ANALYSIS OF ECCENTRIC PLANTAR FLEXORS STRENGTHENING EXERCISE ON GAIT SPEED IN THE ELDERLY

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ABSTRACT

Objective: To investigate the effect of eccentric plantar flexors strengthening exercise on gait speed among the elderly.

Design: quantitative research approach – Quasi-Experimental design

Participants: Based on the Convenience sampling, participants who fulfilled the inclusion & exclusion criteria were recruited for the study. For the Eligible participants, the procedure and purpose of the study were explained along with written consent taken beforehand. The sample recruitment was restricted to the Puchong area as a movement control order has been enforced due to the Coronavirus pandemic.

Main Outcome Measures: Gait speed is quantified by 10MWT.

Results: The result showed gait speed and had statistical significance when the participants were at a comfortable speed.

Conclusions: After four weeks of eccentric plantar flexors strengthening in a sitting position, self-selected gait speed has shown significant improvement in all eighteen participants. From the finding of this study, physiotherapists in the future can very well use this type of exercise, with proper intensity and frequency, which are suitable to prescribe for the elderly population as prevention for functional decline. In addition to that, these exercises only use half of the body weight, it will not cause further damage to the elderly who are more fragile.

***Keywords:** Eccentric; Elderly; Physiotherapy; Strengthening Exercise*

INTRODUCTION

Aging is a natural continuous process, specifically experienced by the elderly (Besdine, 2019) The elderly are categorized as people who aged more than 60 years old globally. (World Health Organization in South- East Asia, 2019) Undesired and uncomfortable changes such

as functional decline and physical changes would happen throughout the aging process, leading to an increased risk of health problems and mortality. (Zamboni, 2007) With regards to functional decline, it is said that the relationship between the reduction in the development of strength and muscle mass loss are closely linked together (Keller and Engelhardt, 2013). This may be a possible reason that those who are categorically classified as elderly have a decrease in activity participation. To emphasize the long-term effects on physical function, with particular respect to balance and gait speed, these changes and the continuous progression of the effects of aging will then lead to a decline in their mood and cognition.

The elderly population is estimated to grow continuously to 1.5 billion by the year 2050 worldwide. (World Health Organization, 2011) A similar phenomenon is occurring in Malaysia where the elderly Malaysian population is expected to increase until 15% of the total Malaysian population comprises people above 60 years old. Tan Sri Lee Lam Thye has acknowledged the rising elderly population would have implications in healthcare and financial areas. (Yusof, 2019) This was supported by Ferrucci et al (2008) who pointed out that this transition would lead to an increase in medical care and social demands since elderly populations are much more likely to suffer from multiple chronic conditions. In addition, Malaysia's current medical system mainly focuses on hospitalization and short-term care whereas long-term rehabilitation and elderly care are still lacking. (Mafauzy, 2000) The optimal goal of healthy aging is hard to fulfill with this issue going on. For that reason, it is necessary to develop specific interventions that will serve as prevention and restoration methods.

Locomotion is an important and inherent part of daily life enabling a person to move from one place to another; additionally, walking is the primary form of locomotion that humans use to perform activities of daily living in order to maintain independence and quality of life. Walking velocity is particularly interesting as it is indicative of overall health status (Studenski et al 2011). Physiological changes with aging, including loss of muscle mass, strength and power are manifested in walking, notably at the ankle joint. Old adults exhibit decreased power of the plantarflexors and increased power of the hip extensors. This distal to proximal shift in function could be due to plantarflexor weakness, so strengthening the plantarflexors may help reverse the negative physiological effects of aging and help preserve functional capacity in old adults. the elderly population will have a decline in functional activities and this will, unfortunately, include an issue in walking, or gait. In terms of gait and how to plan

