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Oxygen Uptake and Neuromuscular Electrical Stimulation of Antagonists during Aerobic Cycling Exercise

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Introduction

In recent years, it has been suggested that using both Electrical Stimulation (ES) and Volitional Contractions (VC) together is more effective than using either ES or VC alone for muscle strengthening and hypertrophy [1-2]. A hybrid training system (HTS) has been developed that uses the force generated by its electrically stimulated antagonist to resist the motion of an agonist muscle that is voluntarily contracting. One of the methods that compensates for the drawbacks of Neuromuscular Electrical Stimulation (NMES) is HTS, which can train both electrically stimulated antagonist muscles and voluntary contracting agonist muscles simultaneously. Compared to ES alone or conventional weight training, resistance training with HTS has been shown to increase muscle strength and hypertrophy at relatively low ES intensity. Over the course of eight weeks, using HTS, elbow flexion isometric torque increased by approximately 56% and the biceps muscle grew by approximately 14%, significantly more than or comparable to isotonic weight training and NMES [3].Over the course of six weeks, using HTS, the knee extension isokinetic torque at 30°/sec increased by approximately 28% in the lower extremity, which was comparable to weight training with maximum loads of 15 repetitions. In these studies, HTS was used in place of weights as exercise resistance for joint bending exercises. However, HTS has never been used in conjunction with other exercises to increase resistance (such as cycling or dumbbell exercises). In theory, HTS can be used to exercise all agonist-antagonist muscle groups [4].We concocted another activity method that joins HTS with cycling exercise in view of the idea that vigorous activity and electrically capricious activity are conceivable all the while. On the other hand, it is unknown how HTS affects aerobic exercise.

Cycling exercise is broadly utilized as a vigorous activity technique to further develop practice limit or actual wellness [5]. Although there are some reports that cycling exercise improved muscle strength in the lower extremity, its effect on muscle strengthening has not generally been demonstrated. However, studies have looked at cycling exercise and eccentric muscle contractions. Exercising eccentric muscles is more beneficial for muscle strengthening than exercising concentric muscles because eccentric muscles produce 30% to 50% more force than concentric muscles. Also, eccentric exercise produces a lot of force with little need for energy. Lastayo and coreported that in healthy young subjects, 8 weeks of eccentric cycling exercise resulted in a 36% improvement in isometric leg strength and a 52% increase in fiber area when performed at exercise intensities that did not promote strength or size increases concentrically. HTS includes both passive (electrically stimulated) eccentric exercise and active voluntary concentric exercise, even though this eccentric cycling exercise is passive. Both the agonist and antagonist's muscle strength and activity can be increased by electrically stimulated eccentric antagonist contractions [6]. Combining voluntary concentric contractions with electrically stimulated eccentric contractions raises metabolic cost, as a result.

The percentage of maximal oxygen uptake (Equation) is frequently used as one of the targets for exercise intensity in exercise prescription. In this manner, to work out a suitable activity solution knowing Condition during the activity with HTS is fundamental. We compared VO2 during a voluntary moderate cycle ergometer alone (VER) to VO2 during HTS with a moderate cycle ergometer (HER). Setting and Participants The clinical design of this study protocol was approved by Kurume University's Ethics Committee and the Japan Aerospace Exploration Agency. The Ethics Committee of Kurume University and the Japan Aerospace Exploration Agency gave their blessing to the study, which was designed in accordance with the ethical guidelines outlined in the Helsinki Declaration of 1975. Participants who gave written informed consent to participate were fully informed of all procedures. 11 young men in good health, ranging in age from 21 to (1.3) years, level 173.3 (6.5) cm; and weighing 67.7 (8.1) kilograms consented to take part. A non-participant orthopedic specialist examined the participants after they gave their consent. If they clearly deviated from the inclusion criteria, they were excluded. This included a check for normal physical fitness, strength, sensation, and range of motion in accordance with the Japanese Orthopedic Association's criteria, as well as a requirement that they had no adverse medical history. Even though they were permitted to participate in sporadic sports, they had not engaged in any regular or ongoing sports activities. Before the beginning of this investigation, a computer-generated randomized sequence of exercise order was used for randomization. Each participant was tested during either VER or HER, which were chosen at random, and an hour later, they were tested for the other.

Intervention The ramp exercise test and two cycle ergometer exercise tests were used to determine each participant's peak oxygen consumption Equation, as were measurements of height and body weight [7]. On an electronically braked cycle ergometer, the first exercise test consisted of a ramp protocol that was performed until exhaustion levels were reached. Participants were measured for gas exchange during exercise on a cycle ergometer in accordance with the following protocol on the second exercise test, which was performed on a different day. Throughout each exercise test, they pedaled with their feet firmly anchored to the pedals.

