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Effect of Balance Circuit Training versus Modified Otago exercise combined with trunk stabilization on risk of fall in older adults: A Comparative study

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Abstract: Falls among older adults are a major public health concern leading to reduced mobility, independence, and quality of life. This study aimed to compare the effectiveness of Balance Circuit Training (BCT) and Modified Otago Exercise Program (MOE), both combined with trunk stabilization exercises, on fall risk in older adults.

A total of 40 participants aged 65–80 years were randomly divided into two groups. Group A received BCT with trunk stabilization, while Group B received MOE with trunk stabilization for 4 weeks. Fall risk was assessed using the Timed Up and Go (TUG) test.

Both groups showed statistically significant improvement ($p < 0.05$). However, inter-group comparison revealed no significant difference ($p > 0.05$), indicating that both interventions are equally effective in reducing fall risk.

Keywords **– Balance Circuit Training, Modified Otago Exercise, Trunk Stabilization, Fall Risk, Older Adults, TUG Test**

INTRODUCTION

Aging is the slow decline of the body's physiological functions that happens as time goes by. It's a natural aspect of the human life cycle that impacts everyone in the species. It begins in fourth decade of life. The process of human aging is intricate and unique to each person, occurring across biological, psychological, and social dimensions. [1] Aging is a gradual process characterized by physical and mental decline that happens over time as a person moves from adulthood into old age. (2) Person above 65 years considered as geriatric.[2] 65 years to 75 years = Young old 75 years to 84 years = Older old 85 years Above = Oldest As life expectancy rises, societies and healthcare systems worldwide need to adjust to accommodate an aging population. Falls in older adults can lead to severe social isolation and significant economic burdens. They often trigger a cycle of decreased mobility, loss of confidence, and increased dependency, which can result in the need for institutional care. Despite ongoing efforts, fall-related hospital admissions have not decreased in the past decade. Therefore, it is crucial to create effective, long-lasting fall prevention strategies that are both acceptable and sustainable for older individuals.[3]

Impairments in balance and lower limb muscle strength significantly increase fall risk in older adults. As people age, there is a natural decline in muscle strength, particularly in the hip abductors, hip adductors, and knee extensors. research indicates that older adults tend to engage their primary motor muscles more intensely that their leg stabilizers in daily activities potentially compromising support during walking and standing. Therefore, it is crucial to focus on strength training for lower limb muscles, especially the knee extensors and stabilizers. Additionally, there is strong evidence that targeted exercise can effectively lower risk and incidence of falls in this population.[4] As we age, bones often decrease in size and density, leading to weakness and a higher risk of fractures, which can also result in a slight reduction in height. Additionally, muscles typically lose strength, endurance and flexibility, impacting balance, stability and coordination. As we age, our balance function declines due to a loss of sensory components, reduced ability to process information and issue motor commands, and decreased musculoskeletal function. Additionally, common age – related diseases can further impair balance in some individual.[5]

Gait impairments are common among adults living in the community, which can elevate their risk of falls, being placed in institutions, and experiencing higher mortality rates.[20] As people age, their balance and posture control abilities deteriorate, which raises the likelihood of falls. Every year, approximately 300,000 individuals worldwide lose their lives due to falls. Among adults aged 65 and older, 30% experience at least one fall, and 15% suffer from multiple falls. Consequently, fall related injuries have become a significant public health issue, severely affecting the quality of life and overall health of older adults.[6,21] Aging leads to both functional and structural changes in older adults, resulting in muscle weakness due to reduction in muscle mass and size, which contributes to a decline in physical abilities. These changes can impact an elderly person's capacity to perform everyday task. Specifically, weakness in the trunk and pelvic muscles along with reduced proprioceptive sensitivity, can interfere with mobility and balance. As a result, the risk of falls and related injuries is heightened.[7] Balance is the ability to keep the body's center of mass

within the stable area of support.[8] Poor balance and mobility issues have consistently been linked to a higher risk of falling in older adults [8]

