



Original Article

Differences in postural stability and dynamic visual acuity among healthy young adults in relation to sports activity: a cross sectional study

YOSHINORI KOIDE, PT, MSc¹⁾, YOSHINO UEKI, MD, PhD^{1)*}, YUJI ASAI, PT, PhD²⁾, HIROYUKI MORIMOTO, PT, MSc¹⁾, HAYATO ASAI, PT, MSc¹⁾, ERIC G. JOHNSON, PT, DSc³⁾, EVERETT B. LOHMAN, PT, DSc³⁾, EISUKE SAKUMA, MD, PhD⁴⁾, JUN MIZUTANI, MD, PhD⁵⁾, TAKATOSHI UEKI, PhD⁴⁾, IKUO WADA, MD, PhD¹⁾

¹⁾ Department of Rehabilitation Medicine, Graduate School of Medical Sciences, Nagoya-City University: 1 Kawasumi, Mizuho-cho, Mizuho-ku, Nagoya 467-8601, Japan

²⁾ Department of Physical Therapy, School of Health Science, Nihon Fukushi University, Japan

³⁾ Department of Physical Therapy, School of Allied Health Professions, Loma Linda University, USA

⁴⁾ Department of Integrative Anatomy, Graduate School of Medical Sciences, Nagoya-City University, Japan

⁵⁾ Department of Orthopedic Surgery, Graduate School of Medical Sciences, Nagoya-City University, Japan

Abstract. [Purpose] Sports activity has been shown to improve postural stability and vestibular function in healthy older adults. The hypothesis was that healthy young adults undertaking sports activity will also have better postural stability and vestibular function compared with healthy young adults who do not undertake sports activity. The purpose of this study was to investigate the differences in postural stability and vestibular function between healthy young adults who undertake sports activity and those who do not undertake such activity. [Participants and Methods] Thirty-nine healthy young adults were recruited and divided into sports and non-sports groups on the basis of their response to a questionnaire concerning regular participation in sports activities over the past 12 months. In both groups, postural stability was measured during quiet standing and standing during head rotation, and dynamic visual acuity was assessed during head rotation. [Results] The results showed significant differences in postural stability during head rotation and dynamic visual acuity between the two groups, whereas no significant differences were found in postural stability during quiet standing. [Conclusion] The results suggest that healthy young adults who undertake sports activity have better postural stability during head rotation and better dynamic visual acuity. The causal effect of these differences is not clear and further investigation is warranted.

Key words: Neck rotation, Postural stability, Dynamic visual acuity

(This article was submitted Aug. 8, 2018, and was accepted Oct. 7, 2018)

INTRODUCTION

Previous research has demonstrated that decreased postural stability¹⁻⁴⁾ and visual acuity⁴⁻⁶⁾ can be induced by active head rotation and/or head tilt in healthy people. Dynamic head movements such as head rotation provide stimulation to the vestibular organs creating additional vestibular input that needs to be integrated during standing or moving. This creates an

*Corresponding author. Yoshino Ueki (E-mail: yueki@med.nagoya-cu.ac.jp)

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additional challenge to the sensory organizational mechanism making postural stability and visual acuity more difficult¹⁻⁶). Conversely, a previous report demonstrated that simple oculo-motor and gaze stability exercises typically used for patients with vestibular dysfunction improved visual acuity and postural stability during head movement in healthy young adults⁴). Moreover, sports activities have also been shown to improve postural stability^{7, 8}) and dynamic visual acuity (DVA)^{9, 10}). However, in these studies, DVA measurements were taken with the participant's head stabilized while the target was moved on a screen^{9, 10}), thus DVA measurements in these studies did not focus on vestibular function. The effect of sports activities on both postural stability with active head rotation and DVA focused on vestibular function in healthy young adults has not been reported in the literature. The purpose of this study was to investigate the differences of postural stability with active head rotation and DVA between health young adults with and without sports activity.

