Official Title: The Effects of Electrical Muscle Stimulation Exercise on Upper, Lower Extremity and Core Strength in Sedentary Women

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Participants

Our study was conducted with 27 sedentary women between the ages of 19-24. The optimal number of subjects to participate in the study was determined using the GPower 3.1.3 program. The results indicated that a total of 16 subjects would be an appropriate sample size for the study (effect size r: 0.87, lower and upper critical p: 0.53, true power: 0.92). Before the study, the subjects were informed in detail and included in the study by obtaining an "Informed Consent Form".

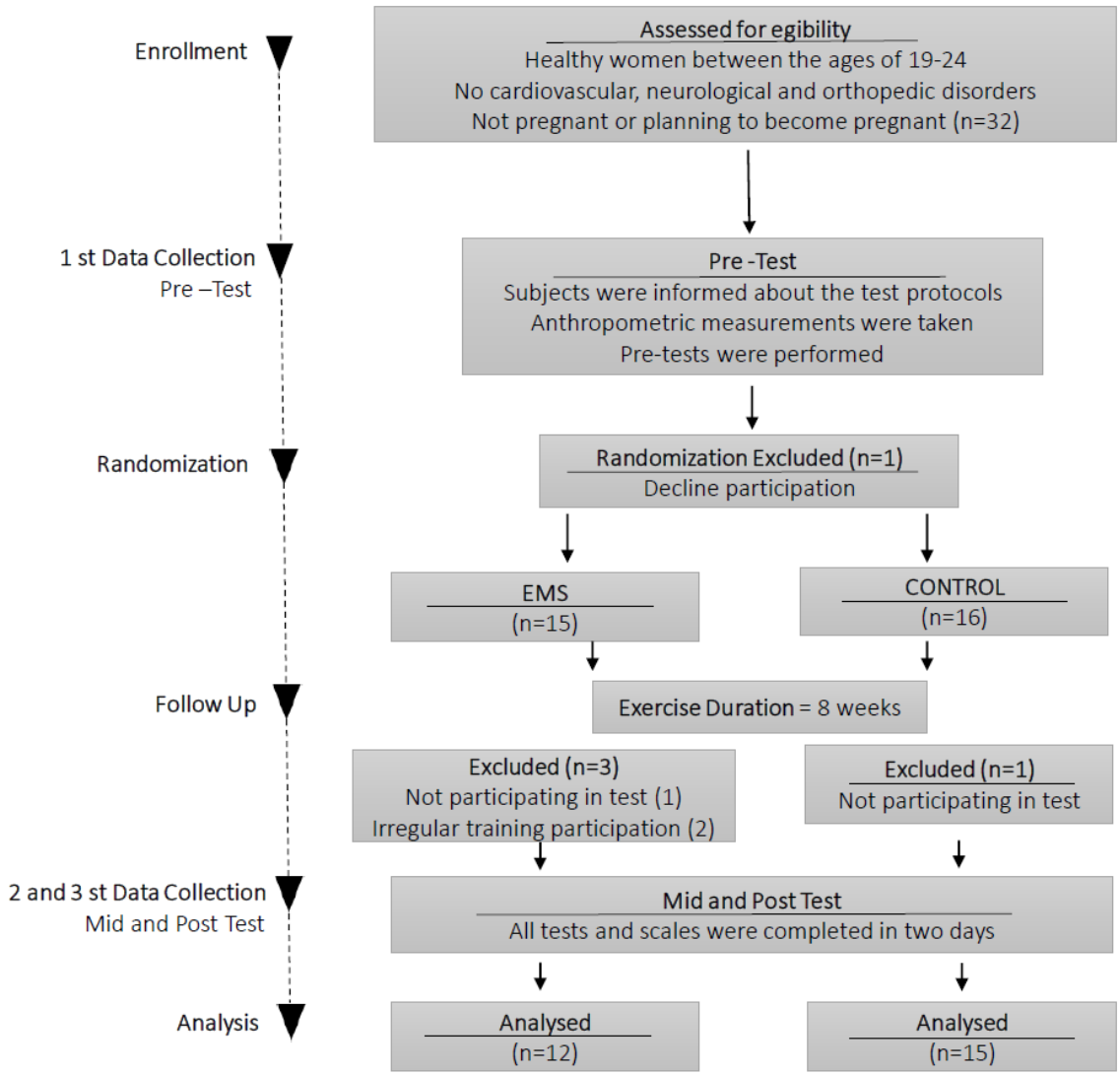

Figure 1. Flowchart

Study Design

This study was designed as a 2-arm parallel-group randomized controlled trial comparing

the effects of submaximal EMS exercises. The study was approved by the Ondokuz Mayıs University Clinical Research Ethics Committee (approval number: 021/482) and was conducted as per the ethical principles stated in the Declaration of Helsinki. The inclusion criteria of the participants were determined as being between the ages of 19-24, being female, and volunteering. Exclusion criteria were those who had cardiovascular, neurological, or orthopedic disorders, were pregnant or were planning to become pregnant. Subjects made a total of 10 visits, including the familiarization session for the study. During the first visit, participants were informed about test protocols. Anthropometric measurements were then taken and trial measurements were made. In the pre-, mid (week 4), and post (week 8) test periods, all participants performed 3 visits at 24-hour intervals for a total of 9 visits according to the test protocols they selected from the practice cards specified for each period, and mid and post-tests were arranged so that they did not coincide with training days. Practice cards were as follows: 1- modified push-up (MPU),Handgrip strength (HS), single hop for distance (SH), Biering Sorensen (Bie-sor), 2- Bent arm hanging (BAH), triple hop for distance (TH), crossover triple hop for distance (CH), v-sit flexor (V-sit) and 3- deep squat (DS), medial side triple hop for distance (MSTH), sit-up. After completion of the pre-tests, participants were randomized into one of two exercise groups using computer-validated software (www.random.org) and divided into EMS (n=15) and Control (CON) (n=16) groups. Participants who did not participate in regular exercises and tests in both groups were excluded from the study and the study was completed with 12 participants for the EMS group and 15 participants for the CON group. All measurements and exercises were done at the same time of the day (12:00-16:00). The participants performed warm-up exercises before the tests. Both groups were asked not to make any changes in their usual physical activity behavior. Also, all participants were instructed to maintain their normal dietary intake before and during the study. The endpoint of the study was determined as the participant withdrawing consent to participate in the study, the experts deciding that it was not appropriate for the participant to continue in the study, and non-compliance with the study protocol.

Electro Muscle Stimulation (EMS) Implementation: Participants were instructed that the clothing they would wear during training should be cotton and of a length that would cover their major muscle groups. Then, before the EMS vest was put on, water was sprayed on the main muscle groups where the apparatus that will transmit the current inside it corresponds. After the vest was put on, cable connections were made to the device.Participants were subjected to EMS currents in cardio mode (continuously alternating low-frequency currents

ranging from 1 to 1000 Hz) in a 9 s current/2 s rest pattern for 20 minutes. The muscles stimulated with EMS were: gluteus maximus, quadriceps and hamstrings of the lower extremity, biceps brachii, triceps brachii, pectoralis major and teres major of the upper extremity, and rectus abdominis and latissimus dorsi of the trunk. The content and scope of the exercise to be performed were designed as intermittent, low intensity/low intensity to affect the lower, upper, and core strengths.

