Walking exercise combined with neuromuscular electrical stimulation of antagonist resistance improved muscle strength and physical function for elderly people: A pilot study

Improvement of muscle strength and physical function in elderly by walking exercise combined with neuromuscular electrical stimulation of antagonist resistance: A pilot study

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Abbreviations: ADL, activities of daily living ; CTR, control group; HTS, hybrid training system; HTSW, HTS during aerobic walking exercise; MV, muscle volume; TUG, Timed up and go test; 1RM, one-repetition maximum

Abstract Both aerobic exercise and resistance exercise are recommended to enhance health in elderly people. A hybrid training system (HTS), that provides resistance to the motion of a volitionally contracting agonist muscle by electrically stimulating its antagonist, was developed as a resistance exercise technique combining the benefits of electrical stimulation and volitional contractions. We then applied this concept to develop a novel training method using electrically stimulated eccentric contractions during aerobic walking exercise (HTSW). This study was designed to evaluate the effect of the new method on muscle strength and physical function by comparing it to unenhanced walking exercise. 16 subjects (2 male, 14 female; age average, 67.2 ± 2.6) were randomly divided into an HTSW group and a control group (CTR). They trained using either HTSW or unenhanced walking exercise (CTR) for 30 minutes three times a week for 12 weeks. Isokinetic knee extension/flexion torque, muscle volume (MV), a one-leg standing test, a functional reach test, 10-meter maximum gait speed, timed up & go test (TUG), and a 6-minute walking test were measured before and after the training period. We compared the differences between pre-training and post-training using the Wilcoxon signed rank test in each group. In the HTSW group, isokinetic knee extension

(12%)/flexion torque (18%), MV (8%), 10-meter maximum gait speed (9%), TUG (26%), and 6-minute walking test (12%) significantly improved after the training period. In the CTR group, isokinetic knee flexion torque (15%), 10-meter maximum gait speed (9%), TUG (22%), and 6-minute walking test (16%) had significantly improved after the training period. HTSW may provide the benefits of both aerobic and resistance exercise.

Keywords : elderly people, walking, muscle strength, electrical stimulation, exercise, volitional contractions

Introduction

Aging causes a decline in the level of physical function[1]. This decline often leads to difficulties in locomotion, e.g walking, getting out of a chair, and stair climbing[2-4]. It may originate from disease, life style, psychosocial and socio-demographic factors, genetic predisposition or a combination of the above[5]. This decline leads to disability, and elderly people with disabilities usually require nursing care at some point. The Japanese Orthopaedic Association (JOA) has proposed the term "locomotive syndrome" to designate a condition in people from high-risk groups with musculoskeletal disease who are highly likely to require nursing care[6]. Locomotive syndrome is caused by weakening of the musculoskeletal organs such as bones, joints, and muscles, so exercise is important for prevention[7]. Walking, in particular, is one of the most basic exercises that most elderly people can do safely. Walking is also one of the basic physical activities of daily living and is associated with life expectancy[8]. Gait speed is a general indicator of physical function. Improving gait speed decreases the risk of falls[9] and fractures[10]. Good walking ability is essential for the formation of a thriving society with a long life expectancy. The Ministry of Health, Labor and Welfare in Japan provides guidelines for the health enhancement of elderly people, and recommends an increase in walking time.

