials and a fall in the total duration of the STS movement (Costa & Rocha, 2013).

In the control groups of Park's study, total duration of STS performance was 3.13 (±0.53) seconds; the value is significantly different from the present study because Park defined initiation of the STS from start of sacral marker trajectory and ending of movement when all of markers were ceased (Park et al., 2003). However, the present study was different in defining the start and end point of the movement.

In this study, there was no significant difference between groups at three plans in the angular velocity of the lower extremities (Table 2). These result exhibit that the kinematics of blind people was similar to healthy subjects and the time of constrain of visual data does not affect the angular velocity in children during the STS performance. Another studies proved that the STS movement mostly perform in the sagittal plane relative to the other plans(Chen et al. 2013; Yoshioka et al 2012). However, in the present study has not been observed any significant differences among the three groups in the sagittal plan. Moreover, O'Meara and et al. reported any significant differences related to the angular velocity among the groups during the STS motion in the sagittal plan (O'Meara & Smith, 2006).

This research imposes a limitation to the time of eyes being closed among the participants in the EC group as the participants in this study were in their early childhood and tolerating having their eyes closed for lengthy periods of time was a little hard for them. Consequently, there were no significant differences among the groups in three anatomical plans related to the angular velocity of the lower extremities; however, all of participants had self-selected speed for the rising from chair. It exhibits CNS's congenital blind children could manage challenges of the dominant and non-dominant sides during the STS maneuver.

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