Protocol for the ramp exercise test Following a two-minute rest period while seated on the cycle ergometer (STB- 2400, Nihon Kohden, Tokyo, Japan), the workload was increased by 20 or 30 W/min based

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on each subject's physiological profile. Depending on the subject's preference, a pedal frequency meter was used to maintain the same pedaling cadence of 60 to 80 rev/min. The test lasted between 8 and 12 minutes based on the ramp rate that was determined. Equation was determined after the exercise test was terminated when the pedal cadence could not be maintained at 60 rev/min. During the ramp exercise test, encouraging words were spoken. The power output (W) that corresponds to the first breakpoint in the carbon dioxide production equation was used to determine the ventilatory threshold (VT) - the so-called V-slope method [8].

Protocol for the VER test The VER test was used to get an analysis of expired gas. The test began at 20 W after a two-minute break while seated on the cycle ergometer, and the workload was increased by 20 W to 100 W every three minutes. Using a metronome and a pedal frequency meter, the pedaling cadence was maintained at 60 revolutions per minute, which is thought to have no effect on heart rate or blood pressure [9-12].The exercise test time was limited to 15 minutes to prevent muscle fatigue.

Protocol for the HER test an analysis of expired gas was obtained through the HER test. The test began at 20 W after a two-minute break while seated on the cycle ergometer, and the workload was increased by 20 W to 100 W every three minutes. The participant's hamstrings were electrically stimulated as he volitionally extended his knee, and his quadriceps were electrically stimulated as he volitionally flexed his knee to provide motion resistance during the HTS portion of the HER test. At 60 rpm, the pedaling cadence remained constant. Using HTS, both lower extremities were stimulated during HER in sync with the bending of the knee. By adjusting the saddle's height, the joint range of motion was set to a nearly 90° arc that went from 20° to 110° (with 110° representing full knee extension).

Electrical stimulation protocol The ES device has been described previously and consists of a joint motion sensor (Mutoh Engineering Inc., Tokyo, Japan) that initiates stimulation of the antagonist upon sensing the initiation of an agonist's VC. The joint motion sensor can deliver stimulating signals with unique frequencies and waveforms to as many as eight pairs of electrodes. Pairs of low impedance gel coated silver fiber electrodes measuring 36 cm in length.Were attached to a detector and placed over each quadriceps and hamstring motor point. Stimulation Parameters The stimulation waveform utilized in this study is comparable to that of "Russian stimulation" in some respects. It consists of a 5,000 Hz carrier frequency modulated at 40 Hz to deliver a rectangular biphasic pulse with 2.4 ms on and 22.6 ms off. The human body is stimulated by the electrical stimulator at a constant voltage (regulated voltage). It has a safety limiter and a stimulus pattern with an interlock. As a result, the effective current is interlocked at 20 mA, and the peak voltage and current are restricted to less than 72 volts and 90 milliamperes, respectively. The stimulation intensities were determined one week prior to the start of the evaluation session. To successfully improve muscle strength and mass without causing pain, we controlled the intensity of the stimulation so that the exercise intensities were adjusted to 80% of the maximum comfortable intensity.

Type II fibers are favored over voluntary muscle contractions when it comes to NMES activation, which is considered nonselective in terms of motor unit type and synchrony. As a result, resistance training is the primary application of NMES, not endurance training. HTS is a type of NMES that uses electrically stimulated eccentric contractions for resistance training. Because these contractions are neuro muscularly more efficient, less metabolically demanding, and more conducive to hypertrophy than concentric contractions, the presence of an eccentric component may also be advantageous. In fact, when used for elbow or knee bending exercises, HTS successfully increased muscle mass and strength in healthy men in previous studies.An eccentric contraction at a given level of stimulation is known to be 20-30% stronger than an isometric contraction. As a result, it is thought that effective resistance exercise such as an eccentric contraction of HTS can increase muscle mass and strength. La Stayo, others reported that, in contrast to a conventional cycle ergometer, eccentric cycling training at a low exercise intensity (50-65% of peak heart rate) without VC could increase muscle size and strength. HER is also training eccentrically with cycling. As a result, HER could potentially provide resistance training, resulting in increased muscular mass and strength. At the same pedaling intensity (workload) as VER, her metabolic cost would rise as well as the perceived intensity of the exercise. In addition, using HER to raise the metabolic rate would cause exercisers to burn more calories. In situations like microgravity or prolonged bed rest, where exercise opportunities and/or equipment are limited, HER may be an option.

Limitations of the Study This study had some limitations. The small number of participants and the fact that they were all young men were limitations. To demonstrate that HER is an efficient method for combining aerobic and resistance exercise by assessing exercise capacity, physical fitness, muscle strength, muscle mass, and other factors, a long-term training study is required. This study demonstrated how HER affects aerobic cycling exercise, and the pilot study demonstrated that HER can be used as both aerobic exercise and electrical resistance exercise simultaneously. Additionally, the study's discovery of HER's exercise intensity made it possible to conduct a subsequent training study.

Conclusions

This study's conclusion is that when aerobic cycling exercise is combined with resistance using an electrically stimulated antagonist (cycle ergometer with HTS), the equation with a linear relationship to workload may increase in comparison to aerobic cycling exercise alone. With the same workload, HER also produced more intense exercise than VER.HER may be a novel exercise strategy that combines resistance training with aerobic exercise.

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