On the other hand, regional muscle strength is a predictor of mortality in elderly people[11)]. Knee-extension strength correlated positively with ADL and the degree of ADL disability decreases with increasing knee-extension strength[12)]. Resistance strength training is recommended for elderly people in the American College of Sports Medicine[13)]. The minimum resistance training intensity to achieve muscle hypertrophy and strength gain is 65% of the one-repetition maximum (1RM)[13,14)]. This exercise intensity is often a problem for elderly people with illness (e.g. locomotorium diseases or heart disease). Neuromuscular electrical stimulation (NMES) is one of the more effective training methods even though exercise intensity is relatively low, and is widely used to lessen immobilization-associated muscle atrophy, strengthen muscles, and improve function in people with neuromuscular disabilities[15-19)]. The combined application of electrical stimulation and volitional contractions is said to be more effective than electrical stimulation or volitional contractions alone[20,21)]. A hybrid training system (HTS) that resists the motion of a volitionally contracting agonist muscle, with force generated by electrically stimulating the corresponding antagonist, was developed as a technique to combine the application of electrical stimulation and volitional contraction[22-24]. Matsuse et al. reported that elbow flexion torque had increased about 56%, and the muscle cross-sectional areas of the upper arm had increased about 10%, as a result of HTS over an 8-week period; and those increases were better than those produced by isotonic weight training and NMES[22]. Iwasaki et al. studied the benefits of HTS compared to conventional weight training, with 15 RM loads, for increasing muscle strength around the knee at both slow and fast joint speeds (at 30 and 180°/sec), and reported that HTS is comparable to weight training with the exception of high-speed contractions (HTS + 25 - 28%, WT + 24 - 33%, at 30°/sec)[23]. In elderly people, HTS has been shown to produce improvements in muscle strength by about 40% and mass by about 10%, which is as good as or better than those achieved with a knee flexion machine used at 30% of maximum voluntary contraction (MVC)[25]. One of the major advantages of HTS is that ES can be combined with voluntary activity simultaneously. We have shown that HTS could be combined with aerobic cycling exercise simultaneously[26,27]. Walking is one of the most basic moderate intensity physical activities for elderly people. Consequently, we then developed a new exercise device that would enable us to perform muscular strengthening exercise using HTS while walking (HTSW).

The purpose of the present study was to examine the effects of HTSW with regards to muscle strength and physical function in elderly people as a pilot study.

Subjects and Methods

Subjects

The Ethics Committee of Kurume University approved the clinical design of this study protocol (approval ID: 13006). Subjects who independently lived at home were recruited using posters displayed in local community centers in Okawa City, Fukuoka, Japan. The subjects were given oral and written explanations of the study including the objective of the training method and its risks, and then asked to sign consent forms for participation in this research. They were assured that they could quit at any time if they wished. The exclusion criteria for the training intervention were cases of acute orthopedic problems, cerebrovascular, or heart disease within the past year, as well as dementia. Subjects underwent medical and musculoskeletal examinations conducted by a physician. The 16 subjects (2 males and 14 females), with an average age of 67.2 ± 2.6 (ranging 62-72 years), were randomly divided by a blinded assessor using a computer into two groups: the HTSW group and a control group (CTR). The HTSW group, who trained with HTS while walking, consisted of 8 subjects (1 male and 7 females) with an average age of 67.4 ± 3.4 (ranging 62-72 years), while the CTR group included 8 subjects who trained by walking only (1 male and 7 females) with an average age of 67.0 ± 1.9 (ranging 65-71 years).

Training protocol

The walking exercise was conducted for 30 minutes per session, 3 times a week for 12 weeks (a total of 36 sessions). Each session was separated by an interval of at least 48 hours. All the sessions were conducted at the University Laboratory. The subjects were instructed to carry on their ordinary daily lives. They were prohibited from participating in new activities for the purpose of resistance movement and physical strength improvement. During the exercise, an assistant was always present to provide guidance and monitoring in order to ensure that the exercise was performed safely and properly. Every exercise session began and ended with a 5-minute stretching session supervised by an assistant. To improve muscular strength and cardiovascular fitness in middle-aged and elderly populations, several societies[28,29)] have published guidelines that recommend combining training intensity, volume, and frequency to optimize muscle hypertrophy and strength gains as well as improve cardiorespiratory function. The guidelines also recommend a training frequency of 3-5 days per week for aerobic training and 2-3 days per week for resistance training[28)]. HTSW is an exercise method that combines resistance exercise with walking. Therefore, we made subjects exercise in this study three times a week rather than every day.

HTSW protocol

During the walking exercise both lower extremities were stimulated using HTS in response to the gait phase of each foot. Electrical stimulation of the quadriceps started gradually from just before heel contact and stopped with heel off (Fig. 1). Conversely, electrical stimulation of the hamstring started gradually from just before heel off and ended with heel contact (Fig. 1). The subjects performed the walking exercise by stride. If the subjects were tired and could not continue walking, they were instructed to take breaks at will. The joint range of motion during walking was not prescribed.

