ASSESSMENT OF DYNAMIC BALANCING ABILITY OF SYNCHRONIZED ICE SKATERS

Zsófia PÁLYA[1], Bálint PETRÓ[1], Orsolya A MEGYIK[1], Rita M KISS[1]

[1] Budapest University of Technology and Economics, Faculty of Mechanical Engineering, Department of Mechatronics, Optics and Mechanical Engineering Informatics, 1111 Budapest, Muegyetem rkp 3., Hungary. E-mails: palya.zsofia@mogi.bme.hu; petro@mogi.bme.hu; megyikorsolya@gmail.com; rita.kiss@mogi.bme.hu

1. Introduction

Balancing ability can be affected by regular and high-level athletic training. This effect has not been fully explored in synchronized ice skaters, who receive special balance training and perform on ice which provides an unstable support surface [1]. Synchronized skaters' performance includes long-lasting and spectacular spins, indicating high adaptability to rotational motion [2].

The PosturoMed device is a freely oscillating platform that can provide a unidirectional perturbation to elicit a balanced recovery response. The effectiveness and the recovery motion can be assessed to quantify balancing capabilities [3].

Fig. 1. Perturbation test setup.

The aim of this work was to compare a group of young, female synchronized skaters to a control group to identify differences between their strategies of balance recovery before and after performing repeated spins.

2. Materials and methodology

Twelve young female synchronized ice skaters (20.7±3.1 years, 59.2±5.9 kg, 166.3±4.4 cm) and twelve healthy female age-matched non-skaters (21.5±1.2 years, 61.1±5.5 kg, 171.3±3.5 cm) as control participated. Sudden perturbation provocation tests were performed using the PosturoMed free oscillating platform (Haider Bioswing, Germany). An optical motion capture system (OptiTrack, Natural Point Inc., Oregon, USA) was used to record the platform's movements at a sampling frequency of 100 Hz. The system's accuracy is within millimeter [4], according to the calibration file the mean error was 0.609 mm.

First, the perturbation test was performed (pre-test) in bipedal stance, then in single-leg stances for both legs (**Fig. 1**). The test was repeated up to five times to achieve three successful trials for each stance. After the pre-tests, a rotational fatigue session using a spin-trainer device (a foot-sized plate with a curved contact surface to the ground) was followed to simulate the effects of spinning. Participants had to perform ten complete rotations in quick succession, standing with their preferred leg on the spin-trainer, stopping after each rotation. Immediately after the spins, the perturbation tests were repeated (mid-test) once for both bipedal and single-leg stances. The rotational fatiguing and the tests were repeated another time (post-test).

Applying the platform's 3D position data, the derived parameters were the end time of balancing (T_{end}), the damping ratio (D), and the directional ratio (R), all calculated using Matlab (R2019b, The Mathworks Inc., Massachusetts, USA) [3]. The skater and control groups were compared with Wilcoxon's rank-sum test; to test the effect of fatigue, Wilcoxon's sign rank test was used comparing pre-test with mid-test and post-test. The

significance level was 0.05 in both statistical analyses.

3. Results

The pre-test showed no difference between the two groups for any parameter (**Table 1**). Skaters were more often successful on their non-preferred legs than non-skaters before and after the rotations as well.

Table 1. Success rates and differences between groups (pre-test).

	Success (skater) [%]	Success (control) [%]	Tend [s]	D [%]	R [-]
bipedal	100	100	0.2145	0.5067	0.9310
preferred	90	88	0.8173	0.3408	0.3123
non-pref	97	90	1	0.7950	0.3123

The effect of the first fatiguing session was that both groups took more time to recover stability both in bipedal and one-leg stances (**Table 2**). Moreover, in the case of the skater group, all three parameters changed significantly (p_T=0.0049, p_D=0.0342, p_R=0.0093) in bipedal stance.

Table 2. Difference of pre-test and mid-test. *p<0.05

skaters	Success [%]	Tend [s]	D [%]	R [-]
bipedal	100	0.0049*	0.0342*	0.0093*
preferred	86	0.0049*	0.1099	0.9097
non-pref	92	0.1514	0.1294	0.0210
control	**Success [%]**	**Tend [s]**	**D [%]**	**R [-]**
bipedal	100	0.0024*	0.0923	0.2661
preferred	86	0.0425*	0.021*	0.2661
non-pref	86	0.0015*	0.2036	0.3804

The effect of the second fatiguing session was less significant, the recovery time increased, and the skater group bipedal stance's result significantly differed from the pre-test result (**Table 3**).

Table 3. Difference of pre-test and post-test. *p<0.05

skaters	Success [%]	Tend [s]	D [%]	R [-]
bipedal	100	0.0122*	0.0024*	0.0068*
preferred	86	0.791	0.0771	0.5186
non-pref	92	0.0923	0.2036	0.2036
control	**Success [%]**	**Tend [s]**	**D [%]**	**R [-]**
bipedal	100	0.1099	0.5693	0.7334
preferred	86	0.021*	0.1514	0.4697
non-pref	86	0.5693	0.0771	0.5059

4. Conclusions

The purpose of this study was to compare a group of synchronized ice skaters to control group dynamic balancing abilities. Unidirectional perturbation tests were performed to quantify the balancing compatibilities. Considering the success rate derived from the successful trials, skaters were more effective on their non-preferred legs than non-skaters. The statistical analysis results showed that significantly more time was necessary for both groups after the fatiguing sessions. Interestingly, skaters performed less effectively than the control group in the simplest condition (bipedal stance), which is in line with previous studies [5]. This phenomenon assumes a more advanced vestibular system since skaters are constantly practicing under unstable stability conditions. Moreover, thanks to the skate edge-ice condition, they are less able to rely on the somatosensory system. Overall, the hypothesized superior balancing ability of skaters manifested.

Acknowledgements

We thank the Hungarian National Team of Synchronized Skating for their participation and the help of Ms. Renáta Kiss with data recording. This research was supported by OTKA K135042, NKFIA TKP-BIO at BME and NKFIH FIKP-TKP.

References

[1] Keller, M., Röttger, K., Taube, W. Ice skating promotes postural control in children. *Scand J Med Sci Sports*, 2014, 24(6), e456-461.

[2] Menshikova, G., Kovaleva, A., Klimova, O., Chernorizova, A., Leonova, S. Testing the vestibular function development in junior figure skaters using the eye tracking technique. *Proc Soc Beh Sci*, 2014, 146, 252-258.

[3] Petró, B., T. Nagy, J., Kiss, RM. Effectiveness and recovery action of a perturbation balance test–a comparison of single-leg and bipedal stances. *Comp Met Biomech Biomed Eng*, 2018, 21(10), 593-600.

[4] Carse, Bruce, et al. "Affordable clinical gait analysis: An assessment of the marker tracking accuracy of a new low-cost optical 3D motion analysis system." *Physiotherapy*, 2013, 99(4), 347-351.

[5] Alpini, D., Mattei, V., Schlecht, H. *et al.* Postural control modifications induced by synchronized ice skating. *Sport Sci Health,* 2008, 3**,** 11–17.