國立體育學院九十一學年度研究所博士班入學考試試題

體育運動論文評論（運動保健組）　　　　（本試題共二頁）

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Neural Control of Motor Output: Can Training Change It?

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BAWA, P. Neural control of motor output: Can training change it?
Henneman's size principle of motor unit recruitment and rate coding reduces fatigue, minimizes error in transfer of information from the nervous system, and produces smooth force output. Plasticity present at various sites of the motor system may change endurance, force, speed, or precision with training, but not the recruitment order. **Keywords:** recruitment, motor unit, human, motoneurons, training

INTRODUCTION

Muscle produces force and movements that can vary in magnitude, speed, and precision. The variety of force profiles and movements depends on both peripheral factors, such as the anatomy and fiber type composition of muscles, and central factors such as the motor commands. The muscle, no matter how sophisticated in design and composition, acts in response to neural commands to produce the required range of motor outputs.

Anatomically, each muscle is innervated by a group of motoneurons known as the motoneuron pool. The neuroarchitectural and biophysical properties of individual members of a motoneuron pool vary over a wide range (1,2). Some of these properties include the membrane surface area (size) of the cell body including dendrites, conduction velocity of the axon, input resistance, afterhyperpolarization, and terminal arborization that determine the number of muscle fibers innervated by the motoneuron. The values of these properties vary within a motoneuron pool and across motoneuron pools depending on the functions of the innervated muscle (*e.g.*, hand vs postural leg muscles). Each motoneuron innervates a group of muscle fibers forming a motor unit; properties of muscle fibers composing a motor unit are quite similar (Fig. 1). The properties of the motoneurons are complementary to the properties of the innervated muscle fibers; in general, the smaller motoneurons innervate a small number of slow-contracting, fatigue-resistant muscle fibers, whereas larger motoneurons in the pool will innervate a greater number of fast-contracting, easily fatigued muscle fibers (2).

The sources and types of inputs to motoneurons are also numerous. Motoneurons receive inputs from the cortex, brain stem, spinal cord, and directly from the sensory afferents (1,2,7). It is the interaction between the synaptic inputs and the biophysical properties of the motor units that provides an enormous force and movement repertoire to which an individual is accustomed. Although many scientists have examined the question of the activation patterns of motoneurons and control of muscle during the 20th century, only Henneman's size principle has stood the test of time. According to the size principle, during any muscle contraction, the smaller, slow-contracting and fatigue-resistant motor units are recruited before the larger, fast-contracting fatigable units (7). The statement appears to be simple but it has required in-depth studies on motoneurons, muscle fibers, and afferent and cortical inputs to the spinal cord using a combination of electrophysiological, histological, anatomical, and modeling techniques to understand the arrangement of the neuromuscular system underlying the control of motor units. For detailed treatment of the subject of recruitment, inputs to motoneurons, and properties of motor units, the reader is encouraged to read previous reviews by Binder *et al.* (1), Burke (2), Calancie and Bawa (3), Enoka and Fuglevand (5), and Henneman and Mendell (7). This review will update the information on recruitment and rate coding of motor units in humans and discuss optimization of force. Because each one of us likes to improve our motor performance, the presence of plasticity in the normal adult motor system and the effects of training are discussed in later parts of the review.

The Effects of Patellar Taping on Knee Joint Proprioception

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Objective: To evaluate the effects of patellar taping on knee joint proprioception.

Design and Setting: In a research unit, 3 proprioceptive tests were performed. For each of the tests, a standardized patellar taping technique was applied in random order.

Subjects: Fifty-two healthy volunteers (27 women, 25 men; age, 23.2 ± 4.6 years; body mass index, 23.3 ± 3.7).

Measurements: We measured active angle reproduction, passive angle reproduction, and threshold to detection of passive movement on an isokinetic dynamometer.

Results: We found no significant differences between the tape and no-tape conditions in any of the 3 proprioceptive tests ($P > .05$). However, when the subjects' results for active angle reproduction and passive angle reproduction were graded as good (≤5°) and poor (>5°), taping was found to improve significantly those with poor proprioceptive ability ($P < .01$).

Conclusions: Subjects with good proprioception did not benefit from patellar taping. However, in those healthy subjects with poor proprioceptive ability as measured by active and passive ankle reproduction, patellar taping provided proprioceptive enhancement. Further studies are needed to investigate the effect of patellar taping on the proprioceptive status of patients with patellofemoral pain syndrome.

Key Words: proprioception testing, patellofemoral pain syndrome

Although patellar taping is readily used by physiotherapists in the treatment of patients with patellofemoral pain syndrome (PFPS), doubts still exist regarding the mechanism for its success. McConnell[1] originally described patellar taping as part of a treatment program for PFPS and theorized that this technique could alter patellar position, enhance contraction of the vastus medialis oblique muscle, and hence, decrease pain. Studies thus far on patients with PFPS have been inconclusive regarding patellar taping enhancement of vastus medialis oblique contractions[2] and taping realignment of patellar position.[3] However, some studies have shown that patellar taping helps to decrease pain in patients with PFPS[2] and in patellofemoral osteoarthritis,[4] although the mechanism for this symptomatic improvement remains unknown. Some investigators have speculated that patellar taping may perform a role in providing a sense of mechanical stability to the patella.[5,6]

Proprioception is thought to play a more significant role than pain in preventing acute injury and in the evolution of chronic injury and degenerative joint disease.[7] A recently updated paradigm described it as the acquisition of stimuli from peripheral mechanoreceptors in joints, muscles, and deep tissues (conscious) and the projection of these stimuli to the central nervous system to modify motor control (unconscious).[8] Proprioceptive deficits have been found in anterior cruciate ligament–deficient knees,[9,10] osteoarthritic knees,[11] and knees with chronic effusions.[12] Application of a knee brace or bandage improves the proprioceptive deficit. The only studies to date on PFPS and proprioceptive capacity have been contradictory. Prymka et al[13] noted poorer proprioceptive capacity in patients with "chondropathia patellae" compared with healthy subjects, whereas Kramer et al[14] could not find any proprioceptive deficits in patients with PFPS in either weight-bearing or non–weight-bearing tests. Interestingly, Prymka et al[13] showed that an elastic knee bandage improved patients' proprioceptive status significantly. A proposed mechanism for this finding was that the bandage stimulated rapidly adapting superficial receptors in the skin during joint motion and increased pressure on the underlying muscles and joint capsule.[15] Jerosch and Prymka[16] speculated that patients who experienced patellofemoral dislocation disrupted a host of neuroproprioceptive structures in the medial retinaculum, capsule, bursae, and vastus medialis. This damage to the position sense receptors[17] may account for the knee's poor proprioception status. Hypothetically, PFPS patients with more subtle forms of chronic patellar malalignment may also exhibit some dysfunction of the peripatellar plexus, detectable with proprioceptive testing. Therefore, just as the restoration to good proprioception status is widely accepted as a key component in the rehabilitation of other knee conditions, modulating proprioception in patients with PFPS may help promote normal knee function and accelerate the rehabilitation process.

Although a plethora of investigators have studied the role of elastic bandages and knee braces on proprioceptive enhancement in both symptomatic and asymptomatic groups,[9–12] to date none have evaluated this phenomenon with patellar taping. Such a study may not only help to define the similarities between taping and bandaging but may also explain some of the mechanisms behind patellar taping. Our purpose was to determine the effect of application of patellar taping on the proprioceptive ability of the knee in a group of healthy subjects.