Electrical stimulation protocol

The electrical stimulation device for this study, which has been described previously[22,23], was remodeled by Panasonic Corporation (Home Appliances Development Center, Corporate Engineering Division, Appliances Company, Panasonic Corporation 2-3-1-2 Noji-higashi, Kusatsu City, Shiga, Japan). The device consists of a custom designed waveform generator capable of delivering stimulating signals with unique frequencies and waveforms to as many as 4 pairs of electrodes. Acceleration sensors as joint motion sensors (EWTS9PD, Home Appliances Development Center, Corporate Engineering Division, Appliances Company, Panasonic Corporation 2-3-1-2 Noji-higashi, Kusatsu City, Shiga, Japan) were placed on the front of each leg 88 mm above the patellar edge. Motion sensors measured the hip joint angular velocity during walking (Fig. 2). They analyzed the algorithm of each walking pattern, and stimulated the antagonist of the motion of each bilateral knee joint during walking. Pairs of 5 x 12-cm low impedance gel-coated silver fiber electrodes (Nihon Medix Co, 315-1, Mukai-machi, Minami-hanashima, Matsudo-shi, Chiba-ken, Japan.) were placed to widely cover each motor point of the quadriceps and hamstrings. They were built into a quick-drying training suit that the subjects could put on easily.

Stimulation Parameters

The stimulation waveform used in this study consists of a 5,000 Hz carrier frequency with a pulse width of 200 μs modulated at 40 Hz (2.4 ms on, 22.6 ms off) to deliver a rectangular biphasic pulse[30)]. The electrical stimulator gives constant voltage stimulus to the human body (regulated voltage). It has a stimulus pattern with interlock and a limiter for safety. Therefore, the effective current is interlocked at 23mArms when using 500 Ω of the human body equivalent circuit, and the peak voltage and current is limited to under 80 V. Stimulation intensities were re-determined every two weeks during the training period. We regulated stimulation intensity so that the exercise intensities were adjusted to 80% of the maximum comfortable intensity that would successfully improve muscle strength and mass without causing pain or numbness[25]. At these electrical stimulation intensities, all subjects were able to walk for 30 minutes.

Evaluations

All the evaluations were performed by a blinded assessor one week before and after the training respectively.

Maximal isokinetic torque of knee extension measurement

All the evaluations were performed by one physical therapist and three assistants. Maximal volitional isokinetic knee extension/flexion torques were measured at angular velocities of 60°/sec with the BIODEX SYSTEM 3 PRO (Biodex Medical Systems Inc., Shirley, NY, USA). To reduce the potential for pain exacerbation or injury associated with maximal eccentric contraction, peak torque was measured 60° per second[31]. McCleary reported the reliability of reciprocal concentric knee extension/flexion torque using the Biodex isokinetic dynamometer. Biodex was conducted using this protocol as previously described[32]. During the strength measurements, the subject was seated on the Biodex in an upright position. Velcro belts were applied to fix the trunk and thigh in position. The seat was adjusted to the same position at each evaluation. Each session began by establishing that the subjects could move their lower extremity comfortably throughout the full 10 - 100 ^{o} arc of the exercise range. They then performed three practice contractions in the direction and at the speed to be tested. A measurement session consisted of 3 sets separated by 3-minutes after the practice; the three measurements from the non-dominant lower extremities were pooled, and the mean adjusted according to each body weight (kg) used for statistical analysis.

Muscle volume of quadriceps femoris muscle measurement (MV)

Ultrasonographic evaluations were performed with an 8 MHz linear probe (SSA-510A [Famio5], Toshiba Medical Systems Corporation, Tochigi, Japan) by the same physiatrist, who was blinded to the exercise groups. Measurements were taken on the rectus femoris muscle of the non-dominant lower extremity. Subjects were positioned supine with their legs extended and their muscles relaxed. A water-soluble transmission gel was applied to the transducer to aid acoustic coupling and also to eliminate deformations of muscle that can occur when pressure is directly applied to the skin. Images were obtained at the levels of 15 cm above the patellar superior border. When imaging for pennation angle and fascicle length was carried out, the probe was held with a light touch so as not to cause any muscle deformation. Muscle thickness was defined as the distance between the deeper and upper aponeurosis (MV).