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Targeted balance exercises have been proven to enhance balance and decrease the risk of falls in the general older population . [3] Circuit training involves a sequence of different exercise activities. After completing the last activity, the individual begins again and progresses through the series once more. The series of activities is repeated multiple times.[3] Various exercise modes can be employed that target both large and small muscle groups, incorporating a combination of static and dynamic efforts. Circuit training can enhance strength and endurance by challenging both aerobic and anaerobic system.[3] The Balance Exercise Circuit may effectively prevent falls by incorporating multimodal exercises that replicate daily activities.[4] These exercises are designed to progressively challenge balance and lower limb strength through a mix of sensory stimuli , force and balance training[4] .Moreover , the BEC has been shown to improve muscle strength , balance , and functional mobility in women aged and older[19] .It requires minimal supervision and low material costs , and it includes a structured manual that offers practical details on training vo lume – such as type , frequency, and duration -to enable easy replication and potential widespread use of the program .[4]

Trunk stabilization involves the muscle control needed to maintain stability around the torso, allowing for both conscious an d unconscious regulation of large or precise movements in the joints. Instability in the trunk can lead to excessive strain on the spinal structure and surrounding soft tissues, disrupting balance and postural control. Consequently, trunk stability is fundamental to all functional movements. Recently, trunk stabilization training has become a crucial aspect of therapy, as strengthening the trunk muscles is essential for maintaining functional stability in the body.[9] The structure that supports the trunk includes the abdomen and the muscles surrounding the lumbar -pelvic area. Its stability relies on the coordination of box- shaped muscles, abdominal muscles at the front, paraspinal and gluteal muscles at the back, the diaphragm above, and the pelvic floor and hip girdle muscles below. The trunk muscles are crucial for strength and mobility, playing a significant role in enhancing balance and overall function. They stabilize the center of the body during movement, help adjust posture against gravity, and facilitate limb movement for daily activities.[9]

Research has shown that various exercise programs are effective in preventing falls worldwide, including the Otago exercise program, fitness exercises for older adults, fall prevention lifestyles, multi-objective stepping exercises, Tai-Chi, yoga, Pilates, and resistance training. Among these OEP has proven particularly effective in enhancing cognitive function, balance, lower limb muscle strength, and overall physical fitness in older adults, while also preventing falls. Additionally, it accelerates recovery of physical function and reduces healthcare costs.[6] The program emphasizes strength and balance exercises which have been shown to improve balance, boost self confidence in balance control after falls and help overcome mental health issues such as social isolation and fear. As population ages, many elderly individuals are unable to participate in outdoor activities due to physical limitation. This leads to reduced physical and mental activity, decreased mobility and balance and increased risk of falls.[6] The Otago Exercise Program was created and evaluated by the New Zealand Falls Prevention Research Group. The OEP originated in NEW ZEALAND, Campbell et al. conducted the intervention pilot study of this exercise therapy for elderly women for the first time and achieved good results. It is one of the few fall prevention initiatives that enhances strength and balance, effectively decreasing falls and injuries related to falls in older adult. OEP is helpful to improve the falling efficiency of older adult, help older adult overcome the fear of falling, and form a positive emotion of" exercise improves exercise "to reduce harm caused by sedentary behavior and improve their subjective well-being [11] Thus, this study was conducted to compare the effects of balance circuit training and Modified Otago exercise, each combined with trunk stabilization, on fall risk in older adults assessed by the Timed up and go test.

NEED OF THE STUDY.

Falls are a major health concern among older adults and are associated with increased morbidity, reduced functional independence, and decreased quality of life. Age related decline in balance, muscle strength, and postural control significantly contributes to an increased risk of falls. Exercise based interventions are widely recommended to improve balance and mobility in older adults. Balance circuit training and the Modified Otago exercise program are commonly used physiotherapeutic approaches for fall prevention. However, there is limited comparative evidence regarding the effectiveness of these two interventions when combined with trunk stabilization exercises. Trunk stabilization plays an essential role in maintaining postural alignment and functional balance. Strengthening core musculature may enhance proximal stability and improve overall mobility during functional activities. Therefore, incorporating trunk stabilization exercises along with balance training may offer additional benefits in reducing fall risk. Hence, the present study was undertaken to compare the effect of Balance Circuit training versus Modified Otago exercise, both combined with trunk stabilization, on fall risk in older adults using the Timed up and go test.