PARTICIPANTS AND METHODS

Thirty-nine healthy young adults were recruited from Nihon Fukushi University for this study. Participants were free from any problems that could affect the postural control and visual acuity, based on self-report, and they completed a questionnaire concerning their participation in sports activities over the previous 12 months. Participants were divided into two groups (sports group and non-sports group) based on their questionnaire response. The sports group (15 participants, age 19.1 ± 0.6 years) reported that they had participated in sports activities more than 2 times per week for approximately two hours each session over the past 12 months. The non-sports group (24 participants, age 19.4 ± 1.4 years) reported that they had not regularly participated in any sports activities over the past 12 months (less than 1 time per week). The university intramural sports activities included basketball, baseball, soccer, volleyball, badminton, and tennis (Table 1). Informed consent was obtained in compliance with Nihon Fukushi University Review Board protocol (IRB Number; 12-13) prior to participation in the study.

Postural stability was measured using a computerized dynamic posturography (CDP) system (BalanceMaster[®], NeuroCom International Inc., Clackamas, OR, USA). The CDP system calculated the mean angular velocity (deg/sec) of center of gravity (COG) sway with center of pressure (COP) on the CDP force plate. The lower angular velocity indicates better postural stability, and the higher angular velocity indicates worse postural stability. The protocol for evaluating postural stability was previously described by Morimoto et al (Fig. 1)⁴). Participants stood on the CDP force plate in a dark room and fixed their eyes on a light spot projected onto a screen 70 cm away from their eyes, and the light spot was projected on the screen at their eye level. Both static and dynamic conditions were measured. The static condition was measured with participants quietly standing on the CDP force plate with focused on the light spot. The dynamic condition was measured with participants standing on the CDP force plate with active head rotation in the yaw plane at a frequency of 2 Hz with focused on the light spot. A metronome was used to maintain head rotation frequency at 2 Hz over a total range of 70 degrees. Three trials were taken for each condition. Each recording took 10 seconds, followed by a 10 seconds rest between trials, and a 30 second rest between the two different conditions.

DVA was measured by using a method described previously⁴). Using Microsoft PowerPoint, we created 10 pieces of paper that each had 5 random numerals, ranging from 12 to 20 point font. Each paper had a total of five numerals at one font size and participants were assigned ten pieces of paper. Participants sat on a chair with the backrest 70 cm away from the piece of paper, which was positioned at eye level. Participants were asked to read each number during active head rotation in yaw plane at a frequency of 2 Hz (Fig. 2). We used a metronome to keep the frequency at 2 Hz during the testing. DVA percent correct score was calculated by totaling the number of answers. Participants were given 5 seconds to answer the numbers during head rotation for each paper. Before testing DVA, we confirmed that all participants were able to read the smallest font size of 12 from 70 cm without head movement.

Statistical analysis was performed using the Mann Whitney U-test for determining differences of age, χ^2 test for gender differences, and Independent sample t-test for differences of postural stability and DVA between groups. Level of significance for all analysis was set at $p < 0.05$.

Table 1. Characteristics of sports activities

Activity	Sports group	Non-sports group
Volleyball	3	0
Basketball	5	0
Baseball	3	0
Soccer	1	0
Tennis	2	0
Badminton	1	0
No activity	0	24
Total	15	24

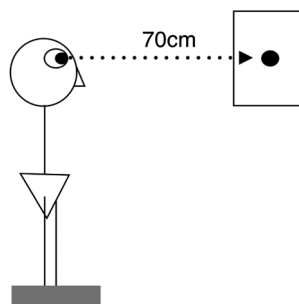


Fig. 1. Postural stability examination.

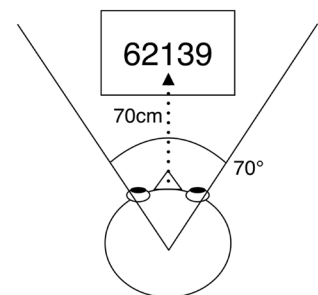


Fig. 2. Dynamic visual acuity examination.

Table 2. Comparison of basic data (Age and Gender), postural stability (static and dynamic condition) and dynamic visual acuity between groups

	Sports group	Non-sports group	p-value
Age (years)	19.1 ± 1.6	19.4 ± 1.4	p=0.83*
Gender	male: 8, female: 7	male: 11, female: 13	p=0.65**
Static condition (deg/sec)	0.22 ± 0.08	0.26 ± 0.09	p=0.19***
Dynamic condition (deg/sec)	0.89 ± 0.35	1.28 ± 0.55	p<0.05***
DVA (% correct)	65.3 ± 30.1	36.2 ± 34.4	p<0.05***

Values are mean ± SD.