One-leg standing test

The one-leg standing test can be a tool for predicting frailty in community-dwelling elderly populations. The one-leg standing test was conducted to evaluate balance function[33)]. The subjects were measured according to the length of time they were able to stand on their non-dominant lower limb without support with eyes open to assess postural steadiness in a static position[34)].

Functional reach test

The functional reach test is useful for detecting dynamic balance impairment, change in balance performance over time, and in the design of modified environments for impaired older persons[35]. The subjects stood straight with one arm stretched out in front at 90°of shoulder flexion with wrists and fingers straight and palms facing down. The starting position was measured at the tip of the middle finger. The subjects were instructed to reach their hand as far forward as possible without taking a step, and the position of the tip of the middle finger at the end of the reach was recorded. The distance between the starting point and the end point was the reach distance automatically measured in centimeters. The subjects performed one test with their dominant hand after one practice.

10-meter maximal gait time (10MW)

Gait speed is a general indicator of physical function[36]. Gait speed is a consistent risk factor for disability, cognitive impairment, falls, and mortality. For the evaluation of the 10-meter maximal gait time, 2 meters were added to allow for acceleration before and deceleration after the 10-meter gait respectively. The maximal gait time for the 10-meter gait was measured to evaluate gait speed. Gait speed is a functional assessment tool to show individual activity of daily living (ADL) or physical capacity[37].

The subjects were instructed to walk as fast as possible. The evaluation was performed by two evaluators, and the times provided by the two evaluators were averaged for analysis.

Timed up & go test (TUG)

The National Institute of Clinical Evidence guidelines also advocate the use the TUG for assessment of gait and balance in the prevention of falls in older people[38]. TUG was conducted to evaluate functional mobility[39]. The subjects were measured according to the time it took to rise from a standard chair (46 cm seat height), walk a distance of 3 m, walk back to the chair and sit down. The evaluation was performed two times, and the scores from the two times were averaged for analysis.

6-minute walking test (6MWT)

A 6-minute walk is a good physiologic health predictor[40]. The 6MWT was chosen because it is easier to administer, better tolerated, and better reflects activities of daily living than other walk tests. The 6MWT is sub-maximal standardized aerobic test. The evaluation was performed in a 25-meter oval walking course at an indoor sports center. The subjects walked at a regular walking speed for 6 minutes, and their walking distances were measured to evaluate physical fitness. Before the test, the subjects rested for 30 minutes, and their blood pressure and pulse were taken. The evaluation was suspended if the subjects were unable to walk or did not feel well. The evaluators did not support them during their walk.

Statistical Analysis

All variables are presented as means and SD. Baselines of the group were assessed using the Wilcoxon rank sum test. Values for knee extension torque/knee flexion torque, MV, one-leg standing test, functional reach test,10-meter maximum gait speed, TUG, and 6 MWT, were assessed using the Wilcoxon signed rank test in order to compare the differences between pre-training and post-training. All the statistical analyses were performed using JMP Version 9.0 statistical software (SAS Institute Inc., Cary, NC, USA) and p values < 0.05 were considered to be statistically significant.

Results

Baseline anthropometric measurements, knee extension torque and knee flexion torque were similar in both groups (Table 1). Knee extension torque in the HTSW group significantly increased from 1.35 ± 0.34 Nm/kg pre-training to 1.51 ± 0.34 Nm/kg post-training ($p < 0.05$) (Table 2). Knee flexion torque in the HTSW group significantly increased from 0.78 ± 0.25 Nm/kg pre-training to 0.92 ± 0.22 Nm/kg post-training ($p < 0.05$). MV in the HTSW group significantly increased from 0.25 ± 0.06 mm/kg pre-training to 0.27 ± 0.05 mm/kg at the end of training ($p < 0.05$). Knee extension torque in the CTR group did not significantly change (Table 3). Knee flexion torque in the CTR group significantly increased from 0.68 ± 0.12 Nm/kg pre-training to 0.78 ± 0.14 Nm/kg post-training ($p < 0.05$). MV in the CTR group did not significantly change.