RESEARCH METHODOLOGY

3.1 Population and Sample

The population of the present study consisted of older adults aged 65 years and above from the urban area of Jalgaon. A total of 40 participants were selected using convenient sampling technique. The selected participants were randomly divided into two groups: Group A (n = 20) and Group B (n = 20). All participants met the inclusion criteria and voluntarily provided informed consent prior to participation.

3.2 Data and Sources of Data

The present study was based on primary data collection obtained directly from participants.

A total of 40 older adults aged between 65–80 years were selected using convenient sampling and randomly allocated into two groups. The data collected included demographic variables such as age and gender, along with functional mobility assessment.

The Timed Up and Go (TUG) test was used as the primary outcome measure to assess fall risk among participants. Baseline (pre-intervention) data was recorded before the commencement of the intervention, and post-intervention data was collected after completion of the 4-week training program.

All assessments were conducted using standard procedures to ensure consistency and reliability. The data was recorded manually and later analysed using Microsoft Excel and Minitab 17 software for statistical evaluation.

Thus, the study relied on primary clinical data collected through direct observation and standardized assessment tools, ensuring accuracy and relevance to the research objectives.

3.3 Theoretical framework

The present study is based on the theoretical understanding that age-related physiological changes, including decline in muscle strength, proprioception, neuromuscular coordination, and postural control, significantly increase the risk of falls in older adults. With advancing age, impairments in sensory input, motor response, and balance mechanisms reduce the ability to maintain stability during functional activities. In this study, fall risk is considered as the dependent variable and is assessed using the Timed Up and Go (TUG) test, a reliable measure of functional mobility. The independent variables include Balance Circuit Training, Modified Otago Exercise Program, and trunk stabilization exercises, all of which are based on established theoretical principles. Balance Circuit Training is grounded in neuromuscular control and motor learning theories, where repeated exposure to dynamic balance tasks improves coordination, reaction time, and stability. The Modified Otago Exercise Program is based on strength and balance training principles, emphasizing lower limb muscle strengthening and functional balance improvement to enhance joint stability and reduce fall risk. Trunk stabilization exercises are based on biomechanical theory, highlighting the role of core muscles in maintaining postural alignment and providing central stability for efficient movement. The integration of these interventions improves muscle strength, neuromuscular coordination, and core stability, which in turn enhances functional mobility and postural control. Thus, the study is theoretically supported by the combined application of neuromuscular control theory, motor learning principles, and biomechanical stability concepts, explaining how structured exercise interventions can effectively reduce the risk of falls in older adults.

3.4 Statistical tools and econometric models

The data collected in the present study were analyzed using appropriate statistical tools to evaluate the effectiveness of the interventions. Descriptive statistics such as mean and standard deviation were used to summarize demographic variables and outcome measures. The normality of the data distribution was assessed using the Shapiro–Wilk test to ensure suitability for parametric analysis. For intra-group comparison (pre-test and post-test within the same group), the paired t-test was applied to determine the significance of improvement in Timed Up and Go (TUG) scores. For inter-group comparison (between Group A and Group B), the independent t-test was used to evaluate differences in post-intervention outcomes. The level of significance was set at $p < 0.05$. Statistical analysis was performed using Microsoft Excel and Minitab 17 software to ensure accuracy and reliability of the results. These statistical methods were selected to provide a valid and objective interpretation of the data and to test the study hypothesis.

3.4.1 Descriptive Statistics

Descriptive statistics were used to summarize the study variables, including demographic characteristics and outcome measures. The age distribution of participants in Group A had a mean of 65.9 ± 2.27 years, while Group B had a mean age of 65.8 ± 3.12 years, indicating that both groups were comparable at baseline. Gender distribution showed that Group A consisted of 13 males and 7 females, whereas Group B included 11 males and 9 females, with a slightly higher proportion of males in both groups.

