P02-12 ID230

TESTING OF ROTATIONAL EXERCISE EQUIPMENT TO IMPROVE THE VESTIBULAR SYSTEM

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The primary purpose of this study was to test the effect of training using the rotational exercise equipment developed in this study on the improvement of the vestibular system. In order to test the rotational exercise equipment developed in this study, 15 ordinary college students had trainings for 8 weeks and their nystagmus intensity was analyzed. The findings showed that the rotational training using the rotational exercise equipment affected vestibular balance, as it significantly decreased the slow phase velocity (SPV) immediately after rotational stimulation and reduced the recovery time of nystagmus to normal.

KEY WORDS: rotation exercise, equipment, vestibular system

INTRODUCTION: Dancers use a method called spotting when they rotate. Through this method, dancers utilize the principle of maximizing the visual effect to maintain dynamic stability as much as possible when rotating. It is reported that such technique affects the degree of dizziness which ordinary people and dancers feel after rotation due to long-lasted training (Park & Lim, 2008). In dynamic activity state, in particular, maintaining the stability of the head is essential, since the vestibular system and the visual system are in the head (Pozzo, Levik & Berthoz, 1995). Therefore, the fact that dancers try to maximally maintain the stability of the head with the spotting technique as a method to overcome the dizziness felt during rotation can be interpreted in a very scientific way, because it is a movement to maximize dynamic stability so that the trunk can independently rotate with a time lag from the movement of the head. In addition, it was suggested that the exposure to dizziness during rotation or immediately after rotation significantly reduces rotational training (spotting training) and is helpful for vestibular habituation exercise, which is one of rehabilitation treatments for dizziness (Park, Kang & Lim, 2012). This study thus aims primarily to test the effect of training using the rotational exercise equipment that can provide ordinary people with the similar environment as the rotation method of dancers on the vestibular system.

METHODS: The subject of this study included 15 college students who don't have the experience of dancing, and the symptoms and history of dizziness (age: 21.92±2.64 yrs, height: 169.84± 7.23 cm, weight: 60.23± 9.73 kg). They performed rotational exercises using the rotational exercise equipment developed in this study, twice a week for 8 weeks. In this study, a rotational exercise equipment was developed as seen in <Figure 1>, using the spotting rotation training and the method that could maximize the stimulation of vestibulo-ocular reflex, so that ordinary people could perform a rotational exercise using the machine. As its characteristics, it is operated by an electrical motor, the rotating place can have several rotational angles with the universal joint, and the foothold was developed so that it can be operated at the angle range of -30°~ 30° and induce the plantar-flexion and dorsi-flexion of the ankle at the same time. The diameter of the rotating plate is 700 mm and its height is 400 mm. The criteria for the speed of the rotational exercise equipment were set based on the speed of the rotational training in Yang Sun Park (2006). The first step was set at andante (66 tempo), the second step at presto (184 tempo), and the third step was set by measuring the time that dancers can maximally rotate (0.7sec/1 rotation) as its maximum value. On the rpm basis, the first step is 29 rpm, the second 47 rpm, and the third 100 rpm. For the operation of the wireless transmitter unit, when users control the button, the signal is amplified and entered into the AD converter of the microprocessor (ATMEGA128, Atmel, USA), and then sampling into 10 bit, 200 Hz, which then is processed and transmits the signal to the wireless communication unit. For the wireless communication, the specification of 2.4 GHz Bluetooth (ACODE-300, Comfile Tech, Korea) was used. The wireless receiver unit provides power to the motor that can control the speed preset at 3 levels using the on/off power and the speed control unit installed inside, so that it can control the desired rotation speed of the rotation unit. The speed control unit is connected to the power source of 220 V, 60 Hz, and controls rotation speed by controlling the current supplied to the motor. The wireless receiver and transmitter units are equipped with a power LED and a transmission LED to check whether they are normally operated so that users can easily check the operation of the device.

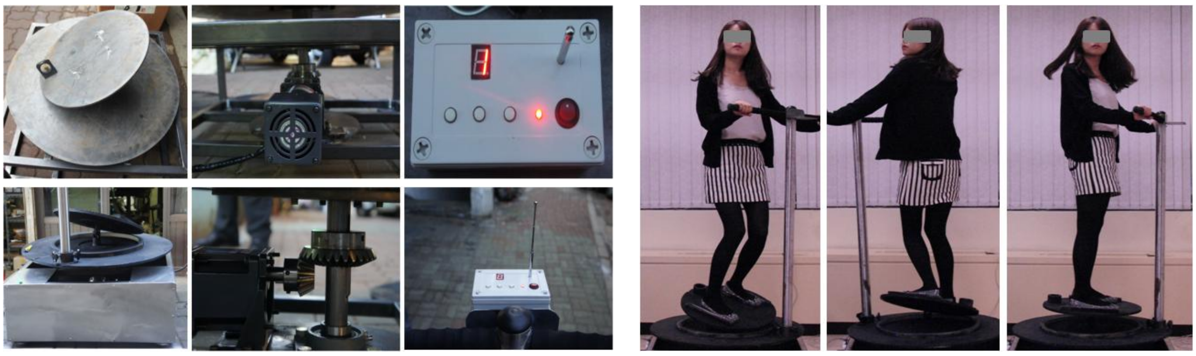

Figure 1: The rotational exercise equipment

The measurement of nystagmus to test the development of the rotational exercise equipment was performed before training and 8 weeks after training, using the eye camera (VG40, Otometrics ICS), as seen in Figure 1. For measurement, the subject was asked to rotate clockwise 10 times at the same spot and then take the movement of fixing their eyes on a spot in the front. During this movement, a strong stimulus was induced on both nystagmus and the vestibular system by wearing a head angle immobilizer (Figure 2; Park, Kang & Lim, 2012) and a fixed object was placed in the front view at 30° for the purpose of fixing eye sights and comfort. The speed during rotation was controlled at 160 tempos (Park, 2006). Data were analyzed by dividing the value of nystagmus into 4 events and 2 phases. E1 is the maximum nystagmus intensity during rotation, E2 the maximum nystagmus intensity at the time point when self-rotation stops, E3 the nystagmus intensity at the time point when the nystagmus stops on data, and E4 is the time point when the movement of nystagmus is assessed by a specialist to stop. Also, the recovery time of nystagmus from E2 to E3 was set as phase 1 and that from E2 to E4 was set as phase 2 (Figure 3). For statistical analysis, a paired t-test was performed using PASW Statistics 18.0. Significance level was set at 5%.