a successful pre-emptive plan for the elderly, a focus on the plantarflexors, which consists of the soleus and gastrocnemius, will be the target muscles as it is the main contributors to gait. (Neptune et al, 2001) Considering the modified position used in this study, the soleus muscle will be more focused than the gastrocnemius as the exercise involves only a single joint movement although both muscles will be activated at the same time. This is due to their similar activation profile and distal insertion. If the walking cycle is described by phase, plantarflexors contribute the most in "toe-off" during the stance phase to propel the whole body and shift the center of mass anteriorly for the preparation of the next step. Plantarflexors work eccentrically to control the dorsiflexion of the tibia and fibula especially the soleus which works to induce plantarflexion and knee extension during mid stance. (Lenhart et al, 2014; Magee, 2002, p. 865) Ankle muscles produce a greater explosive force for the toe-off movement which contributes to the gait momentum, thereby reducing the overall workload. Without the work of ankle muscles, especially the soleus which plays a more important functional role in walking due to its consistent contractile behavior, walking speed is hard to maintain. (Huang et al, 2015; Cronin et al, 2013) The importance of gait speed on the good quality of gait has been emphasized. (Fukuchi, Fukuchi and Duarte, 2019; Huijben et al, 2018).

Recent studies have focused on developing exercise interventions for the elderly, especially for those who developed age-specific muscle weakness with the aim to enhance physical performance. To decide the suitable exercise for the elderly in order to improve their gait speed, several considerations need to be taken including the type of strengthening method. In general, there are three types of muscle contraction: concentric, eccentric and isometric which present with muscle lengthening or shortening under different conditions. Among them, concentric and/or eccentric were the common types of strengthening exercises being applied in published programs (Kinsella et al., 2017) However, there is an ongoing disagreement between the application of concentric and eccentric with regards to their benefits. The increase in strength after eccentric training was more specific in terms of speed and contraction method when compared with concentric training, which resembles the gait speed that will be used as one of the outcome measures in my study. (Roig et al, 2008) We can conclude that eccentric training is better when compared to concentric training with regard to muscle strength from the systemic review. In addition, eccentric exercise has been shown to bring several advantages to the elderly population. It only requires minimal cardiorespiratory burden and appears to be less delayed onset of muscle soreness as it uses only minimal energy consumption when compared to concentric training. (Lim, 2016) Eccentric exercises also can

promote muscle repair and improve maximal strength in key functional muscles. (Gault et al, 2013) Apparently, an eccentric mode of strengthening is preferable for the elderly but the limitation does not clarify which type of eccentric exercise is beneficial for the improvement of gait speed in a practical situation. self-selected walking speed to young adults, but when asked to walk faster (increasing the demand relative to the capacity), the age-related difference in walking speed becomes apparent with the old adults walking slower than young (Zijlstra, 2004).

In a nutshell, the aim of this study was to explore the effects of eccentric strengthening of plantarflexors on gait speed among the elderly. It is hypothesized that eccentric plantarflexors strengthening in a sitting position has a significant effect on the dependent variables. Gait speed has been recommended as a potentially useful clinical indicator of well-being among older adults.

METHODOLOGY

A quasi-experimental design was implemented in the study. The convenience sampling method was applied in my study. The sample recruitment was restricted to the Puchong area as a movement control order has been enforced due to the Coronavirus pandemic. (The Star Online, 2020) Hackshaw (2008) has mentioned that small sample size studies need to be interpreted carefully as they may produce the false-positive result. Thus, the anticipated sample size for this study was 20 participants. Unfortunately, two participants were dropped out from the study on the second week of intervention due to personal issues. At last, a total of eighteen participants (mean age of 71.7±7.5 years; weight 57.5±8.3 kg; height 161.5±2.8 cm; 61.1% females and 38.9% males) who have met both inclusion and exclusion criteria were chosen.

The inclusion criteria were: being 60 to 90 years of age; no vision, hearing, vestibular and proprioception impairment as they will affect balance ability (Hansson, Beckman, and håkansson, 2010; Kanegaonkar, Amin and Clarke, 2012); able to comprehend and follow simple instructions (Vafaeenasab et al, 2019) and able to walk independently. (Lee et al, 2017) The exclusion criteria were: having an inflammation of the musculoskeletal system or experiencing fever; fractures of lower limbs in the past twelve months (Horstmann et al, 2013); severe cardiac disease; peripheral vascular disease; lower limb joints instability; diagnosed osteoporosis; diabetes that will cause lower body neuropathy and diagnosed

vestibular disorders (Amirzadeh et al, 2018). After participants were eligible for the study, the procedure and purpose of the study were explained along with a written consent form given to be signed by each of them. A written consent form was signed by the participants. Ethical approval was obtained from the Faculty of Health Sciences Research Review Committee, MAHSA University (FRRC) to ensure that my study does not cause harm.

