

EFFECTS OF PERTURBATION DIRECTION ON SINGLE-LEG STANCE BALANCE RECOVERY PERFORMANCE

Balint Petro¹, Rita M. Kiss¹

¹ Budapest University of Technology and Economics, Department of Mechatronics, Optics and Mechanical Engineering Informatics. Bertalan L. Street 4-6, Budapest, Hungary H-1111. E-mails: petro@mogi.bme.hu; rikiss@mail.bme.hu

1. Introduction

The assessment of balancing abilities is an integral part of orthopaedic and physiotherapeutic evaluation. There is a need to test abilities associated with complex coordination as stabilizing posture and recovery of balance after a sudden perturbation. A widely used therapeutic and diagnostic method is to apply a sudden unidirectional perturbation on a free oscillating platform. Following the perturbation, the participant instinctively attempts to regain postural balance. This balancing acts as a damping agent to decrease and eventually stop the oscillation. Previous works suggested that different balance recovery strategies can be observed based on stance, personal abilities and sports background [1]. The goal of our current study is to evaluate the effect of the medio-lateral (ML) perturbation direction on balancing performance in a single-leg stance. We hypothesize that one of these directions is more difficult to recover from and the successful completion of both directions can be associated with superior balancing abilities.

2. Methods

2.1 Participants

Thirty-two young collegiate men (age: 22.8 ± 1.3 yrs, height: 182.3 ± 7.1 cm, body weight: 76.9 ± 10.4 kg) participated in sudden perturbation balance measurements. Exclusion criteria included any pathological condition of the central nervous system or the musculoskeletal system. The tests were authorized by the Science and Research Ethics Committee of Semmelweis University (174/2005) and written consent was obtained from participants.

2.2 Procedure

The free oscillating platform PosturoMed® (Haider Bioswing, Weiden, Germany) was used to deliver sudden unidirectional perturbations as previously described in [2]. Direction of

perturbation depends on the direction of the stance with respect to the fastening apparatus. Please note that the perturbation direction is the opposite of the initial platform motion.

Balance regain tasks were carried out in bipedal and single-leg stances standing on the preferred (dominant) leg. The balancing task was repeated with the participant facing in all four directions to change the direction of perturbation. For this study, only ML perturbation during single-leg stance was considered: the lateral (L, towards the outer edge of the body) or contralateral (CL, towards the raised leg) nature of the test was noted. Participants were allowed up to three trials to complete each balance regain successfully with the goal of two successful attempts facing every direction and in both (bipedal and single-leg) stances. Participants unable to perform the single-leg task in none of L or CL directions were excluded from this study.

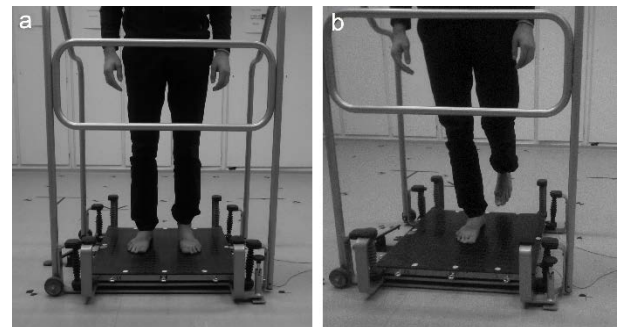


Fig. 1. Measurement setup: a) bipedal stance; b) single-leg stance

2.3 Data collection and analysis

Motion of the platform was captured with sub-millimetre precision using an OPTITRACK (NaturalPoint Inc., Oregon, USA) infra-red 18 camera motion capture system with passive reflecting markers at a frame rate of 120Hz. The calculated parameters were damping time (T_{end}), path length in AP and ML directions (S_x , S_y), total path length (S_{xy}), directional ratio (R) defined by the AP-ML path length ratio, and Lehr's damping factor (D). Boxplots were created and independent

samples t-tests were carried out using MatLab (The MathWorks Inc., Natick, Massachusetts, USA).

3. Results

The number of targeted successful balance recoveries were 128 for the whole group, of which 98 attempts were successful: 61 out of 68 (90%) in L direction and 37 out of 68 (54%) in CL direction. The results of independent samples t-tests (**Tab. 1**) shows that the end time and damping of balance recovery are statistically similar for L and CL directions but the travelled path and the trajectory of balancing are significantly different ($p=0.001$). This means that different balancing strategies with similar effectiveness are used depending on the direction of perturbation.

single-leg: L vs. CL	equal variances	df	Sig. (2-tailed)
T_{end}	assumed	96	0.112
D	assumed	96	0.690
S_{xy}	not assumed	91.7	0.001
R	not assumed	45.5	0.001

Tab. 1. Results of independent samples t-tests: L vs. CL directional perturbation

The rate of successful attempts suggest that the CL perturbation is more difficult to recover from when single-leg stance must be maintained. However, the end time and the path length (**Fig. 2**) have smaller variations with CL perturbation, showing consistently more effective balancing. This suggests that participants who can recover from CL perturbations have superior balancing abilities than those who can recover only from L perturbations.

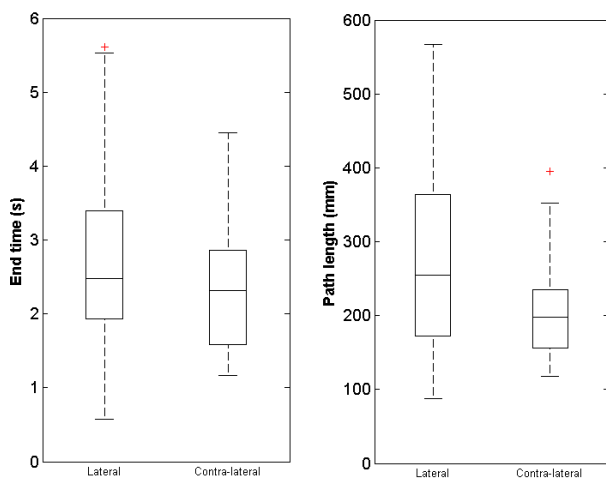


Fig. 2. Box-plots of end time and path length for lateral and contra-lateral perturbations

To test for possibly superior balancing abilities, the participants were sorted into two groups: 'group A' for those who could recover in both directions ($n=17$) and 'group B' who could not ($n=15$). Single-leg L perturbation recoveries were compared with t-tests (**Tab. 2**). End time and path of recovery were significantly lower ($p=0.012$ and $p=0.014$, resp.) for 'group A'. This can be quantitative proof that participants able to recover from CL perturbations have indeed superior balancing abilities.

single-leg, L, group A vs. B	equal variances	df	Sig. (2-tailed)
T_{end}	assumed	59	0.012
D	assumed	59	0.108
S_{xy}	not assumed	48.6	0.014
R	assumed	59	0.193

Tab. 2. Results of independent samples t-tests: L directional perturbation for group A vs. group B

4. Remarks

- It was shown that recovering from a contra-lateral perturbation is more difficult than recovering from a lateral perturbation and this may require a different recovery strategy.
- Participants who were able to recover from contra-lateral perturbations showed significantly better balancing abilities in the lateral direction as well.
- A future study can aim at identifying different recovery strategies used following lateral and contra-lateral perturbation directions.

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References

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