For the outcome measure, the Timed Up and Go (TUG) scores were analyzed using mean and standard deviation. In Group A, the pre-test TUG score was 16.70 ± 3.21 seconds, which reduced to 16.00 ± 3.30 seconds post-intervention. In Group B, the pre-test TUG score was 17.10 ± 3.14 seconds, which improved to 14.95 ± 3.01 seconds after the intervention. These values indicate an overall improvement in functional mobility and reduction in fall risk in both groups.

The descriptive analysis demonstrated that the data were evenly distributed across both groups, and the observed changes in TUG scores suggest a positive effect of both interventions. The results were further presented using tables and graphical representations for better interpretation and comparison between the groups

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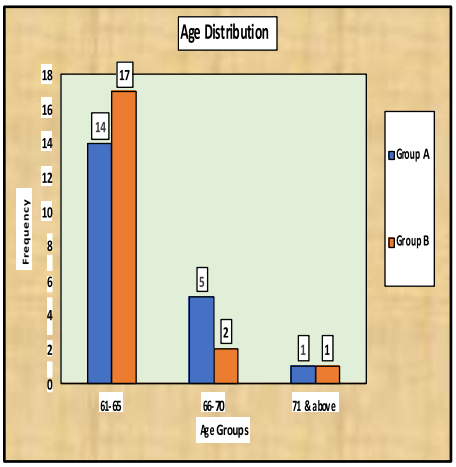
IV. RESULTS AND DISCUSSION

4.1 Results

Table no:1 Age Distribution

Sr. No.	Variable	Groups	Group A		Group B	
			Frequency	Percentage	Frequency	Percentage
1	Age (in years)	61-65	14	70.00	17	85.00
		66-70	5	25.00	2	10.00
		71 & above	1	5.00	1	5.00

	Group	Mean	SD	U	p value
Age	**A**	65.9	2.269	169.00	0.25
	B	65.8	3.12		

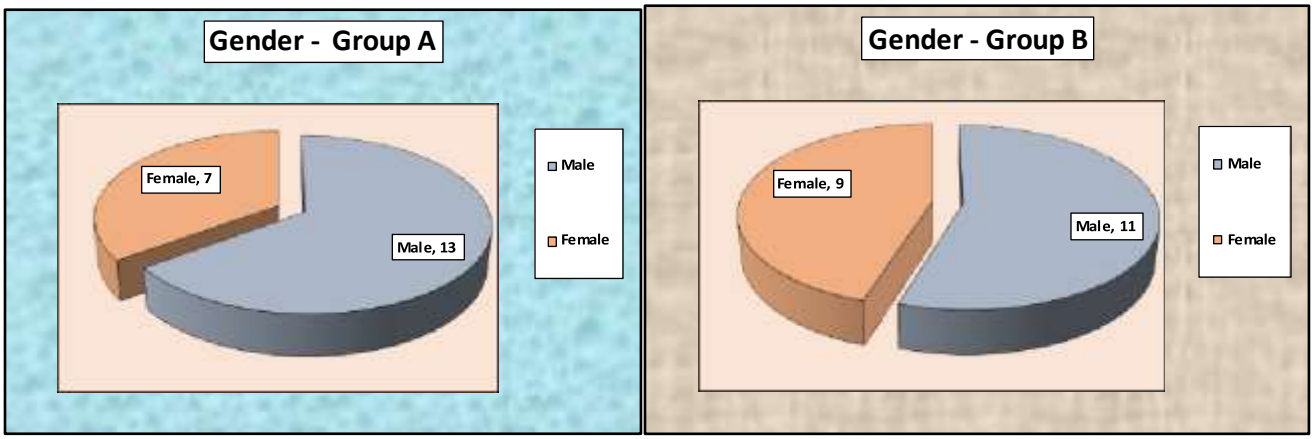


Interpretation:

The mean age of participants in Group A was 65.9 ± 2.27 years, while in Group B it was 65.8 ± 3.12 years. Comparison of mean age between the two groups using the Mann– Whitney U test revealed a U value of 169.00 with a p value of 0.25. Since the p value is greater than 0.05, there is no statistically significant difference in age between Group A and Group B. This indicates that both groups were age-matched and comparable at baseline, and age is unlikely to have influenced the outcome measures of the study.

