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A COMPARATIVE ANALYSIS OF ISOLATED ECCENTRIC TRAINING VS TRADITIONAL STRENGTHENING EXERCISE FOR CALF MUSCLES ON FUNCTIONAL REACH AND SIT TO STAND AMONG ELDERLY POPULATION

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ABSTRACT

INTRODUCTION: Aging is characterized by a gradual decline in muscle strength, balance, and functional mobility, resulting in dependency in activities of daily living and a high risk of falls in elderly individuals. Calf muscles are essential for balance, forward propulsion, and postural stability in functional activities such as “sit to stand” and “reaching”. Although traditional strengthening exercise are commonly prescribed, the specific effect of isolated eccentric calf muscle training remains insufficiently explored

AIM: To compare and analyse the effectiveness of isolated eccentric calf muscle training and traditional strengthening exercises on functional reach and sit-to-stand ability in elderly populations.

MATERIALS AND METHODS: The experimental study was conducted at the Outpatient Department in Chennai. A total of 52 elderly subjects above 60 years of age were selected and they were split into two groups,each group with 26 participants. One group was subjected to isolated eccentric calf muscle training, and another group was subjected to traditional strengthening exercises. Both interventions were carried out for a period of four weeks. The 30-Second Chair Stand Test (30-sec CST) and the Functional Reach Test (FRT) were used both before and after the therapies to evaluate the functional performance of the older subjects. Mann-Whitney and the Wilcoxon signed-rank test were used to analyse the data.

RESULTS: Improvement was observed in both groups after the intervention. Significant improvements were observed in the experimental group in terms of 30-sec CST ($Z = -4.685$, $p < 0.001$) and FRT ($Z = -4.542$, $p < 0.001$). Similarly, in the control group, a significant improvement was observed in terms of 30-sec CST ($Z = -2.646$, $p = 0.008$), whereas no significant improvement was observed in FRT ($p = 1.000$). Between-group analysis showed a statistically significant difference in favour of the experimental group in terms of both 30-sec CST ($U = 71.500$, $Z = -4.959$, $p < 0.001$) and FRT ($U = 163.000$, $Z = -3.215$, $p = 0.001$**).**

CONCLUSION: The results showed that isolated eccentric training was more effective than traditional strengthening exercises in improving functional performance, balance, sit-to-stand and reaching ability in the elderly. Hence, isolated eccentric training can be regarded as an effective and beneficial intervention in physiotherapy to enhance functional independence in the elderly.

KEYWORDS: Calf muscle, Eccentric exercises, Elderly, Functional reach test, Strengthening exercises, 30 sec chair stand test

INTRODUCTION

Ageing is linked with a gradual reduction in muscle strength, balance, and functional movement, thereby increasing the likelihood of falls and dependence in (ADL) [1] .The muscle strength in the lower limbs is considered an important predictor for functional limitations among elderly people in the community[2]. Ageing leads to decreased recruitment of motor units in the muscles of the lower limbs, especially in the distal muscles such as the calf muscles.[3] Ankle muscles play a critical role in performing many activities of daily living, such as walking, stair climbing, and chair rising, which will promote good health and well-being and functional independence for all ages. The ability to carry out these activities is closely related to plantar flexor muscle strength. Between the ages of 73 and 97, the strength of the plantar flexor muscles decreases by 2.1% annually for females and 2.5% annually for males.

This data emphasizes the need to ensure of gender equality in the provision of interventions to combat the effects of functional decline among both males and females. It is widely recognized that muscular strength exercises can improve body function and performance[4] .Therefore, ongoing efforts have been made to recommend exercises for addressing sarcopenia in the elderly; however, most prescribed exercises involve general strength training and aerobic activities [5] . It is a fact that as people age, their muscles become weaker. Nevertheless, muscle weakness depends on the type of work

the muscles perform. Although age-related reductions in muscular strength are characteristic of muscle contraction, the decline is significantly less in eccentric contractions compared to isometric and concentric contractions. Based on the specificity principle of strength training, it is suggested that "eccentric and concentric" contractions have different impacts on muscle strength decline with age.

Movements provide a different type of stimulation to the muscle and may lead to different adaptations. "Sit-to-Stand and Reaching movements" are two of the most important functions that need to be addressed to promote the independence of the elderly. Training calf muscle increases the strength at the same time, facilitates the relearning of the movement, brain adaptation that increases coordination and efficiency in the execution of the reaching and STS movements [6]. During the final stages of the STS movement, the calf muscles, including the gastrocnemius and soleus, play a very vital role in the forward propulsion [7]. The ability to produce corrective ankle torque is limited among elderly due to reduced calf muscle strength which may lead to compensatory strategies such as expanded stance or excessive trunk flexion [8]. Thus, strengthening of isolated eccentric calf muscles helps to improve balance when reaching, highlighting the need of high-quality education in rehabilitation awareness.