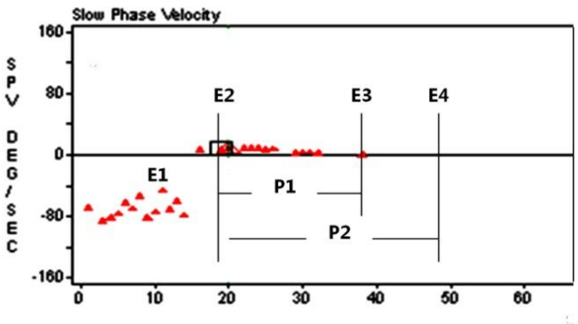

Figure 2:Eye camera & angle immobilizer **Figure 3:Events and phases to nystagmus**

RESULTS: No significant difference was found in E1, the maximum nystagmus SPV during rotation, and E2, the maximum nystagmus SPV at the time point when rotation has stopped, while significant difference was found in E3, the time point when the nystagmus SPV has stopped, by training (p<.05) (Table 1). As for the time of events, the time at E2 did not show significant difference, while at E3, the recovery time of nystagmus decreased by training (p<.05). At E4, a time point when a specialist assessed that the movement of nystagmus was completely stopped, the recovery time of nystagmus significantly decreased (Table 2). In phase 1, which is the time difference between the maximum nystagmus SPV at the time when rotation stops and the nystagmus SPV at the time when the nystagmus stops, no significant difference was found. However, in phase 2, which is the time difference between the time when rotation stops (E2) and the time point when a specialist assessed that nystagmus has completely stopped, the recovery time of nystagmus significantly decreased (Table 3).

Table 1
Result of nystagmus SPV (unit: degree/sec)

	Pre	Post	t	p
E1	-92.91±26.49	-104.20±35.03	.738	.478
E2	18.92±10.59	10.90±8.04	2.027	.065
E3	3.70±1.17	2.36±0.85	3.382*	.005

Note. values are Mean±S.D., significant at *p<.05

Table 2
Resulg to event time of nystagmus (unit: sec)

	Pre	Post	t	p
E2	16.85±1.95	16.54±1.33	.501	.625
E3	25.46±4.41	22.15±2.79	2.344*	.037
E4	33.62±6.21	25.62±3.15	4.609*	.001

Note. values are Mean±S.D., significant at *p<.05

Table 3
Result of nystagmus recovery time (unit: sec)

	Pre	Post	t	p
P1	8.62±4.46	5.62±2.75	2.142	.053
P2	16.77±6.10	9.08±2.90	4.576*	.001

Note. values are Mean±S.D., significant at *p<.05

DISCUSSION: In order to test the effect of training using the rotational exercise equipment, the intensity and recovery time of nystagmus were analyzed on the college students who performed 8 weeks of rotational exercise, twice a week. The findings showed that the nystagmus intensity after 10 clockwise rotational exercises was significantly different from the time point when the nystagmus intensity stopped on data (E3) (p<.05). The results in <Table 2> showed that the nystagmus intensity after training increased in E1. However, it was found that the intensity in E3 significantly decreased after training. This result indicates that spotting rotation maximizes nystagmus during rotation, but shortens the recovery time of nystagmus to normal when rotation stops. This result supports the finding of the previous study by Yang Sun Park et al. (2012) that the nystagmus intensity of the group that performed a rotational training showed more significant nystagmus intensity during rotational movement. In addition, the recovery time of nystagmus significantly decreased in both the time point when nystagmus completely stopped (E3) and the time point when a specialist assessed that the movement of nystagmus completely stopped (E4) (p<.05). These results are consistent with the previous study (Yang Sun Park et al., 2012) that the recovery time of nystagmus in the group that had 12 weeks of rotational training, twice a week, decreased after training. Human balance is maintained through a complicated process: the afferent information from the vestibular system, visual system and somatosense is combined with sensory input, which is the input information including visual proprioception and the vestibular sense in the vestibular system, at the several stages of the central nerve system (brainstem, cerebellum, basal ganglia, and thalamus) and integratedly controlled in the central nerve system, and reflectively controls the tension of the muscles involving the movement of eyeballs and four limbs (Peterka et al., 2004). Considering the previous study, the evaluation result of nystagmus in this study has resulted in the effect of recovering nystagmus to normal within a short period of time after the rotational exercise stimulated nystagmus reflex, which is believed to verify the positive effect of the rotational exercise equipment developed in this study on vestibular balance.

CONCLUSION: The purposes of this study was to test the effect of training using the rotational exercise equipment that can provide ordinary people with the similar environment as the rotation method of dancers on the improvement of the vestibular system. After 8 weeks of training period, the following conclusion was made: the rotational exercise using the rotational exercise equipment affected vestibular balance by significantly reducing the nystagmus intensity immediately after rotational stimulation and shortening the recovery time of nystagmus to normal.

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Acknowledgement

This work was supported by the Korea Research Foundation Grant funded by the Korean Government (NRF-2009-351-G00073)