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The effect of Weight-bearing Exercise for Better Balance (WEBB) by telerehabilitation on tibialis anterior and gastrocnemius muscles activation in obese men

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***Abstract*---**Weight-bearing Exercise for Better Balance (WEBB) is an exercise method to improve balance and leg muscle strength. It was previously shown that WEBB has a significant effect on balance and lower extremity muscle strength, however, there is no scientific

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evidence of the WEBB program's effect on muscle activation. This study examines the effect of the Weight-Bearing Exercise for Better Balance (WEBB) program by telerehabilitation on the activation of the Tibialis anterior (TA) and Gastrocnemius medialis (GM) muscles in obese men. To the best authors' knowledge, this research is the first study conducted to provide a WEBB program intervention by telerehabilitation. 10 healthy men with grade 2 obesity (BMI≥30 kg/cm2) participated in this study and received a telerehabilitation WEBB program intervention for 8 weeks. GM and TA muscle activation are assessed by looking at the amplitude value and amplitude normalization of the muscle Maximal Voluntary Isometric Contraction (%MVIC) when performing closed eyes One Leg Stance (OLS) test through recording with sEMG examination. This study found that there was a significant effect on the amplitude value of the right GM (p=0,040) and %MVIC of the left TA (p=0,037) muscles after 8 weeks WEBB program by telerehabilitation. In conclusion, telerehabilitation WEBB program can improve muscle activation in healthy men with obesity.

***Keywords*---**muscle activation, obesity, sEMG, telerehabilitation, Weight-bearing Exercise for Better Balance.

Introduction

People with obesity are at risk of impaired mobility, due to disturbances in maintaining balance. In the obese group, the higher risk of falling is associated with a decreased ability to maintain balance (Fjeldstad, Fjeldstad, Acree, Nickel, & Gardner, 2008). Balance is a basic element in carrying out activities of daily living. It is found that obese people have a 15-79% higher likelihood of injury-related falls requiring medical treatment than non-obese people and that injuries such as sprains, strains, and dislocations are associated with falls (Teasdale et al., 2013). In addition, in obese people, there is an accumulation of intermuscular adipose tissue (IMAT) which is correlated with a decrease in muscle performance (Akhmedov & Berdeaux, 2013). Decreased ability to generate the force on leg muscles has been generally accepted as a contributing factor to impaired balance and risk of falls (Abd El-Kader & Ashmawy, 2014). A person will initiate balance control to maintain a certain position and stimulate muscle activation and modulation of joint range of motion. When these internal and external forces act on the body all the time, the body's muscles must respond to these forces to maintain balance (del Porto, Pechak, Smith, & Reed-Jones, 2012). Muscle activation is the state of the muscle and is related to the magnitude of the force that a muscle actively produces relative to its maximum ability to produce force actively (Vigotsky, Halperin, Lehman, Trajano, & Vieira, 2018).

Based on previous studies, ankle joints and muscles such as the TA and GM play an important role as terminal structures in the limbs that contribute to balance. The GM muscle will be activated to maintain balance if there is a sway in the posterior direction of the body, while the TA muscle will be stimulated when there is sway on the anterior side of the body. To assess the characteristics of muscle activation, an sEMG examination can be used. This examination has been widely used in rehabilitation research to identify the physiological components of muscles (Rahman, Azaman, Mohd Latip, Mat Dzahir, & Balakrishnan, 2017). In a study conducted by Nagai et al, it was concluded that there was a decrease in coactivation of the anterior tibialis muscle after being given a balance exercise intervention twice a week for eight weeks compared to the control group (Nagai et al., 2012). On the other hand, the research conducted by Chimera et al gave an improvement in lower leg muscle activation after plyometric exercise for 6 weeks (Chimera, Swanik, Swanik, & Straub, 2004). There has been supported for the contribution of increased ankle muscle activation on postural sway variables during quiet stance (Warnica, Weaver, Prentice, & Laing, 2014).