Discussion

The primary objective was to evaluate the present training system to see whether it would improve muscle strength and physical function in older adults. No subjects withdrew from this training, and they all completed their 12-week (3 times/week) training program. There were no adverse events in this study. The findings of this study show that the simultaneously combined application of electrical stimulation to walking exercise using the HTS technique (HTSW) can improve muscle strength and physical function in elderly people. HTSW could be a novel effective exercise method for elderly people.

Aerobic exercise is recommended for improving physical function and for preventing geriatric diseases[13)]. In particular, walking is a very simple aerobic exercise and does not cost money for elderly people who have difficulty performing moderate or severe intensity exercise. The aerobic intensity of exercise is light to moderate intensity, so there is lower risk of injury or pain exacerbation than at a higher intensity. Aerobic exercise is commonly used to improve physical fitness or physical activity. In this study, both CTR and HTSW improved the 6-minute walking test as an effect of aerobic exercise.

Strength training is also recommended for improving physical function and physical activity and preventing falls in elderly people[13)]. Lower limb muscles (e.g. particularly the quadriceps) which influence physical function (e.g. gait speed and body balance) are especially important[41,42]. Knee flexion torque significantly increased in both groups. As far as we know, a few of studies have investigated the effect of endurance training on knee flexion in elderly people. Knee flexion (i.e., hamstrings) involves two-jointed muscles (TJM) that act as hip extension as well as knee flexion. During walking, the hamstring muscles serve the role of hip extension in the stance phase and knee flexion in the swing phase, respectively. Furthermore, before heel contact, the hamstrings as well as the quadriceps are activated during normal walking[43]. These results indicate that increased hamstring coactivity is useful for stabilizing the knee by increasing the compressive force. Sipila reported that the number of endurance (walking) training sessions is significantly related to the change in the cross-sectional area knee flexors[44]. Kubo et al. investigated the effects of 24 weeks of walking training on muscle strength in the elderly[45]. The participants performed exercises for 30 to 40 minutes four times a week. The knee extension torque did not significantly improve (4.5%), but knee flexion torque significantly improved (19.6%). Accordingly, it seems reasonable to suppose that walking training in older people has an effect on the function of the hamstrings.

In this study, HTSW increased the strength of the quadriceps and hamstring muscles, and improved physical function. The quadriceps are the largest muscles in the human body. Knee extension strength and ADL correlate positively, and the percentage of people with ADL disability decreases with increased knee extension strength[12]. Also, many physical functions are related to the lower limbs. Thus, the target of this stimulation was the quadriceps and hamstrings. In general, strength training intensity was performed at light to moderate, around 60% of 1 RM or 50%-100% of 10 RM[46]. We developed HTS as a method of strength training utilizing electrically stimulated eccentric antagonist muscles[24]. Eccentric contractions are more conducive to hypertrophy than concentric contractions[47]. HTS succeeded in increasing muscle strength and mass even at low-intensity exercise (15-20% of 1RM)[22-25]. Takano showed that HTS was an effective exercise technique for elderly people who have difficulty doing high intensity exercise[25]. It follows that HTSW could be effective not only as aerobic exercise, but also as resistance exercise. It would also be efficient in terms of time because HTS is effective as both aerobic exercise and resistance exercise simultaneously. However, in this study, HTSW did not improve balance function associated with the risk of falling for elderly people. The improvement of balance function is said to require a separate balance training program[48] and may not be improved by HTSW. The development of an exercise method that is effective for muscular strength, physical strength, and balance function would be ideal. The aerobic intensity of exercise is light to moderate, so there is lower risk of injury or pain exacerbation than at a higher intensity. Aerobic exercise is commonly used to improve physical fitness or physical activity. In this study, both CTR and HTSW resulted in improvement in the 6-minute walking test as an effect of aerobic exercise. However, weight bearing exercise such as walking might aggravate knee pain for people with knee osteoarthritis which is common in elderly people[49,50]. Indeed, in this study, 4 out of 8 subjects developed aggravated knee pain in the CTR group. (We didn’t show the data.) In contrast, HTSW was able to lessen knee pain in all four subjects who began the study with knee pain. NMES is effective for pain relief[51]. Therefore, we suppose that HTSW would be effective not only for prevention of the usual knee pain exacerbation, but also physical fitness since HTSW is a form of NMES. In addition, the electrical stimulation of HTSW stimulated the antagonist muscle of the knee joint bending motion during walking (quadriceps and hamstrings alternately). The antagonist muscles have the role of maintaining joint stability[52]. So HTSW may contribute to the stabilization of the knee joint. Additional long-term prospective studies are needed to determine the long-term effect of pain relief and the level of arthropathy prevention.