Figure 2. EMS Device and Vest

Table 1: Exercise Protocol

Exercise	Rest
Rope skipping – 30 sec×2	10 sec
Overhead stand crunch – 30 sec×2	10 sec
Overhead side bends – 30 sec×2	10 sec
Squats 30 sec×2	10 sec
Sumo squats 30 sec×2	10 sec
Overhead lunge – 30 sec×2	10 sec
Side lunges - 30 sec×2	10 sec
Sit-up -30 sec×2	10 sec
Reverse shuttle -30 sec×2	10 sec
Single leg drop – 30 sec×2	10 sec
Flutter kicks – 30 sec×2	10 sec
V-sit – 30 sec×2	10 sec
Leg hold – 30 sec×2	10 sec
Reverse leg lift – 30 sec×2	10 sec
Heel touch – 30 sec×2	10 sec
Point single leg bridge drop – 20 sec×2	10 sec
Plank – 30 sn×2	10 sec

Procedures

Modified Push Up Test (MPU)

Participants were positioned face down on a mat with only their palms and toes touching the floor. Then, the participants were instructed to start by bending only their elbows and lowering and raising their bodies so that the chest did not touch the floor. The participant repeated as many movements as possible for 30 s and the movement was recorded in units (Chen et al., 2018).

Handgrip Strength Test (HS)

The measurements were made using a hand dynamometer that can measure force between 0-100 kilograms, and the dynamometer was adjusted according to the hand of the athlete to be measured before the measurement. The person to be measured was asked to squeeze with maximum force while standing, with arms hanging down so that the dynamometer did not touch the body. 3 measurements were made, with 1 minute of rest between measurements, and their averages were recorded (Melo et al., 2025).

Bent Arm Hanging Test (BAH)

This test was based on the measurement of the hanging time of the athletes with their arms in full flexion (elbow joint angle less than 75o). During the test, the athlete was verbally warned to remain in the position in question. The test was terminated when the participant's chin dropped below the bar level. The test result was recorded with a CASIO timer as the time the participant could hang under defined conditions (Clemons, 2014).

Single Leg Hop Tests (SLHT)

SLHTs were implemented on a single line by the parameters SH, TH, CH, and MSTH (Reid et al., 2007; Kivlan et al., 2013). For the line to be used in the test, a 0.3 m strip was determined as the starting point, and a 6 m long and 5 cm wide strip extending from the middle was placed vertically. Before starting the test, the test protocol was shown to the subjects verbally and practically. Each participant performed 1 trial forward from the baseline for each test and each limb. They then performed 3 trials for the actual test and the result was recorded in cm. A 30-second rest was given between trials. The best-recorded score was measured between the baseline and the subject's heel. No restrictions were made on arm swings. After the jump, care was taken to ensure that the subject was on the line in the limb that was tested in a controlled manner. The test was repeated if the subject lost balance landed on a limb different from the test limb, or made an additional jump after landing (Kehribar et al., 2022).

Deep Squat Test (DS)

In the deep squat test, individuals place their feet shoulder-width apart with their toes pointing straight ahead. On command, participants stand in the lowest squat position they can reach without lifting their heels off the floor. Although each individual has three attempts, if they complete the test on the first attempt, they do not need to repeat the test (Stanton et al., 2021).

V-Sit Flexor Test

For the V-sit flexor endurance test, testing the endurance of the flexor muscles began with the person being placed in a sitting position and leaning on a jig with the back at an angle of 55

degrees from the floor. Knees and hips were flexed 90 degrees, arms folded across the chest, and feet secured under the strap. To start, the jig was pulled back 10 cm (4 inches) and the person tried to hold it as long as possible without disturbing the posture of the body. Failure in the test was determined to occur when the subject's back was touched or when the subject was asked to stop (Chai et al., 2024).

Sit- Up Test

In the sit-up test, the participant lay on their back on a gymnastics mat and locked their hands behind their neck. The sole was fixed to the mat with the knees at a fixed angle (90°). An aid was used to stabilize the sole. The number of sit-ups the subject would perform for 30 seconds was recorded (Kukic et al.,2022).

Biering Sorensen Test (Bie-sor)

For the Biering-Sorensen-back extensor test, the upper body was extended over the end of a stretcher and then the pelvis, knees, and hips were fixed. The test began after the hands were fixed crosswise on the chest. Failure in the test occurred when the upper trunk broke its horizontal position when it failed to maintain its position after a verbal warning, and when the participant requested to stop (Nuzzo & Mayer, 2013).