Balance-based exercises are exercises that can be given to improve balance function. Weight-bearing Exercise for Better Balance (WEBB) is a balance-based exercise consisting of warm-up, coordination exercises, and a combination of coordination exercises with muscle strengthening (Abd El Mohsen, Abd El Ghaffar, Nassif, & Elhafez, 2016). Telerehabilitation is part of the remote health system and can be developed in the future (Zampolini et al., 2008). Telerehabilitation is a rehabilitation service provided through communication and information technology. Clinically the scope of telerehabilitation includes assessment, monitoring, prevention, intervention, supervision, education, consultation, and counselling (Brennan et al., 2010; Sarsak, 2020). There are currently no studies on the effect of WEBB on muscle activation in obese men. This study was conducted to determine the effectiveness of WEBB given by telerehabilitation on muscle activation in obese subjects. The indicator used is the activation of the GM and TA muscles through sEMG examination.

Method

This research received ethical approval from the Health Research Ethics Committee of the Regional General Hospital (RSUD) Dr. Soetomo, Indonesia. The research was carried out from August to December 2021. Before being given the exercise, the subjects were asked to come to the Medical Rehabilitation Clinic at Dr. Soetomo Hospital to be given a detailed explanation about the study, fill out informed consent, and collect data before training. After completing the exercise for 8 weeks, the subjects returned to the Medical Rehabilitation Clinic at Dr. Soetomo Hospital for post-exercise data collection. 10 healthy obese men participated in this study. The WEBB program is provided for 8 weeks with telerehabilitation. Muscle activation was assessed by sEMG examination, by looking at the amplitude and normalization of the amplitude of the Maximal Voluntary Isometric Contraction (MVIC) when the subject did the OLS test. All participants were male students of the Faculty of Medicine, Universitas Airlangga.

The inclusion criteria in this study were male students of the Faculty of Medicine, Universitas Airlangga with obesity grade 2 according to the BMI criteria of Asian people (BMI≥30 kg/cm^2), aged between 18-40 years. There were no participants with chronic diseases such as hypertension, Diabetes Mellitus (DM), history of heart disease, persistent asthma, Chronic Obstructive Pulmonary Disease (COPD), neuromusculoskeletal and vascular disorders in the lower limbs, and visual and hearing impairments that can interfere with the exercise process.

Outcome measures in this study were MVIC, amplitude, and amplitude normalization of MVIC (%MVIC) when performing the OLS test on the GM and TA bilaterally through recording with sEMG. Surface electromyography (sEMG), also known as kinesiological electromyography, is an electromyographic analysis that allows the recording of electrical signals from the muscles that move the body. This study is used to assess dynamic movements, but can also be used for static actions that require muscle activity to maintain a posture (Massó et al., 2010). Muscle activation was assessed by looking at the amplitude and %MVIC of each muscle during the OLS test, where recordings were taken at 6^{th} to 10^{th} seconds when the subject was performing OLS. Recording with sEMG Mespec 4000 System device.

Interventions

The WEBB program in the current study was performed three times per week for eight weeks with telerehabilitation via video and zoom meetings. Repetitions of each exercise of the WEBB program were increased gradually (Sherrington, Canning, Dean, Allen, & Blackman, 2008). The WEBB program consists of a warm-up, coordination exercises, and combines strength and coordination exercises. Warm-up exercise with high stepping on the spot for one minute. The exercise was continued with coordination exercises consisting of 1) standing with decreased base (feet together) for one minute; 2) standing with decreased base (tandem stance) for one minute; 3) standing with decreased base (standing on one leg) one minute for each leg; 4) stepping in different direction (long step with narrow based of support) one minute for each leg; 5) stepping in different direction (stepping forward over an object) one minute for each leg; 6) stepping in a different direction (stepping sideways over an object) for two minutes. The height of the object in this exercise is 15 cm in the first four weeks and increased to 20 cm in the second four weeks. Combination of coordination and strength training consists of 1) sit to stand (squatting with the help of hands); 2) sit to stand (squatting without the help of hands) two sets, ten repetitions for each set; 3) sit to stand (squatting with support on one leg) two sets, ten repetitions for each set, for each leg; 4) tiptoe with both feet three sets, ten repetitions for each set; 5) tiptoe on one leg two sets, ten repetitions for each set, for each leg; 6) lateral step up exercise; 7) forward step up exercise two sets, ten repetitions for each set, for each leg. The intensity of exercise is increased every two weeks according to the established protocol.