A potential limitation of this study was the limited number of participants, and there was only one male in each group. During this study, adverse events (e.g. falling, grogginess) using HTSW didn't occur. Also, the analysis of the timing of electrical stimulation, and the effect of HTSW on walking need more examination. The main purpose of this study was to serve as a pilot study for developing a novel technique of HTS combined with walking exercise for elderly people. However, a long-term randomized control study using HTSW is necessary to evaluate its effectiveness for the health enhancement of elderly people compared to conventional training methods.

Conclusions

This is a novel training method to electrically stimulate the antagonist as resistance exercise during aerobic walking exercise (HTSW). This study's results show that HTSW was able to improve knee muscle strength and physical function in elderly people.

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The authors have declared that Panasonic Corporation has competing interests. However, the staff of Panasonic Corporation were not involved in direct implementation of this study or analysis of results. We studied the development of a novel effective training method for the treatment of people with knee osteoarthritis.

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Institutional Review

This study was designed in accordance with the ethical standards of the Helsinki Declaration of 1975 and received the approval of the Ethics Committee of Kurume University. All procedures were fully explained to the participants who gave their written informed consent to participate.

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Figure Legend

Fig. 1 Schematic model of HTSW

During walking both lower extremities are electrically stimulated in response to the gait phase of each foot. Electrical stimulation of the quadriceps is gradually initiated from just before heel contact and discontinues with heel off. Conversely, electrical stimulation of the hamstring is gradually initiated from just before heel off and discontinues with heel contact. The result is that both muscles are exercised electrically during walking exercise.

Fig. 2 The joint sensor and electrical stimulation

Motion sensors measured the hip joint angular velocity during walking. They analyzed the algorithm of each walking pattern, and stimulated an electrical eccentric contraction to a quadricep, hamstring muscle.

Table 1. Baseline anthropometric measurements, knee extension torque and knee flexion torque of patients

[1]Wilcoxon rank sum test. BMI: Body mass index; NS: Not significant

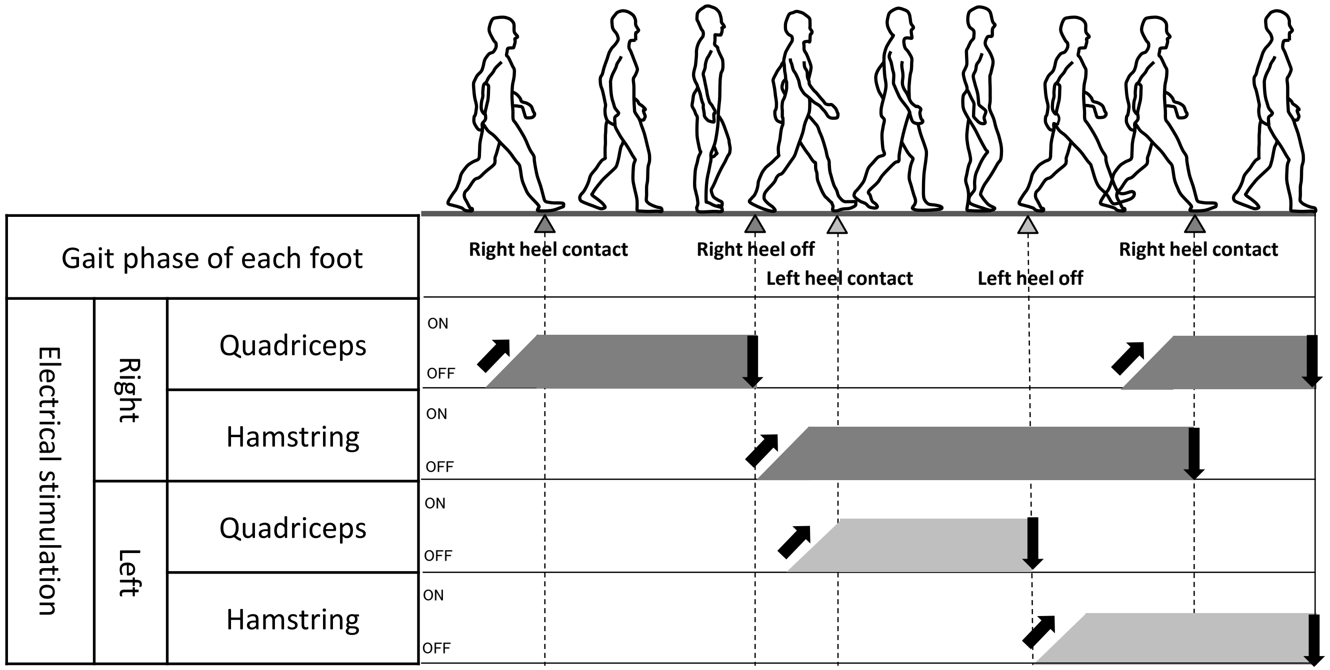
Table 2. The differences between pre-training and post-training in the HTSW group