Outcome measures: A10 Meter Walk Test (10MWT) can be used to evaluate gait speed in meters per second over a short distance. (Physiopedia contributors, 2018). Every participant was fully informed beforehand about the procedure. To start with, a 10 meters straight walk passage is measured. Additional marks between two meters and eight meters from the starting point are marked by using masking tape. Eventually, the middle six meters is the true area to measure walking while the remaining is the area that allows acceleration and deceleration phase to reduce variability and increase consistency. (Middleton et al, 2015) The weight would be placed on the thigh in a sitting position while the movement to be performed is to raise the heels and lower them in a controlled manner on a small step to produce an eccentric contraction. The exercise was executed with exclusivity or emphasis on eccentric action by manual support from the researcher during the concentric phase and only concentrated on the eccentric movement of the muscle. (Reeves et al, 2009; Valour, Rouji and Pousson, 2004).

IBM SPSS Statistic 26.0 was used to analyse the mean of a single group at two different points of time by using paired t-test or sometimes called a dependant t-test (Ross and Willson, 2017).

RESULTS

Throughout the four weeks of intervention, two participants dropped out of the study. Therefore, statistical analysis was performed on eighteen participants. Their demographic data were summarized in Table 1.0 and the descriptive analysis of their demographic data was shown in Table 1.0 (mean age of 71.7±7.5 years; weight 57.5±8.3 kg; height 161.5±2.8 cm; 61.1% females and 38.9% males). Results in Table 2.0 showed in the form of mean± standard deviation, 10MWT: 10-meter walk test, mean differences indicate significant differences between pre and post-test.

Table 1.0: Descriptive Analysis of Participants

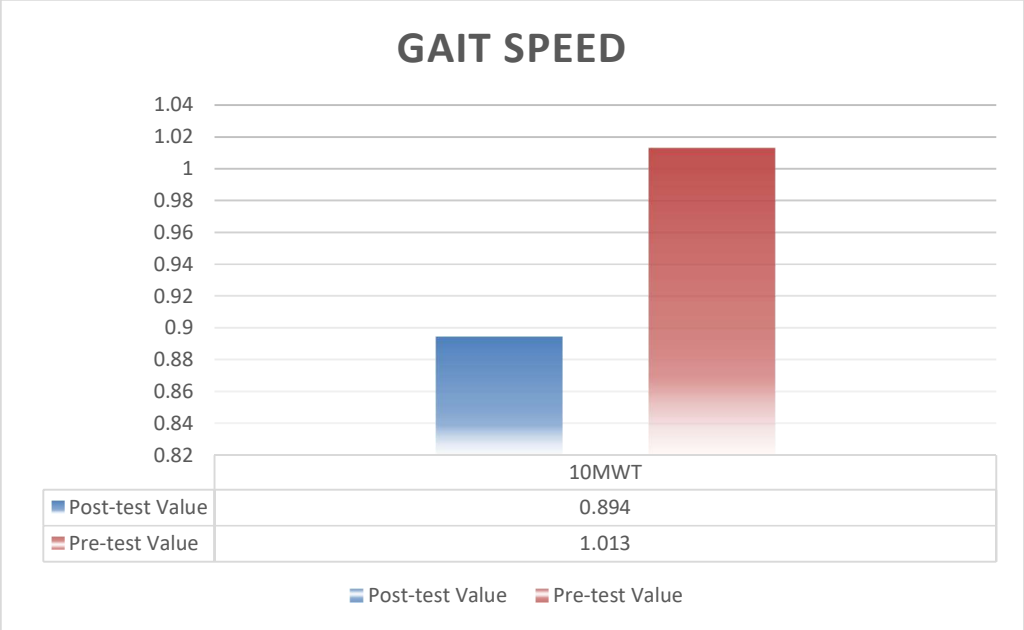
VARIABLE (N=18)	Mean	SD
Age (years)	71.7	7.5
Weight (kg)	57.5	8.3
Height (cm)	161.5	2.8

cm: centimeters, kg: kilograms, SD: standard deviation

Table 2.0: Results of Paired t-test for the 10 MWT

Variables	10MWT(m/s)
Pre Test	0.894±0.248
Post Test	1.013±0.331
Mean Differences	-0.118±0.163
t- value	-3.075
p- value	0.007