Considering the global trend of increasing age and the prospect of entering super-aging society, this could be a future assignment to increase healthy life expectancy for the elderly. To the best of our knowledge, the effects of isolated eccentric calf muscle training have not been determined till date. Therefore, we hypothesized to determine the effects of isolated eccentric calf muscle training on functional reach and sit-to-stand among the elderly.

MATERIALS AND METHODS

This experimental study was approved by the Institutional Ethical Committee for student projects (Ref: **No: CSP-III/25/DEC/32/566).** The study was registered with the clinical trials registry of India with the number **CTRI/2026/01/101820.** The simple random sampling method was used among the 52 elderly subjects above 60 to 75 years of age, of both sexes.

This study was conducted in a physiotherapy outpatient department for four weeks. Participants were included if they possessed a normal range of motion in their upper and lower limbs and could walk independently. Individuals were excluded if they presented with ankle-related deformities, acute fractures of the foot or ankle, neurological or systemic conditions, chronic ankle instability, plantar fasciitis, Achilles tendinopathy, or a history of foot and ankle surgery. The participants were divided into two equal groups, Group A, received isolated eccentric training, and Group B, participants underwent traditional strengthening exercises.

All participants provided written informed consent before participation. The baseline measurement was done using the 30-sec CST and FRT. At the end of the intervention period, post-test assessments were conducted using the same outcome measures. The data was analyzed statistically to compare the pre-test and post-test results between the groups and to assess the effectiveness of the interventions.

STUDY PROCEDURE

Group A (Isolated eccentric calf muscle training)

Group A consists of eccentric calf muscle exercises, includes tiptoe raising on both legs, tiptoe raising on one leg with a straight and bent knee, and heel drops over a step edge, respectively. The exercises are carried out with support, either a wall or a staircase, to ensure safety and proper posture. The exercises are repeated 10-15 times, twice a day.

Group B (Traditional calf muscle strengthening)

Group B includes exercises for calf and ankle muscles, which are meant for developing muscle power and functional movements. The exercises include toe pointing, long sitting, and prone, along with calf raising, half-standing single heel raising, step up, and sitting ankle pumps, respectively. The exercises are carried out for 10-15 repetitions, twice a day, to improve strength and functional movements, especially for gastrocnemius and soleus muscles

OUTCOME MEASURES

30 SECOND CHAIR STAND (30-sec CST)

The 30-Sec CST was conducted to evaluate the strength of the lower limb and functional movement of the participant. The participant was seated on a 44 cm chair without armrests and with feet flat on the ground and arms crossed on the chest. On the command of 'Go,' the participant stood up and sat down repeatedly for 30 seconds. The number of repetitions was recorded with a hand counter. This test was conducted during the pre-test and post-test phases

FUNCTIONAL REACH TEST (FRT)

The FRT was conducted to evaluate the balance of the participant. The participant was asked to stand near the wall without touching the wall and with the inch tape placed at shoulder level. The participant was asked to reach with one arm at 90 degrees of shoulder flexion and reach as far as possible without stepping or losing balance. The participant's distance between the starting position and the end position was recorded. This test was conducted during the pre-test and post-test phases.\

RESULTS

Statistical analysis was done using IBM SPSS version 26.0. Demographic data was analysed using descriptive statistics, where continuous variables were expressed as mean ± standard deviation and categorical variables were represented as frequencies and percentages. Because the outcome variables did not follow a normal distribution, non-parametric tests were used for all analyses. Within-group comparisons (pre-test vs. post-test) for the 30-second Chair Stand Test (CST)

and Functional Reach Test (FRT) was conducted using the Wilcoxon matched-pairs signed-rank test. For between-group comparisons of post-test outcomes, the Mann-Whitney U test was applied. Statistical significance was set at a 95% confidence interval with a p-value threshold of $p < 0.05$.

While both groups showed good progress, the experimental group illustrated highly significant improvements in both the 30-sec CST ($Z = -4.685$, $p < 0.001$) and the FRT ($Z = -4.542$, $p < 0.001$).In contrast, the control group showed significant improvement in the 30-sec CST ($Z = -2.646$, $p = 0.008$) but did not reach significance in the FRT ($p = 1.000$). Between-group analysis showed a statistically significant advantage for the experimental group in both the 30-sec CST ($U = 71.500$, $Z = -4.959$, $p < 0.001$) and the FRT ($U = 163.000$, $Z = -3.215$, $p = 0.001$).