[1]Wilcoxon signed rank test, p for difference between pre-training and post-training, MV: muscle volume; TUG: Timed up & go test; 6MWT: 6-minute walking test; NS: Not significant

Table 3. The differences between pre-training and post-training in the CTR group

1Wilcoxon signed rank test, p for difference between pre-training and post-training, MV: muscle volume; TUG: Timed up & go test; 6MWT: 6-minute walking test; NS: Not significant

Fig.1



Gait phase of each foot
Right heel contact
Right heel off
Left heel contact
Left heel off
Right heel contact
Electrical stimulation
Right
Left
Quadriceps
Hamstring
Quadriceps
Hamstring
ON
OFF
ON
OFF
ON
OFF
ON
OFF

Fig.2

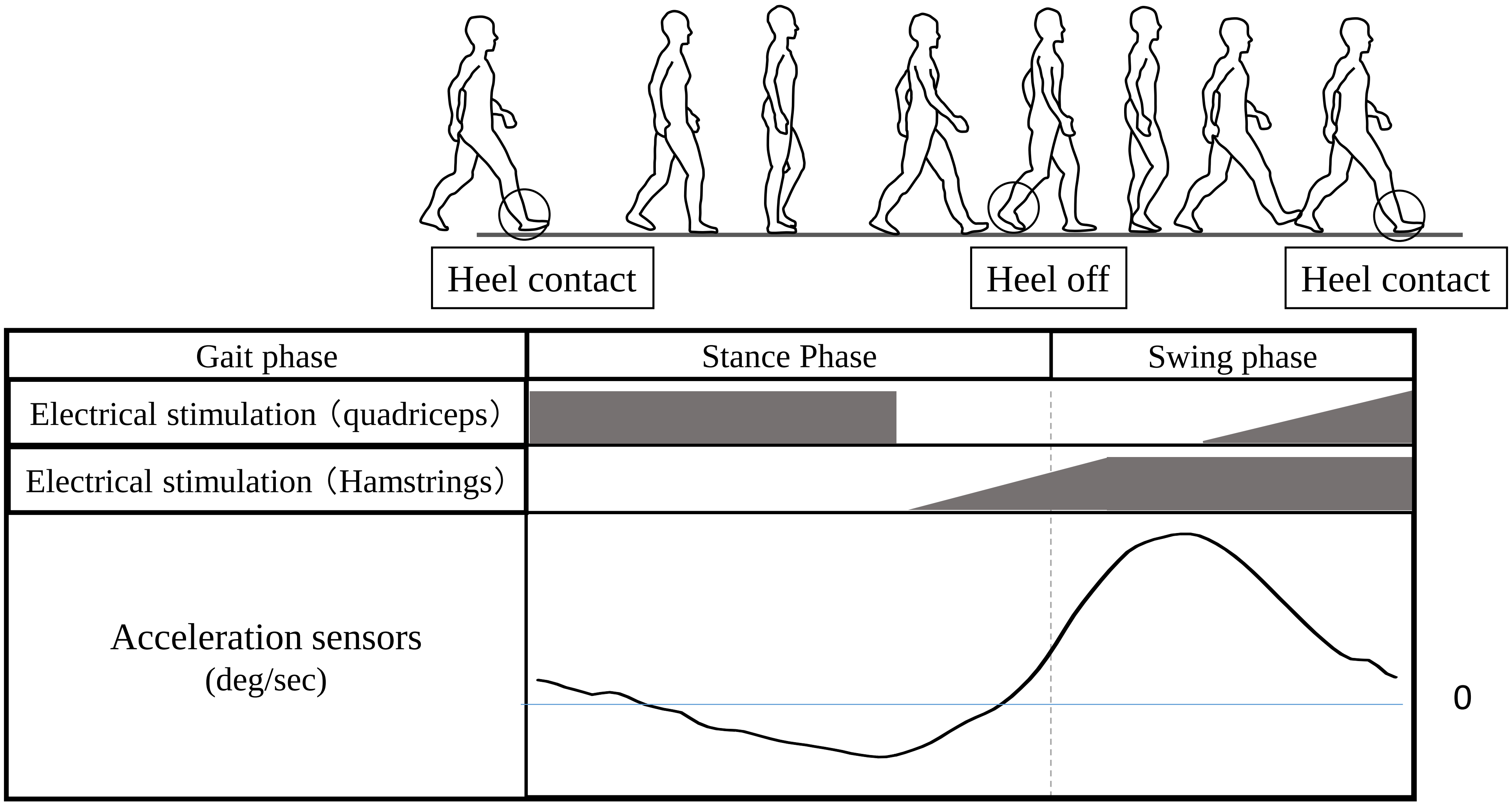

Heel contact
Heel off
Heel contact
Gait phase
Stance Phase
Swing phase
Electrical stimulation（quadriceps）
Electrical stimulation（Hamstrings）
Acceleration sensors
(deg/sec)
0

Table1

characteristic	HTSW group	CTR group	P value[1]
age	67.4±3.4	67.0±1.9	NS
Height(cm)	156.9±10.58	153±4.09	NS