Static condition: quiet standing.

Dynamic condition: standing during active head rotation at 2 Hz.

DVA: dynamic visual acuity.

*Mann Whitney U-test, ** χ^2 test, ***Independent t-test.

RESULTS

Age and gender were not significantly different between groups. In the sports group, postural stability in static condition was 0.22 ± 0.08 deg/sec and postural stability in dynamic condition was 0.89 ± 0.35 deg/sec. DVA was $65.3 \pm 30.1\%$. In the non-sports group, postural stability in static condition was 0.26 ± 0.09 deg/sec and postural stability in dynamic condition was 1.28 ± 0.55 deg/sec. DVA was $36.2 \pm 34.4\%$. There were no significant differences in postural stability in static condition between groups, however, there were significant differences in postural stability in dynamic condition and DVA between groups ($p < 0.05$) (Table 2).

DISCUSSION

The differences of postural stability with and without active head rotation and DVA between healthy young adults with and without regular sports activity were investigated. There are many reports that decreased postural stability¹⁻⁴⁾ and visual acuity can be induced by active head rotation and/or head tilt⁴⁻⁶⁾ in healthy people. However, there have been no reports on the differences of postural stability and DVA with head rotation between healthy young adults with and without regular sports activities. Our results demonstrated that postural stability in standing with active head rotation and DVA were better in the sports group compared with the non-sports group. The results support previous studies that young or older adults who perform sports activities have better postural stability^{7, 8, 11, 12)}. During sports activities, the head and body move with control in order to perform tasks under a variety of conditions. These activities require adjustments by the postural system to maintain the control of body orientation despite variations in the pattern of stimulation. Regular participation in sports activities could develop sensorimotor adaptabilities transferable and making postural stability less dependent on vision to control the posture¹³⁻¹⁵⁾. In this study, participants had to maintain their posture during active head rotation and the frequency and the speed of head rotation during this activity was beyond the visual system capacity for maintaining the posture^{5, 16)}. Thus, the visual information in our condition was not useful for postural control. We speculate that regular participation in sports activities may lead to improved postural stability caused by developing sensorimotor adaptabilities and less dependence on vision.

During head movement, gaze stability is maintained by the vestibulo-ocular reflex to see objects and environment clearly. The DVA test is one of assessment tools for evaluating vestibular function pertaining to gaze stability^{5, 17)}. However, in previous reports^{9, 10)}, the participants' head was stabilized while a target on a screen was moved during the DVA measurement, thus the protocol for measuring DVA in these reports did not consider the vestibular function. In the present study, the participants' head moved during DVA testing that considered the vestibular functions. Our results demonstrated that the sports group had better DVA score than that the non-sports group. We speculate that the difference of DVA was the result of vestibular adaptation, which was forced neural adaptation of the vestibular nuclear complex and/or cerebellum^{18, 19)} as well as enhanced central pre-programming²⁰⁾ resulting from their regular participation in sports activities. During sports activity, head movements are estimated and head moves in various intensities and frequencies²¹⁾, and these head movements induced by sports activity may effect the adaptation of vestibular system and enhance the central pre-programming. Evidence suggests that healthy older adults involved in low energy physical activities had better vestibular sensitivity based on vestibular function test compared with healthy older adults without physical activities^{11, 12, 22)} and vestibular function could be improved by simple head and eye movements in health young adults^{4, 23-25)}.

There were several limitations of this study that other body functions influencing postural stability and DVA such as neuro-muscular, sensorimotor, or cognitive function were not measured. We relied on only self-report of regular participation in sports activities to divide the group, and also, the intensity of different sporting activities impacts postural stability and DVA differently and this is a focus of future investigations. Moreover, the design of this study is a cross-sectional study, therefore, the causal effect of the differences of dynamic postural stability and DVA are not clear. The causal effect of these

differences should be investigated in further study.

In conclusion, healthy young participants who regularly participated in sports activity had better postural stability during active head rotation and DVA compared to participants who did not. The causal effect of the differences of dynamic postural stability and DVA are not clear, and it should be investigated in further study.

Conflict of interest

We disclose any financial and personal relationships with other people or organizations that could inappropriately influence or bias the work.

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