Table no:2 Gender Distribution

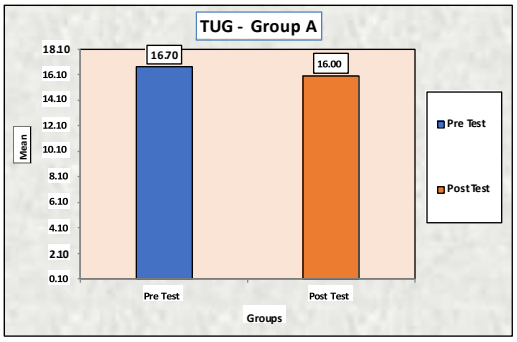
Sr. No.	Variable	Groups	Group A		Group B	
			Frequency	Percentage	Frequency	Percentage
2	**Gender**	Male	13	92.86	11	73.33
		Female	7	50.00	9	60.00



Interpretation: The gender-wise distribution of participants indicates that males constituted a higher proportion in both groups. In Group A, males (n = 13) outnumbered females (n = 7), demonstrating clear male predominance. In Group B, males (n = 11) were also more than females (n = 9), though the difference was less marked compared to Group A.

Table no:3 Intra-group Comparison of the effect of Balance Circuit training combined with trunk stabilization in group A

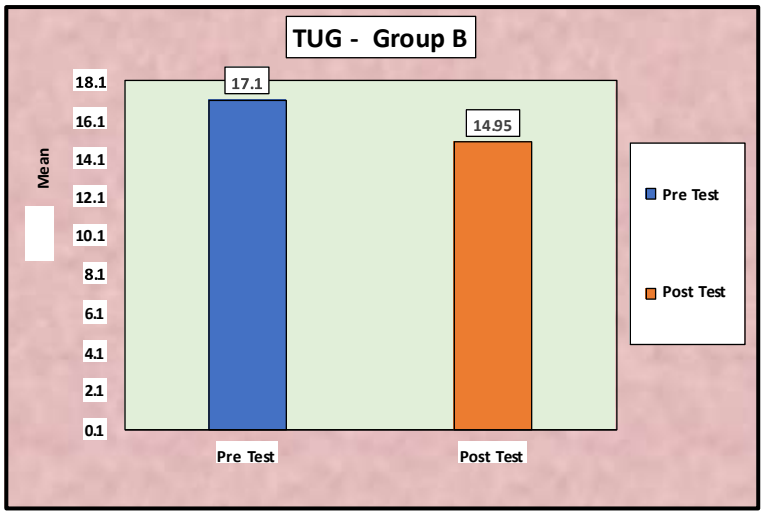
Group A	Test	Mean	SD	p value
TUG score	Pre Test	16.70	3.21	0.007
	Post Test	16.00	3.30	



Interpretation: The within-group comparison for Group A shows a reduction in the Timed Up and Go (TUG) score following the intervention. ▪ The pre-test mean TUG score was 16.70 ± 3.21 seconds. ▪ The post-test means TUG score decreased to 16.00 ± 3.30 seconds. ▪ The p-value was 0.007, which is less than 0.05. ▪ This indicates that the reduction in TUG score from pre-test to post-test is statistically significant. Since lower TUG scores represent better functional mobility and reduced fall risk, the results suggest that the intervention given to Group A was effective in improving mobility and balance within the group.

Table no:4 Intra-group Comparison of the effect of Modified Otago exercise combined with trunk stabilization of Group B.

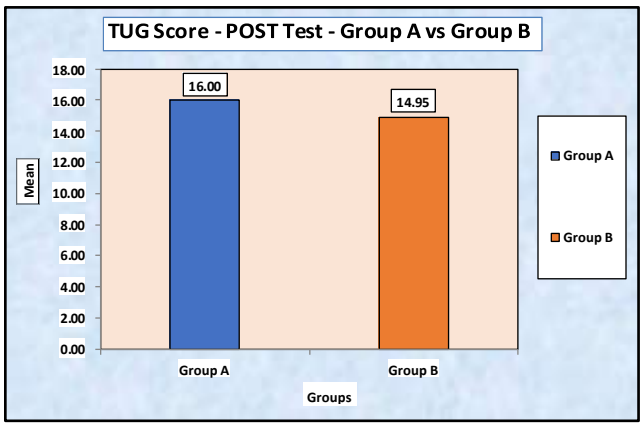
Group B	Group	Median	SD	p value
TUG score	Pre Test	17.1	3.14	0.000
	Post Test	14.95	3.01	