Body weight(kg)	56.21±11.97	52.33±6.99	NS
BMI(kg/㎡)	22.61±2.93	22.19±2.25	NS
Sex(male/female)	1/7	1/7	
Knee extension torque(Nm/kg)	1.35±0.34	1.56±0.18	NS
Knee flexion torque(Nm/kg)	0.78±0.25	0.68±0.12	NS

Table2 HTSW group

	pre	post	p
Knee extension torque(Nm/kg)	1.35±0.34	1.51±0.34	0.031
Knee flexion torque(Nm/kg)	0.78±0.25	0.92±0.22	0.016
MV(mm/kg)	0.25±0.06	0.27±0.05	0.016
TUG(sec)	7.74±0.90	5.70±0.92	0.007
6MWT	529.79±46.92	595.84±70.64	0.007
10-meter maximal gait time	5.27±0.49	4.76±0.59	0.031
Functional reach test	32.45±5.47	34.33±6.71	NS
One-leg standing test	4.20±1.93	7.52±8.40	NS

Table3　CTR group

	pre	post	p
Knee extension torque(Nm/kg)	1.56±0.18	1.66±0.22	NS
Knee flexion torque(Nm/kg)	0.68±0.12	0.78±0.15	0.016
MV(mm/kg)	0.28±0.12	0.31±0.06	NS
TUG(sec)	6.14±0.65	4.78 ±0.58	0.008
6MWT	563.66±45.21	654.24±34.69	0.008
10-meter maximal gait time	5.17±0.71	4.37±0.57	0.016
Functional reach test	28.62±5.95	30.47±5.12	NS
One-leg standing test	4.33±2.25	7.54±6.98	NS