Figure 1.0: Figure Analysis of Pre and Post Test of Gait Speed



The result of all outcome measures including 10MWT in comfortable speed pre and post-intervention were listed separately in Table 3.1.2. For 10MWT in comfortable speed, there was a difference in mean for pre and post-intervention with the number of 0.118 m/s. Since

the p-value for this outcome measure was less than 0.05, (p=0.007) null hypothesis was rejected. In other words, there was a significant difference before and after interventions in the same group of participants. From the result, although it was statistically significant in comfortable speed, it was still considered small in changes.

DISCUSSION

In this study, the effect of eccentric plantarflexors strengthening in a sitting position was investigated among the elderly in terms of balance and gait speed. The comparison between pre and post-four weeks of intervention was done in the same group of participants and the results revealed that improvement was seen in every outcome measure. Throughout the intervention period, participants claimed to have experienced improvement in strength, especially during walking and climbing stairs. Some participants even mentioned having the feeling of calf tightness being relieved, making it easier to move their ankles. They have shown good compliance to the exercise given.

The mechanism behind the force production during eccentric contractions is now only slowly being discovered. Extra force is generated during the stretch and remained as residual force stored inside muscle fibers after the muscles back to their initial length or are deactivated. Their unique adaptations make them well suited for elderly rehabilitation who has reduced physical tolerance and bring beneficial effects in the production of higher force with less metabolic and cardiorespiratory cost. Despite the positive sides of eccentric contraction, the stretching effect might cause exercise-induced muscle damage and delayed pain. (Hessel, Lindstedt and Nishikawa, 2017; Hody et al, 2019) Roig et al (2010) proposed an idea for the preservation of eccentric strength in older adults. They suggested several potential ideas in the aspects of cellular and mechanical that accumulation of non-contractile material during aging increases passive stiffness and offers advantages in eccentric contraction. This idea could have implications for the prescription of exercise among the elderly. It is preferable to start with eccentric exercise for the initiation of resistance training since eccentric strength is reserved in their muscle fibers. Considering the negative sides of this contraction, a careful and safe exercise regimen including progression is advised. Yet, there is a lack of studies searching for suitable exercise protocols focusing on eccentric contraction with proper intensity and frequency. The exercise proposed in my study, which showed improvement in gait speed and balance, might give a clue to prescribing exercise to the elderly.

The possible reason behind the results of this study showing eccentric exercises does improve gait speed could be explained by the positive relationship between gait speed and muscular strength. (Garcia- Flores et al, 2015) As mentioned earlier in the introduction, plantarflexors play an important role in the good quality of gait. It contributes over 70% of total support power during the stance phase of gait and becomes the strong predictor for both self-selected gait speeds (Uematsu et al, 2014). Santos et al (2016) supported the increase in gait speed is related to lower limb muscular strength. Once plantarflexors strength has improved by eccentric training, eventually, balance and gait speed would be improved. However, Muehlbauer et al (2018) opposed the idea by stating gait speed did not correlate with muscle strength. Unfortunately, these studies have low validity to generalise the findings towards the elderly population as they included a small sample size. The interpretation of results from a systemic review and meta-analysis is somewhat in line with the prediction of the hypothesis in my study. The interesting part was that it also included a comparison between preferred and fast gait speeds. This topic still remains unclear and unexplored in the existing literature to summarize and compare the differential effects tested on two different kinds of gait speed, especially in their study, it was suggested that the self-selected gait speed was associated with fast gait speed. Therefore, assessment of gait speed by only self-selected speed was sufficient since they were correlated. It concluded that the effect of resistance exercises has improved more than coordination and multimodal training in gait speed (Hortobágyi et al, 2015) Although there are some hypotheses mentioned above, the true reason for how eccentric works and whether it really helps to improve balance and gait speed is still unclear.