TABLES

OUTCOME MEASURES IN EXPERIMENTAL GROUP	TEST	TOTAL (N)	MEDIAN	STANDARD ERROR	Z VALUE	P VALUE
30 SEC CHAIR STAND TEST	PRE TEST	26	10.00	37.462	-4.685[b]	<0.001
	POST TEST		12.00			
FUNCTIONAL REACH TEST	PRE TEST	26	25.00	38.639	-4.542[b]	<0.001
	POST TEST		27.50			

Table 1: shows Pre and Post Values of 30 - Sec CST and FRT in Experimental Group (Using Wilcoxon Signed Rank test)

OUTCOME MEASURE IN CONTROL GROUP	TEST	TOTAL (N)	MEDIAN	STANDARD ERROR	Z VALUE	P VALUE
30 SEC CHAIR STAND TEST	PRE TEST	26	9.00	5.292	-2.646[b]	<0.008
	POST TEST		10.00			
FUNCTIONAL REACH TEST	PRE TEST	26	24.00	7.794	.000[c]	1.000
	POST TEST		24.00			

Table 2: shows Pre and Post Values of 30-Sec CST and FRT in Control Group (Using Wilcoxon Signed Rank test)

BETWEEN GROUP	TEST	TOTAL (N)	MEDIAN	Standard Error	Mann-Whitney U	P Value
30 SEC CHAIR STAND TEST	Experimental post	26	12.00	53.737	71.500	<0.001
	Control post		10.00			<0.001
FUNCTIONAL REACH TEST	Experimental post		27.50			<0.001

	Control post	**26**	**24.00**	**54.424**	**163.000**	**<0.001**

Table 3: Comparison of Post values of 30-Sec CST and FRT in Between Group (Using Mann Whitney U test)

DISCUSSION

The goal of this study is to ascertain whether, an isolated eccentric exercise program for older adults would result in a larger gain in strength and functional capacity in contrast with traditional strengthening exercise. Activities of daily living demand the use of absolute power to perform a task. Eccentric contractions are a good way to strengthen muscles because they take less energy than isometric and concentric contractions. [1] As a result, eccentric training is seen to be the best strategy for peak performance, encouraging senior citizens' good health and wellbeing. [1] While both interventions had a positive effect on functional performance, the isolated eccentric training had a greater impact than the traditional strengthening exercises. The experimental group showed highly significant gains in the 30-Sec CST and FRT ($p < 0.001$), according to the within-group analysis using the Wilcoxon signed rank test. These improvements indicated that the experimental group had increased strength in the lower limbs, improved functional mobility, and improved dynamic balance. On the other hand, the control group had a significant improvement in the 30-Sec CST ($p = 0.008$), but no significant improvement in the FRT ($p = 1.000$), indicating no significant improvement in balance. For the between-group analysis, the Mann-Whitney U test was applied, and it was found that the experimental group had significant differences in the post-test scores in both the 30-Sec CST and FRT indicating that the experimental group had greater improvements in the performance of the30-Sec CST and FRT than the control group ($p < 0.001$, $p = 0.001$). The greater improvement noted in the eccentric training group may be attributed to the physiological characteristics of eccentric muscle contractions, whereby more force is achieved with less metabolic demand, resulting in enhanced neuromuscular adaptations [3] These adaptations may result in improvements in muscle strength, coordination, and control, all of which are important for balance, as well as functional movements such as reaching forward and rising from a chair. In another study it was [9], observed that slightly greater increases in muscle strength were obtained in elderly individuals through eccentric resistance training compared to traditional training. In another study, [2] it was observed that eccentric calf lowering exercises were effective in improving plantar flexor strength and walking performance in elderly individuals. These results align with the current study's findings, which showed more significant gains in functional mobility and balance. Training the lower limb muscle groups through resistance training increases balance and functional mobility in elderly individuals. [10] Training the calf muscles increases functional performance in elderly individuals suspected of having sarcopenia. Thus, the results obtained in the current study emphasize the importance of training the calf muscles in increasing functional performance and preventing falls in elderly individuals. [4] Furthermore, from a biomechanical perspective, the gastrocnemius and soleus are crucial for maintaining ankle stability and moving the body forward during functional tasks. Weakness of plantar flexor muscle may cause instability and slow execution of movement, and individuals may rely more heavily on other muscle groups, including hip and knee extensors[4]. Eccentric muscle training of the calf muscle enables individuals to maintain stability of their centre of mass and improve their balance. The current study's findings indicate that isolated eccentric muscle training of the calf muscle is more beneficial than traditional muscle-strengthening methods for enhancing functional performance of the lower limb and functional movements such as reaching forward and rising up from a chair and balance of elderly individuals. Limitation of the study was small sample size, and the study period was limited to 4 weeks. There were only two outcome measures, and there was no long-term study to observe the long-term effects.

CONCLUSION

Both isolated eccentric training and traditional strengthening improved functional performance; however, eccentric training produced more pronounced results. This study confirms that eccentric strength is better maintained in older adults than other muscle actions, making it an effective tool for reversing age-related functional decline when implemented through a consistent exercise program.

CLINICAL IMPLICATION

1. Specific eccentric calf muscle strengthening will improve dynamic balance and stability while standing and walking
2. Eccentric calf training will reduce the risk of falls in older adults.
3. Eccentric exercises for the calves can be incorporated by physiotherapists into therapy sessions alongside other exercises.

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