The exercise intervention was given every Tuesday, Thursday, and Sunday, where the first two days the subjects did independent exercises following the exercise videos that had been given, while still reporting the condition of the subject's pre and post-exercise. Subjects were also asked to send photos of exercise diaries, photos and videos of subjects during exercise to researchers via the WhatsApp application. On Sundays, all subjects and researchers conducted join exercises through a zoom meeting. All subjects managed to complete the exercise for up to 8 weeks without significant problems, some subjects complained of post-exercise muscle pain which was reduced by the management of muscle pain. After the end of the exercise intervention in the eighth week, the subject was asked to come back to the Medical Rehabilitation Clinic at Dr. Soetomo Hospital for post-exercise data collection.

Statistical analysis

Prior to statistical tests, a normality test was performed for all variables recorded during the sEMG examination. These variables include MVIC from the TA and GM muscles for both the right and left limbs, the amplitude and %MVIC of the TA and GM muscles bilaterally when performing closed eyes OLS before and after the intervention. Variables with data that were normally distributed were then tested statistically with a parametric paired sample T-test, while for variables with data that were not normally distributed, a statistical test was performed using a non-parametric test, namely the Wilcoxon signed-rank test.

Results

Tabel 1
Characteristics and homogeneity of subjects

Variable	Mean±SD	P Value
Age (Years)	20,7±2,11	0,011
Body weight (kg)	98,3±13,6	0,126
Body height (cm)	167,3±5,89	0,734
Body Mass Index (kg/m²)	35,1±4,37	0,134
Waist-Hip Ratio	0,93±0,065	0,098
Daily Food Intake (kcal)	6,92±2,51	0,677

*The Saphiro Wilk test is normally distributed if the p value>0.05

The subjects analyzed in this study were 10 male university students with grade 2 obesity based on BMI criteria in Asian adult males. The average age of the subjects was 20.7 ± 2.11 with a mean weight of 98.3 ± 13.6 and a body height of 167.3 ± 5.89. The average BMI of the subjects was 35.1±4.37 with a WHR of 0.93±0.065. The subjects' average daily food intake was 6.92±2.51. The normality test of the research subject characteristics data was carried out using the Shapiro-Wilk. Table 1 shows the distribution of data that is normally distributed (p>0.05) on the variables of weight, height, BMI, Waist-Hip Ratio (WHR), and daily food intake. Variables of age was not normally distributed (p>0.05).

Tabel 2
Variable normality test

Variable	P value
MVIC Right GM Pre	0.126*
MVIC Right GM Post	0.531*
Amplitude Right GM Pre	0.350*
Amplitude Right GM Post	0.451*
%MVIC Right GM Pre	0.022
%MVIC Right GM Post	0.709*
MVIC Right TA Pre	0.428*
MVIC Right TA Post	0.966*
Amplitude Right TA Pre	0.058
Amplitude Right TA Post	0.007

%MVIC Right TA Pre	0.114*
%MVIC Right TA Post	0.050
MVIC Left GM Pre	0.836*
MVIC Left GM Post	0.550*
Amplitude Left GM Pre	0.554*
Amplitude Left GM Post	0.559*
%MVIC Left GM Pre	0.000
%MVIC Left GM Post	0.014
MVIC Left TA Pre	0.795*
MVIC Left TA Post	0.928*
Amplitude Left TA Pre	0.519*
Amplitude Left TA Post	0.152*
%MVIC Left TA Pre	0.000
%MVIC Left TA Post	0.001

*The Saphiro Wilk test is meaningful when the p-value p>0.05

Table 2 shows the results of the normality test using the Shapiro-Wilk test on the variables, the data obtained were normally distributed (p>0.05) on the right and left GM muscle MVIC variables and right and left TA, right and left GM muscle amplitude variables and the left TA muscle. Variables that were not normally distributed (p<0.05) included the amplitude of the right TA muscle, %MVIC of the right and left GM muscles, and the right and left TA muscles.

