外国語要旨

学位論文題目　Motor control ability in trained dancers: neurophysiological features of voluntary movement in the plantar flexors.

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Skilled movements are often seen in artistic activities, such as dancing and playing musical instruments. The complex, sequential finger movements of pianists or the repetitive fast wrist tapping movements of drummers are very complex motor skills. Several studies have indicated that the brain of musicians show structural and functional changes when compared with non-musicians. Even in daily activities, manual dexterity is higher than that of the lower limbs. Moreover, the act of playing musical instruments could provide an opportunity to investigate fine-tuned neural adaptations in humans since the body regions associated with these skilled movements can be easily identified, along with the advantage of being in a seated position during the investigation.

Dance is an artistic human behavior having numerous forms. In ballet, dancers must have the aesthetic and technical expertise required at a professional level. Ballet includes skilled movements, which require intense sensory and motor training from an early age; for example, repetitive turns/maintaining balances using a small base for support.

It is well known that neural changes are associated with acquiring a skilled movement. Accordingly, some investigations have reported modulation of the corticospinal tract for long-term training in ballet dancers. The corticospinal tract conveys the commands for voluntary movements from the cortex to the spinal cord. Previous studies have suggested that the corticospinal tract might be related to motor control ability of voluntary movements. Therefore, it is expected that ballet dancers possess fine motor control than non-dancers, especially in the plantar flexor muscles. However, very little information is available on the potential differences in fine motor control and/or neurophysiological features of ballet dancers.

Therefore, we designed two experiments in this study. First, we determined the ability of dancers and non-dancers to perform fine, controlled ankle movements during a simple heel-raise task, which is routinely carried out in ballet training. Simultaneously, we determined if there were any differences between the two groups in electromyograms of the primary plantar flexor muscles. Results revealed that the errors between the ankle joint angle and target were significantly lower in dancers than in non-dancers regardless of the movement velocity. During heel-down movement, the peak electromyographic power of the soleus at ~10 Hz was significantly larger in non-dancers

than in ballet dancers. These results indicated that compared with non-dancers, ballet dancers had a higher degree of motor skill to control ankle joints in heel-raise tasks and exhibited adaptations in the rate coding and/or recruitment of motor units during skilled dynamic movements. (Chapter 4)

Next, to reveal the changes in the nervous system of ballet dancers, we investigated whether long-term ballet training affected in corticospinal excitability of the soleus muscles. Results showed that the slope of the regression line between the amplitudes of motor evoked potentials elicited by transcranial magnetic stimulation during muscle contraction and the background electromyography was significantly greater in ballet dancers than in non-dancers. This result suggested that the corticospinal tract of ballet dancers had adapted to the long-term repetition of plantar flexion during regular ballet training. (Chapter 5)

In conclusion, ballet dancers exhibited significantly higher accuracy in performing a heel-raise ankle-joint tracking task compared to non-dancers, and have plastic changes in the corticospinal excitability of the soleus muscle. The exact neural mechanisms underlying the changes in corticospinal excitability are unclear at present, and further studies are required to elucidate them. However, we report that long-term ballet training leads to a higher degree of control over the ankle joint movement and to adaptive changes in the neuromuscular system, especially in the soleus muscle. These findings may be beneficial not only for ballet/dance trainings but could also be extended to various types of physical training and rehabilitation.