【国際セッション】

Effects of Balance Training on Two Spinal Modulatory Mechanisms in Humans

Koichi Kitano¹, Masaaki Tsuruike^{1,3}, David M. Koceja^{1,2}

Motor Control Lab., ¹Dept. of Kinesiology and ²Program in Neural Science, Indiana University, Bloomington, IN, USA

³Health Science Lab., Osaka University of Health and Sport Sciences, Osaka, Japan

Introduction

Spinal modulation of motoneuron excitability has been extensively investigated during various tasks in humans. Motoneuron excitability has been observed to be greatly adjustable to motor tasks as well as dependent upon activation history of synaptic transmission. Typical mechanisms which predominantly modulate motoneuron excitability are reciprocal inhibition, recurrent inhibition, and presynaptic inhibition. Previous studies have revealed that balance tasks induce a decrease in motoneuron excitability which has been attributed to elevated levels of presynaptic inhibition. It is, on the other hand, proposed that there are two mechanisms in presynaptic inhibition, namely extrinsic and intrinsic. Extrinsic presynaptic inhibition (EPI) is considered to be conventional GABAergic presynaptic inhibition which consists of an axo-axonal connection. Modulation of soleus H-reflex is also observable by applying paired stimulation pulse in the tibial nerve, which is suggested to be more related with history of synaptic activation (Paired reflex depression, PRD). The purpose of this study was to compare effects of balance training upon these two spinal inhibitory mechanisms.

Methods

Soleus H-reflex amplitudes were measured from 6 healthy adult subjects before, during, and after 20 minutes of balance training. Subjects stood on a custom designed balance board and performed plantar and dorsiflexion. Auditory cues for movement were given by a metronome with a frequency of 1 Hz. In order to measure reflex modulation in spinal motoneuron excitability, two soleus H-reflex conditioning techniques were applied: 1) common peroneal nerve stimulation (EPI) and 2) paired tibial nerve stimulation (PRD). In EPI conditioning, also known as D2, a conditioning stimulus was delivered to the common peroneal nerve 100 ms before the test stimulus to the tibial nerve. In PRD, 100 ms interval was set between the conditioning stimulus and a test stimulus both of which were delivered to the tibial nerve. Initial amplitude of the unconditioned soleus H-reflex was set at approximately 50% of H-max and stimulus intensity was maintained during the entire experiment. Reflexes were recorded prior to, at beginning of, and post balance training (C1, T, and C2, respectively). During the task, a conditioning stimulus for EPI and PRD was delivered at the initiation of plantarflexion followed by a test stimulus with 100ms delay. Stimulation for unconditioned H-reflex was delivered 100ms after initiation of plantarflexion, so that timing of eliciting the soleus H-reflex was synchronized in each condition. A series of H-reflex stimulations was performed for two minutes immediately after the training began, containing 20 trials of three conditions (EPI, PRD, and unconditioned). Inhibition ratios were calculated within each block by dividing each conditioned H-reflex by the unconditioned value. 3 x 3 ANOVA with repeated measure was applied for statistical analyses (3 conditions x 3 blocks) and significant level was set at 0.05. Tukey's post-hoc was used for further analysis.

Results

A significant interaction was found ($F(4,20)=4.97$). Post-hoc analysis revealed that the unconditioned H-reflex was significantly facilitated during training and inhibited after training (44.9%, 80.8%, and 16.6%, respectively). EPI conditioned H-reflex was significantly facilitated from 25.6% to 74.6% during training. After training it was decreased to 12.6%, however this decline was not significant compared with C1. PRD conditioned H-reflex was significantly facilitated from 3.47% to 43.6% in T. This facilitation was diminished in C2 training (3.08%).

Discussion/Conclusion

The significant interaction from condition x block factorial design implies that balance training has different effects upon two different mechanisms. The magnitudes of alterations, compared with C1, in unconditioned H-reflex were 80% increase in T and 63% decrease in C2, respectively. An increase in EPI conditioned H-reflex from 25.6% to 74.6% was nearly a three-fold increase while facilitation of PRD conditioned H-reflex was roughly 12-fold. In C2, unconditioned H-reflex was significantly inhibited, however the ratio of EPI was similar in T (92.3% and 75.9%, respectively). Current results showed a significant increase in EPI conditioned H-reflex resulting in decline of inhibition percentage, from 43% to 8%. Interestingly, EPI ratio in C2 was roughly maintained at the elevated level observed in T. This is caused by depressed amplitude of unconditioned H-reflex and it may be appropriate to interpret that inducible inhibition was limited after training. PRD conditioned H-reflex was restored to the level at C1 immediately after training. Obtained results suggest that the depression in motoneuron excitability after balance training is due to EPI rather than PRD. Considering effect size of EPI and PRD in T, PRD mechanism is suggested to contribute to the facilitation in the unconditioned H-reflex more than EPI. Moreover, durations of modulatory effects of these two mechanisms after training were different and further investigation is needed for recovery and retention of these short- and long-lasting effects.

References

- Hultborn H et al (1996). *Exp Brain Res*. 108(3):450-62
- Mynark RG and Koceja DM (2002). *J. Appl. Physiol*. 93:127-33
- Zehr EP and Stein RB (1999). *Exp Brain Res*. 124:474-80

Figure. Modulation of Reflex H, unconditioned; H1, EPI conditioned; H2, PRD conditioned reflex.