Effects of Transcranial Magnetic Stimulation on Knee Joint Function during Recovery

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In this study, we hypothesized that the reason full recovery is not achieved after rehabilitation in the case of knee injuries such as anterior cruciate ligament injuries, which are typical of sports injuries, is the involuntary interference on the central nervous system, of the movement signals transmitted from the primary motor area of the cerebral cortex. We established a hypothesis that it might be because the signal strength is lowered, and searched for a mechanism and ways to improve its function. The phenomenon in which the muscle contraction ability cannot be restored even when the level of recovery of the ligaments and related muscles at the injured site reaches the level before the injury when there is no psychological disturbance is called AMI(Arthrogenic Muscle Inhibition), which is a reflex problem. In this study, AMI Transcranial magnetic stimulation(TMS), which is transmitted to the motor cortex and temporarily activates the motor nerve of the relevant muscle, is transmitted during rehabilitation exercise under the hypothesis that this phenomenon may be caused by a change in the mechanism of the central nervous system due to an injury, and its effect on AMI symptoms was verified.

Compared to the condition in which only rehabilitation exercise was performed without TMS stimulation, the AMI patients in the TMS and exercise combination condition showed a significant increase in the degree of muscle contraction, and the effect persisted until after the exercise was finished. In addition, to overcome the limitations of the muscle contraction (EMG) measurement method for test-retest reliability over two experiments, normalization of MVC using MEP during MVC+TMS treatment was performed. As a result, AMI patients performed exercise along with TMS. It could be seen that the degree of muscle contraction reached the maximum value of the improved muscle at the beginning of the exercise, but the effect of the repeated exercise period was not realized due to factors such as muscle fatigue. In previous studies, TMS was regarded as a factor directly affecting the mechanism of rehabilitation, but the reported effect was insignificant. In addition, it was possible to confirm and emphasize the applicability of the field by using the treatment and measurement method that can be used in the actual rehabilitation environment, differentiated from the existing experimental approach.

The subjects to participate in the experiment were set as 12 men between the ages of 19 and 30 who had knee surgery or injury before at least 12 months and had only one leg, and had cardiovascular and neurological diseases that could cause side effects to TMS stimulation, who did not have a specific history of depression, epilepsy, or migraine. The surgery subjects received included all surgeries performed by opening the knee, such as partial and total menisectomy, and reconstruction of the anterior and posterior cruciate ligaments. In addition, through screening, subjects with no pain or abnormalities in other areas except for the knee were selected, and when

the muscle strength of the quadriceps muscle was measured by performing knee extension in that area, the condition was 85% or less than the muscle strength of the opposite side. Those who had to be satisfied and did not have a reason to be disqualified from rehabilitation were selected.

Subjects received consent to participate and screening before participating in the experiment, and participated in the TMS condition in random order over a total of two visits. Upon arrival at the experimental site, the EMG sensor was first attached to the quadriceps muscle, and then the position of the motor cortex involved in the contraction of the quadriceps was identified through TMS stimulation. In the preliminary measurement, three isometric contractions were performed first, which contracted the quadriceps muscles as much as possible. At this time, feedback on the degree of muscle contraction was delivered to the subject in real time, and the value of the maximum MVC maintained for 3 seconds was recorded. Afterwards, to measure TMS stimulation during MVC, 2T of TMS was delivered to the motor cortex previously designated during MVC generation at the same level as above, and the motor evoked potential (MEP) generated by adding to the existing MVC was measured three times. This was repeated even after the resistance exercise session, and MVC measurement was performed after rest 30 minutes after the third exercise was finished. In addition, the Sham TMS condition, a control condition, was also performed in the same way, and each condition was measured in a random order with an interval of at least 7 days.

In this study, focusing on the fact that AMI is a phenomenon caused by pre-synaptic muscle inhibition originating from the central nervous system, using TMS, the motor nerve of the corresponding muscle is artificially (and temporarily) activated, and then a rehabilitation protocol applicable to the actual situation is performed We observed what kind of change in muscle contraction ability of AMI patients. Compared to the condition in which only rehabilitation exercise was performed without TMS stimulation, the AMI patients in the TMS in addition to exercise combination condition showed a significant increase in the degree of muscle contraction, and the effect persisted until after the exercise was finished. In addition, in order to overcome the limitations of the muscle contraction (EMG) measurement method for test-retest reliability over two experimental sessions, normalization of MVC using MEP during MVC with TMS treatment was performed. When it is performed, it can be seen that the degree of muscle contraction reaches the maximum value of the improved muscle at the beginning of the exercise, but the effect of the repeated exercise period after that was not realized due to factors such as muscle fatigue.

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In this study, the effect of TMS was approached from a different research point of view from the point of approaching the effect of increasing muscle strength in previous studies. In other words, previous studies have recognized the importance of TMS as a tool to treat AMI or muscle weakness in the knee joint and have succeeded in exploring its possibility, but it is believed that TMS itself will solve the problem of muscle contraction caused by AMI. We paid attention to the fact that the approach did not yield any meaningful results. Although the effectiveness of TMS

tends to exist in all of the related prior studies performed previously, the reason that it was difficult to present sufficient evidence is that TMS itself does not directly have an effect of strengthening the muscle, but temporarily activates the muscle nerve to enable the strengthening of the muscle. was seen to play a role.

Continuous weakness of the quadriceps muscle after knee injury or surgery has been consistently reported in previous studies. The muscle strength and durability of quadriceps are essential for normal knee joint function, so restoration of normal quadriceps function is an important factor in the rehabilitation process, and improved rehabilitation tools are needed. In the case of ACL injuries, with reconstructive surgery, muscle strength does not return to its original level even after 2 years or more after rehabilitation (although other clinical and active functions appear normal and joint stability is restored). An important underlying factor contributing to persistent weakness is the as-yet unknown Arthrogenic Muscle Inhibition (AMI), which causes muscle disturbances in the quadriceps after trauma that presumably interfere with rehabilitation.