Tabel 3
Right GM Muscle Activation

Variables	Mean ± SD		P Value
	Pre Intervention	Post Intervention	
MVIC Right GM	0.09030± 0.583	0.11150± 0.034	0.258
Amplitude Right GM	0.07110±0.042	0.09670±0.0355	0.040*
%MVIC Right GM	108.48070±100.816	97.27450±50.102	0.959

*Paired T-test and Wilcoxon signed-rank test were meaningful when the p-value <0.05

Tabel 4
Right TA Muscle Activation

Variables	Mean ± SD		P Value
	Pre Intervention	Post Intervention	
MVIC Right TA	0.17210±0.077	0.22640±0.098	0.125
Amplitude Right TA	0.07350±0.518	0.08600±0.068	0.646
%MVIC Right TA	41.43740±19.81	44.96910±33.25	0.878

*Paired T-test and Wilcoxon signed-rank test were meaningful when the p-value <0.05

Tabel 5
Left GM Muscle Activation

Variables	Mean ± SD		P Value
	Pre Intervention	Post Intervention	
MVIC Left GM	0.08130±0.051	0.09870±0.038	0.280
Amplitude Left GM	0.07850±0.0201	0.07200±0.024	0.534
%MVIC Left GM	200.43320±274.87	86.59400±52.194	0.386

*Paired T-test and Wilcoxon signed-rank test were meaningful when the p-value <0.05

Tabel 6
Left TA Muscle Activation

Variables	Mean ± SD		P Value
	Pre Intervention	Post Intervention	
MVIC Left TA	0.16120±0.075	0.18550±0.0755	0.310
Amplitude Left TA	0.09980±0.0368	0.08410±0.029	0.250
%MVIC Left TA	91.00490±93.309	58.58230±50.165	0.037*

*Paired T-test and Wilcoxon signed-rank test were meaningful when the p-value <0.05

The results showed an increase in the MVIC variable of bilateral GM and TA muscles. In the amplitude variable, there was an increase in the right GM and right TA muscles, while the left GM and left TA decreased. The %MVIC variable showed an increase only in the right TA, while the left TA and bilateral GM showed a decrease. Of all the muscles, the statistically significant difference was an increase in the right GM amplitude (Table 3) and a decrease in the %MVIC of the left TA (Table 6). To assess the large difference between groups, the mean effect size was calculated with effect size values of 0.2-0.49 being considered small, 0.5-0.79 is considered medium, and >0.8 being considered large. The results of the calculation of the mean effect size showed medium results for the right GM muscle amplitude variable (Cohen's D = 0.76), while for the %MVIC variable the left TA muscle showed small results (Cohen's D = 0.46).

Discussion

Oliveira & Goncalves concluded that specific exercises show different responses to isometric and dynamic contractions (Oliveira & Gonçalves, 2009). In current studies, it was found that the MVIC value in the GM and TA bilateral muscles increased when compared between before and after exercise, but did not differ statistically significantly. In the amplitude variable, there was an increase in the right GM and TA muscles, but only significantly different in the right GM muscle. On the left side, there was a decrease in amplitude but not significantly different in the two muscles. In the %MVIC variable, there was a decrease in the right and left GM muscles, and left TA, while the right TA increased not significantly. A significant decrease in %MVIC was only found in the left TA muscle. The muscles in the ankle joint play a dominant role in controlling posture when standing. Success in maintaining balance depends on how the body maintains the Center

Of Gravity (COG) is in Base Of Support (BOS). Normally a healthy adult activates the calf muscles more dominantly to maintain this balance. In a study conducted by Muehlbauer et al showed that when the subject performed the OLS test with his eyes open and on a solid surface, the leg muscle activation was significantly lower than if the conditions were more difficult, for example doing OLS with his eyes closed and on a less surface. congested. This shows that muscle activation will increase in an effort to improve balance. The muscles assessed in this study included the Tibialis anterior, Gastrocnemius medialis, Soleus, and Peroneus longus (Muehlbauer, Mettler, Roth, & Granacher, 2014).

This study showed a significant difference in the amplitude of the right GM muscle (p=0.040) and the %MVIC of the left TA muscle (p=0.037) after the WEBB program was administered 3 times a week for 8 weeks in adult male subjects with grade 2 obesity. In this study, subjects were given training with the WEBB program for 8 weeks. The WEBB program consists of coordination exercises and a combination of coordination and muscle strengthening. The results of this study are in line with research conducted by Gray et al which showed an improvement in the activation of the anterior tibialis muscle after the administration of functional exercises consisting of squats and steps with a predetermined protocol (Gray, Ivanova, & Garland, 2012). Research conducted by Chimera et al also gave an improvement in lower leg muscle activation after plyometric exercise for 6 weeks. They concluded that improvements in the coactivation of the abductor and adductor hip muscles would simultaneously position the knee joint into a more biomechanically neutral position. It has also been shown that exercise can modify motor control strategies and increase joint movement stability. Another study concluded that proprioception exercises can improve balance and activation of the lower leg muscles, namely the lateral and medial gastrocnemius, and the tibialis anterior in healthy subjects (Jang & Lee, 2017).