Interpretation: The within-group analysis of Group B demonstrated a statistically significant improvement in Timed Up and Go (TUG) scores following the intervention. The median TUG score decreased from 17.1 ± 3.14 seconds in the pre-test to 14.95 ± 3.01 seconds in the post-test. This reduction indicates improved functional mobility and balance among participants. The observed change was highly statistically significant ($p < 0.001$), suggesting that the intervention was effective in reducing the risk of falls in older adults.

Table no: 5 Inter-group comparison of the effect of balance circuit training and modified Otago exercise, both combined with trunk stabilization in Group A & Group B.

Variable	POST Test	Mean	T	p value
TUG score	Group A	16.00	1.0	0.30
	Group B	14.95		



Interpretation: Between-group post-test analysis of the Timed Up and Go (TUG) scores revealed no statistically significant difference between Group A and Group B. The mean post-test TUG score was 16.00 seconds in Group A and 14.95 seconds in Group B. Although Group B demonstrated a marginally lower TUG score, indicating slightly better functional mobility, the difference was not statistically significant ($t = 1.0$, $p = 0.30$). These findings suggest that both interventions were comparably effective in improving functional mobility among the participants.

Discussion:

The present comparative study aimed to evaluate the effectiveness of Balance Circuit Training (BCT) versus Modified Otago Exercises (MOE) both combined with trunk stabilization on fall risk in the elderly, as measured by the Timed Up and Go (TUG) test. The findings of this study demonstrate that both interventions resulted in a statistically significant reduction in fall risk. However, no statistically significant difference was observed between the two protocols, including that both approaches are equally effective in improving functional mobility in the elderly population.[8,11] Balance Circuit Training with Trunk Stabilization:

In Group A, a statistically significant improvement was observed following the intervention. The mean TUG score decreased from 16.70 ± 3.21 seconds at pre-test to 16.00 ± 3.30 seconds at post-test, with a p-value of 0.007, indicating a significant within-group change. A reduction in TUG score reflects improved functional mobility, balance, and gait efficiency, which are crucial factors in minimizing fall risk among older adults.[15] The significant improvement seen in Group A suggests that the intervention was effective in enhancing neuromuscular control, postural stability, and coordination. These improvements may be attributed to better trunk control, increased lower-limb strength, and improved balance strategies developed through the training program. The findings are consistent with previous studies that have reported significant improvements in functional mobility following structured balance and stabilization exercises in elderly individuals. Modified Otago Exercise with Trunk stabilization: The mean TUG score decreased from 17.1 seconds in the pre-test to 14.95 seconds in the post-test, indicating enhanced functional mobility and balance among the participants. Since the TUG test is a reliable measure of mobility and fall risk in older adults, the observed reduction suggests a meaningful decrease in the risk of falls after the intervention.[10,22]

The improvement in TUG performance in Group B may be attributed to the combined effects of the intervention protocol, which likely enhanced lower limb strength, postural control, and dynamic balance. Improved neuromuscular coordination and trunk stability may have enabled participants to perform transitional movements such as standing, walking, turning, and sitting more efficiently, resulting in reduced completion time during the post-test assessment. These findings are consistent with previous studies that have reported significant improvements in functional mobility and balance following structured exercise programs in older adults.[6,11] Similar reductions in TUG scores have been associated with better gait stability and reduced fall risk, supporting the effectiveness of balance-oriented and stabilization exercises. These suggest that both training approaches are effective in enhancing functional mobility and reducing fall risk among older adults. The improvements can be attributed to better balance control, muscle activation, and postural stability gained through the interventions. Age and gender distribution showed no significant baseline differences between the groups, confirming that the groups were comparable at the start. This strengthens the validity of the results, ensuring that improvements were due to the interventions rather than demographic factors.[6,23]