For an exercise session of 50 minutes, ten AMI patients and ten normal subjects performed submaximal isometric voluntary muscle contraction tasks, and TMS was applied during pre-designated leg muscles locomotive hot point. Maximal voluntary contraction force (MVC) and voluntary activation (VA) of the muscles were examined for every twelve minutes during the session and fifty minutes after the exercise to trace the changes and consequences of exercise accompanied with TMS. Results showed significant improvements in MVC in the experimental group, and no significant effect on the control group. This effect maintained until the point of aftereffect measurement, 50 minutes after completion of exercise. Current study confirmed the possibility of TMS stimulation as suggested previously. This term is used to describe a phenomenon in which the muscle is not fully contracted despite the absence of structural damage to the muscle or a problem in the nerve impulse pathway. It is considered from a perspective beyond the scope of conscious and voluntary control, so it is reflexive to joint injury. It is often considered a reaction. However, in this study, we attempted to approach that AMI might be a response of the central nervous system to injury. It has been reported that the degree of muscle contraction will be restored to its original state by stimulating the motor cortex sufficiently without interference from the central nervous system using TMS. In the case of AMI, interference from the central nervous system is ultimately a problem, and abnormalities in the musculoskeletal system or peripheral nervous system after recovery suggested not.

The results of this study enable a theoretical interpretation of the existence of the reflex inhibition phenomenon and its function and mechanism. It has been more than 10 years since the existence of AMI, a type of reflex inhibition, was reported, but only the extent to which this phenomenon is known as a protective mechanism to prevent further damage to the injured area is known. How and where this phenomenon occurs There is not much evidence that it is modulated in This study enables the interpretation that the central nervous system regulates the strength of signals transmitted to effectors actively and subconsciously as needed. The fact that 'reflex' or 'inhibition', which has been traditionally described at the sub-spinal nervous system level, can be modulated at the cerebral level, contributes to broadening the hierarchy in motor control as well

as the ability of the brain to exert some adaptive capacity depending on the situation It will be an important example of showing plasticity. Although it is true that plasticity of the brain like AMI is essential for survival and difficult to control voluntarily, it often acts as a hindrance from a clinical point of view. Attempts such as this study will provide basic data on which additional treatments will cause the central nervous system to withdraw its own safety net such as AMI and restore function to pre-injury levels. AMI is the body's response to an injury. This can be interpreted as a simple reflex action or a protective mechanism, but in a future study, the results of this study can be looked at in relation to the psychological reaction experienced after injury. The task after figuring out where AMI exists and where and through what process this phenomenon occurs is because a follow-up study on the 'why' of this phenomenon is required. This requires an integrated approach to psychology and emotion that goes beyond the level of neurophysiology.

TMS, which will be used in this experiment, is being used not only in cognitive science, psychology, and motor control fields, but also for the purpose of treating neurological diseases. However, the use of TMS for clinical purposes is often not yet academically validated. Efforts to prevent injuries by decreasing the left and right movements of the center of mass were confirmed by increasing the level of knee joint muscle fatigue. However, it is judged that the overweight group exhibits greater left and right movements compared to the normal weight group, and thus the ability to control is low. The sagittal movements of the ankle and knee joints appear to increase as the level of fatigue increases, suggesting that the ankle and knee joints are mainly used for shock absorption during landing. And in the weight effect, the overweight group showed more sagittal movement of the ankle joint than the normal weight group, but the sagittal movement of the hip joint was smaller in the overweight group than in the normal weight group. The increase in the muscle fatigue level of the knee joint appears to decrease the left and right ground reaction force, vertical ground reaction force, absorption power of the knee joint, load factor, and the amount of impact, indicating that efforts are being made to reduce the amount of impact generated during landing. In the weight effect, the overweight group showed a lower ability to absorb shock than the normal weight group, so the frequency of injury is predicted to be high. This study related to the level of muscle fatigue in the knee joint is expected to provide an opportunity to prevent injuries by effectively controlling the load transfer due to impact during various types of landing motions that occur frequently in life tasks or sports sites. In addition, it is judged that the difference in weight leads to a difference in shock absorption capacity, which affects the frequency of injuries, resulting in economic and physical losses. Therefore, by providing an appropriate exercise prescription program, it will be possible to provide basic data for establishing rest strategies in daily life or sports environments. This is also expected to greatly contribute to the prevention of injuries to players. Continuous research related to local fatigue such as knee joint will provide basic data for training prescription, exercise rehabilitation, and fall program development, contributing to interdisciplinary integration. In the case of this study, it is considered that it is a rare case that basic neurological research in the field of movement control suggests a 'treatment' method that can be directly applied to the field. It is thought that cooperative research in the field of motion control can be derived.

One of the most common injuries among Korean elite athletes is a visible external knee injury, and it can be seen that many surgical and rehabilitation methods have already been

identified. However, rehabilitation methods and means for post-traumatic phenomena such as Arthrogenic Muscle Inhibition are regarded as psychological problems, and are being treated simply with on-the-spot rehabilitation. This study is not limited to the theoretical field of physical education, but attempts a clinical approach, and its value can be evaluated as an attempt to solve the chronic but undiscovered problems that may occur in actual exercise situations. In addition, it can be expected that this research field will be a foundational result to provide an opportunity to be applied to the field by attempting a clinical approach from the perspective of physical education, especially exercise control.

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