In the current study, there was an increase in the activation of the right GM and TA muscles after the administration of the WEBB program which authors believe can improve the position of the ankle joint to become more stable when performing the OLS test. Coactivation of agonist and antagonist muscles is also important in the balance of forces acting on joints and increases joint and muscle stiffness during activities (Chimera et al., 2004). Del Balso & Cafarelli found that after a span of 4 weeks there was an increase in activation and MVIC in the Soleus muscle after giving isometric strengthening exercises. This is due to the activation of fast-twitch fibers, changes in the recruitment pattern of the motor unit and the coding speed of the motor unit. An increase in the sEMG parameter indicates that post-strengthening neural adaptation has worked (del Balso & Cafarelli, 2007). After giving balance training, there was an increase in lower leg muscle activation. Harput et al proved that the activation of the GM muscle is more active during single-leg stance exercises compared to other exercise movements. This increased recruitment of the GM muscle during single leg stance is consistent with the strategy to maintain the Center of Gravity (CoG) in the sagittal plane slightly anterior to the ankle rotation axis to maintain balance in the tread (Harput, Soylu, Ertan, & Ergun, 2013).

The TA muscle was found to be more active when performing single-leg squats compared to single-leg stances. This implies that the more posterior the CoG is during exercise, the greater the need for hip and knee joint flexion. In addition, the activation of the TA muscle will increase to maintain a dorsiflexed position at the ankle (Harput et al., 2013). In contrast to previous studies, Nagai et al's study actually got the results of improving postural control after giving balance exercises to elderly subjects, without an increase in muscle coactivation. This study concluded that after the administration of balance training, subjects could maintain postural stability without increasing muscle coactivation associated with compensatory mechanisms in the ankle joint. Balance training has the potential to increase the efficiency of postural control strategies without increasing muscle coactivation (Nagai et al., 2012).

The same thing happened in this study, where there was a decrease in activation of the left TA and GM muscles after the WEBB program was given for 8 weeks. Authors believe that in the left leg there is a better improvement in postural control strategies after exercise, without an increase in muscle activation. This decrease in muscle activation is associated with an increase in motor unit synchronization as a consequence of post-exercise motor learning. On the other hand, there is greater neural activation associated with hypertrophic adaptation which causes increased activation at maximal contraction (Oliveira & Gonçalves, 2009). This may be related to neural adaptations that occur after the WEBB program, which consists of coordination exercises and muscle strengthening exercises (Taube, Gruber, & Gollhofer, 2008). Similar results were obtained in a study conducted by Mangine et al (2015). This study showed an increase in muscle strength and size after 12 weeks of strengthening exercise. On the other hand, there was a decrease in muscle activation as assessed by sEMG. This explains that after the exercise there is an increase in the efficiency of muscle activation which is characterized by a decrease in its activation (Mangine et al., 2015). This difference in muscle activation in the right and left limbs could occur due to the difference in the distribution of body weight between the two legs when the subject was exercising with the WEBB program for 8 weeks. This difference in body load distribution can be influenced by the dominant limb, total body weight, and natural posture of the research subjects (Hashim, Ahmad, Hanif, Sarmad, & Sharif, 2020).

Conclusion

In conclusion, our study shows that the WEBB program with telerehabilitation for 8 weeks affects the activation of TA and GM muscles. The limitations of this study include that the study was only conducted in one group, without any comparison with the control group or groups with different interventions. This study also only assessed the parameters before and immediately after exercise, so the long-term effects of this exercise program are unknown. Recommendations for further research include the need to conduct research on more varied subjects so that the results can be generalized, it is necessary to make comparisons with the control group or groups with different interventions, and it is necessary to conduct research to assess the long-term effects of the WEBB program.

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Conflicts of interest

The authors declare no conflict of interest.

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