The significant reduction in TUG scores within both groups indicates meaningful improvement in gait efficiency, transitional movements and balance recovery strategies. The improvement observed in both BCT and MOE groups suggests that multi component balance training and structured strength balance programs with core activation are equally effective in addressing fall risk among older adults. Previous research consistently supports that both circuit-based training and Otago exercises are beneficial for improving mobility and reducing fall incidence in elderly people.[8] Studies have shown that balance circuits enhance postural responses by continuously challenging stability, while Otago programs primarily improve lower limb strength and static balance. Mechanism of effect of BCT with trunk stabilization: Balance circuit training, when integrated with trunk stabilization exercises, improves postural control and reduces fall risk in older adults through a multi system physiological and neuromuscular mechanism.[18,19]

Mechanism of effect of MOE with trunk stabilization: The MOE improves balance and reduces fall risk in older adults through a progressive combination of strength training, balance tasks and functional mobility exercises. The mechanism of improvement involves neuromuscular strengthening, sensory enhancement and greater functional independence. These results are consistent with previous studies that highlight the importance of multicomponent balance challenges provided by Balance circuit training.[24] Studies by Sherrington et al. and Gillespie et al. have shown that task oriented, circuit-based activities improve reactive balance, functional mobility and confidence in performing daily tasks. BCT typically includes dynamic tasks like stepping, gait variations which stimulate sensory integration and neuromuscular adaptation. On the other hand, the Modified Otago exercise is well established for elderly fall prevention. Literature consistently reports that OEP significantly improves strength of hip and knee muscles, static balance and reduces fall incidence by 35-40%. When combined with trunk stabilization exercises, the programme offers additional activation of deep core musculature which enhances postural steadiness and reduces sway.[21]

Conclusion:

The present study compared the effectiveness of Balance Circuit Training and Modified Otago Exercise combined with Trunk Stabilization on risk of fall among older adults aged 65–80 years. Based on the analysis of Timed Up and Go (TUG) scores before and after the 4-week intervention, the study concludes that both exercise programs are effective in enhancing functional mobility, dynamic balance, and overall safety during movement. Although both interventions were effective, the statistical analysis showed no significant difference between the two groups. This indicates that each program offers comparable benefits in enhancing postural control and improving lower limb stability. Given the absence of significant differences, both interventions can be considered equally effective, practical and clinically valuable fall prevention strategies for older adults.

Future Scope:

1. Future studies should include a larger and more diverse sample to improve the generalizability and statistical power of the findings.
2. Long-term follow-up assessments (3 months, 6 months, or 1 year) are necessary to evaluate the sustainability of balance improvements and determine whether the benefits of each training program persist over time.

3. Conducting trails with more diverse populations like frail elderly, institution zed elderly, individuals with co morbid conditions. This will help determine the applicability of both exercise programs across varied clinical populations.
4. Future studies may explore balance circuit training with virtual reality, modified Otago exercise with delivered through mobile applications.
5. Research can focus on implementing this at community centers, old age homes this will help determine feasibility and cost effectiveness of large-scale fall prevention programs.

Limitations:

1. The sample size was relatively small which may reduce the external validity and generalizability of the conclusions.
2. The intervention period was only 4 weeks. Balance and neuromuscular adaptations often require longer training periods; therefore, results may not reflect long-term changes.
3. The study relied solely on the Timed Up and Go (TUG) Test for assessment. Although valid, a single tool cannot capture all aspects of balance, gait, and fall risk.
4. No follow-up assessment was conducted after the intervention. Thus, the study cannot determine whether the improvements were maintained over time.

Clinical Implications:

Both interventions require minimal equipment and can be easily delivered in home settings. This allows physiotherapists to implement these programs for patients who cannot regularly visit clinics.
Trunk stabilization exercises enhanced core strength and postural alignment. This highlights the need to incorporate core training regularly in geriatric rehabilitation programs to improve balance and reduce trunk sway. By reducing falls, these exercise programs help decrease – fall related injuries, hospital admission.

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