Clark and Patten (2013) reported the effect of eccentric exercise is superior to concentric in enhancing neuromuscular activation and gait speed. Even though the samples included are adults who have experienced a stroke, it showed similar positive findings after eight weeks of intervention including gait training. Kim et al (2019) demonstrated that eccentric exercises had a significant improvement in gait speed among healthy elderly. Additionally, researchers have found eccentric exercises might be more beneficial when compared to conventional resistance training. Dias et al (2015) also supported the effect of eccentric training on strength and functional capacity including gait speed. They have used similar methods that I have utilized in my study by giving a time cue to perform the eccentric movement. All of the studies have used the same outcome measures as my study, including 10MWT when assessing gait speed. They gave a prediction that similar outcomes would be obtained when performing the eccentric exercise. Additionally, the result might get interfered with by the intervention period

since my study only implemented four weeks of exercise rather than six weeks or more which was commonly seen in other studies.

The position utilized in my study to perform eccentric plantarflexors was the sitting position with knee flexed, different from the commonly practiced standing or sitting position with the knee extended. Despite the promising clinical outcome of heel drop eccentric exercise, there is a lack of evidence describing the biomechanics alteration between knee flexed and knee extended. Weinert-Aplin, Bull, and McGregor (2015) have concluded there was no difference in peak tendon force but knee flexed position has shown shorter muscle length change. This might affect the efficacy of rehabilitation in Achilles tendinopathies patients. Indeed, there would be doubt on whether physiological responses would happen in the studied population who are the healthy elderly population without experiences of these disorders. In addition, the performance of heel drop on a block or step has been shown to enhance gastrocnemius thickness and tendon mechanical properties especially if the ankle is dorsiflexed to 10° of angle (Jeong et al, 2014; Gal and Lee, 2016). Under those circumstances, the data suggested plantarflexors strength would be improved in the sitting position with knee flexed and performed heel drop movement on a block to allow some degree of dorsiflexion.

A very similar study was conducted by Lee et al (2017) with 20 samples separated into two groups to compare the effect of heel- raise- lower exercise on a block and on a floor level with strength, balance and gait parameters as the outcome measures. It proposed that standing on the block has a greater improvement after six weeks of intensive exercise. The prediction of the result was based on neurological responses as the samples included were stroke survivors. Hence, it may differ from our hypothesis and the mechanism behind the positive outcome in my study. Even though different targeted populations and intervention protocols could not indicate the relationship between eccentric plantarflexors strengthening in sitting and outcome measures including gait speed and balance, it gave a hint to developing a similar intervention to improve balance and gait speed.

CONCLUSION

After four weeks of eccentric plantarflexors strengthening in a sitting position, self-selected gait speed has shown significant improvement in all eighteen participants. The use of 20% of the total body weight as the resistance given to participants instead of the

whole body weight aimed to improve plantarflexors strength. Incorporated with timing cues and manual support by the researcher to perform eccentric action in plantarflexors, the time used after the intervention had reduced by 10MWT as compared to before the intervention. Paired t-test was conducted as a statistical method to determine the differences between the same participants' pre and post-intervention. The null hypothesis was rejected indicating there was a significant effect of eccentric plantarflexors strengthening in sitting position on gait speed and balance among the elderly. On the basis of this study result, it gives an idea to physiotherapists in the future on the type of exercise, with proper intensity and frequency, which are suitable to prescribe for the elderly population as prevention for functional decline. Rather than doing exercises standing which may increase fall risk to the elderly and put an extra burden on those who are having sedentary lifestyles and experience cardiorespiratory problems, they can perform eccentric exercises which require low cardiorespiratory and metabolic costs in a sitting position. This type of exercise can be performed easily by the elderly at home since there is a trend away from passive to active treatment and actively brings more benefits to the elderly especially. (Cosio et al, 2018) Since the exercise only uses half of the body weight, it will not cause further damage to the elderly who are more fragile. (Siriwardhana et al, 2018)

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