Humanities and Social Sciences

Clarification and Application of Generation Mechanism of Rhythmic Motion of Human Upper and Lower Limbs

Professor, Human Body / Sports Education Course, Faculty of Education,
Tomoyoshi Komiyama

Background of Research

Locomotive movement such as walking or running is one of the most important motor movements that constitute the basis of daily life movements and sports activities. One of the most distinctive characteristics of such locomotive movements is a rhythmic, coordinated motion of the upper and lower limbs. Through studies on experimental animals over a hundred years, it has been found that the neural mechanism that generates motion patterns of such locomotive movements exists in the brain stem and spinal cord. Particularly, the neural mechanism in the spinal cord that is involved in generating walking patterns is termed as central pattern generator (CPG). Our research group has been promoting studies based on the premise that studying the mechanism of human CPG can possibly lead to the development of new sports training methods, etc.

Achievements of Research

One means for observing the dynamic state of human CPG is skin reflex. Skin reflex is quick reflective reaction which is induced by physical contact or mechanical stimulation with pressure against the skin. It has been proved up until now that the neural network responsible for skin reflex is strongly influenced by CPG. Against this background, jointly with a Canadian research group, we observed the skin reflex of the lower limbs when it is induced while engaging in walking movement. As a result, we made it clear that the output of skin reflex considerably changes with the phase of walking movement, and such changes are totally different from static movements in a standing position. (Zehr et al., 1997, 1998) Such results strongly suggests that the changes in the skin reflex while in walking movement are adjusted by CPG unlike intentional adjustments by the motion control system. (Komiyama et al., 2000) In recent years, we have come to know that the functional expression of CPG is in operation in rhythmic movement of not only the lower limbs but also the upper limbs, and the CPG of the upper and lower limbs mutually interact with each other. (Sakamoto et al., 2007) In addition, through application of such research results to a passive ambulation device expected to be a rehabilitation means for those suffering from motility disturbance due to damaged spinal cord, consideration was given to the functional expression of human CPG. The results indicated that in passive ambulation wherein the weight is completely unloaded, the skin reflex does not change, in other words, CPG does not get into operation. (Nakajima et al., 2008) In actuality, CPG may not become activated unless the lower limbs are loaded with 30% of the weight. These discoveries suggest that it is extremely important to activate the lower limbs' load sensitive receptors in rehabilitation for motility disturbance due to damage to spinal cord or similar.

Prospect of Research

The knowledge we have acquired thus far is merely an aspect of the entire CPG function. Our intention now is to clarify in more detail the independent functions and mutual interactions of the CPG between the upper and lower limbs through full utilization of electrophysiological means, and then to use the obtained research results for development of sports training methods and rehabilitation programs for those having motility disturbance in their four limbs.