The Effect of 6 Weeks Closed Eyes - Closed Chain Exercises on Static Balance, Dynamic Balance, Agility and Power of Lower Limb in a Young Healthy Individual: A Pilot Study

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ABSTRACT

Background: Closed kinetic chain (CKC) exercises are a type of exercise designed specifically to help improve the stability and coordination of joints, improve the body's ability to maintain its balance and enhance muscular coordination. When you perform CKC exercises with your eyes closed, you limit the amount of visual input that goes into your body. This may result in an additional challenge for the postural control system and improve the way that your brain interprets the different sensory inputs it receives.

Aim: There is currently limited research available regarding how CKC exercises performed with closed eyes may impact changes in balance, agility, and power in young, healthy individuals. Therefore, the study aims to evaluate effect of six weeks of closed eye closed chain exercises on Agility, Power, Static balance and Dynamic balance.

Material and Method: The study was a pilot randomized controlled trial in which 20 young healthy adults were recruited and randomly assigned to an experimental group or to a control group. All participants completed a six-week intervention consisting of three sessions per week. In addition to physical activity interventions, outcome variables included static balance (FICSIT-4), dynamic balance (Libra Platform), lower extremity power (Single Leg Hop for Distance Test), and agility (Agility T-Test). The assessment took place at baseline, 3 weeks, and 6 weeks into the intervention period and was analyzed using appropriate parametric or non-parametric statistical tests with a predetermined significance level of $p < 0.05$.

Result: The results demonstrated that 6 weeks of closed-eye, closed-chain training improves agility, power, and static/dynamic balance in young, healthy individuals.

Conclusion: Study concluded that a closed eye exercise program effectively improves sensorimotor control as well as lowers-limb functional performance and should be used as a component of preventative and performance-based training programs.

Keywords: *Closed kinetic chain exercise, open eye, closed eye, agility, power, static balance, dynamic balance.*

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INTRODUCTION

The performance of human movement is a product of the interaction of the neuromuscular system and the sensory system. A healthy young person will be able to optimally control their movement for not only performance as an athlete but also to prevent injuries, maintain stability of posture, and perform an action efficiently. Balance, agility, power, and coordination are the most important components of motor performance in both everyday life and in sports, and therefore, are the basis of dynamic stability. Daily movement takes place in the lower limbs, which relies on hip, knee, and foot coordination. According to one study healthy university students aged 18-26 years have experienced 54% of musculoskeletal problems, and the top three problems are with the lower extremities: hip and thigh at 24.9%, ankle and foot at 19.3%, and knee at 17.1%.1 The causes of the problems in daily life activity have resulted from trauma (26.7%), playing sports (18.8%), running (18.0%), and idiopathic factors (9%).19 Each stable step in walking indicates effective lower extremity function depending on kinetic and kinematic factors. (01,02) Balance, also known as postural stability, is a complex motor skill. It is defined as being able to keep the center of mass of a body within the base of support (i.e., the foot) during the performance of a static or dynamic task (03). The means of maintaining

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balance is by the combined use of the visual, vestibular and somatosensory systems, and appropriate motor actions (04).

Agility and power represent a higher level of motor ability; both necessitate the rapid generation of force, neuromuscular coordination, and effective integration of sensorimotor information. Generally, agility is defined as a rapid whole-body movement with change of direction and/or velocity in response to a stimulus (05). Muscle power is a related but different attribute than strength and is defined as the ability to perform muscular work per unit of time (power 5 work/ time). In simpler terms, if strength is defined as the ability to exert force, power is defined as the ability to exert force quickly (power 5 force 3 velocity). (06) In addition, the studies have found that balance, agility, and stability are associated and balance training can improve agility and stability.

Visual sense plays an important role in perceiving space and distance, and risks from the surrounding environment. (07) Visual sense also provides information on the location of each part of the body, and the required intensity of effort for postural adjustment (08). The vestibular system provides information on the movements of the head and the location of the head related to gravity or inertial force. Proprioceptive senses include the position sense that senses the locations of joints, and kinesthesia that senses the movements of joints. (07) These senses continuously maintain and correct posture, and enable conscious perception of body movements (09). If information from the visual sense is not precise, the central nervous system ignores visual input and depends on accurate vestibular and proprioceptive inputs (10). Many studies have proved that limiting visual inputs makes the somatosensory and vestibular inputs more efficient, increasing the sensorimotor adaptability and mechanisms of postural control.

Closed-Chain Exercises and Neuromuscular Control

Based on the fixed point of the extremities during movements there are 2 types of exercises known as open kinetic chain exercise (OKCE) and closed kinetic chain exercise (CKCE). In CKC exercises the distal part of the limb is fixed while the proximal joint moves which requires movement at other joints also (11).

These CKC exercises have been reported for improving balance (11). It efficiently stimulates the proprioceptive system through proprioceptive input when performed with partial or complete compressive loads to initiate and control muscle activation patterns. Additionally, CKC exercises involve concentric, eccentric, or isometric muscle activation and are carried out in functional positions in which they enhance synergy, stability, balance, muscle strength and power. These exercises strains the non-contractile soft tissues such ligaments, tendons, and joint capsules in addition to activation of the muscles (12). In the case of the lower limb, CKC exercises are more functional, as weight bearing is, by definition, a closed kinetic chain activity of the lower limb.

There are two different states of mental activities: Interoceptive state associated with closed eyes (imagination and sensory activities) and Exteroceptive state associated with open eyes(stimulating attentional and oculomotor structures) (13). In light of this, it can be hypothesized that the integration of afferent signals during balance may vary depending on whether the task is completed with eyes open or closed, potentially leading to variations in balance control (14). There are few studies which shows that visual restricted exercises can improve balance while there are no studies who have evaluated the effectiveness of closed eye exercise on the Static balance, dynamic balance, agility and power in young healthy individuals together.

Prior research has demonstrated an association between balance/proprioception training and improved postural stability and functional capacity; however, most studies have been limited to various populations that include clinical populations, professional athletes, or older adults. There are limited studies available to examine the benefits of implementing sensory deprivation closed-chain exercises to multiple motor performance measurements in sedentary/marginally fit young adult populations.

PURPOSE OF THE STUDY

This study aimed to investigate the influence of closed kinetic chain (CKC) exercises conducted with eyes closed compared to those conducted with eyes open on static balance, dynamic balance, lower limb power, and agility performance, as well as to make a comparison between the influence of CKC exercises conducted with eyes closed and those done with eyes open. A well-structured investigation of balance and performance measures while minimizing visual feedback will increase the understanding of sensory integration, specifically the role of proprioception and vestibular systems, in control of posture and movement.

SIGNIFICANCE OF THE STUDY

The results of this study are expected to play an important role in clinical rehabilitation, injury prevention, and performance. Balance and neuromuscular function that has been improved via eyes closed CKC training may help fall prevention. Also, this result may help make evidence-based exercises for maximum sports performance, functional mobility, or efficiency of motion. This is for healthy persons, sportspeople, or those who undergo the rehabilitation process.

AIM AND OBJECTIVES

Aim of the study

In the proposed study, the focus is to determine the impact of closed kinetic chain exercises with eyes closed compared to exercises conducted with eyes open regarding their effect on balance, muscular power, and agility.

Objectives of the Study

- To assess and compare the effect of CKC exercises done with the eyes closed and the eyes open on static balance in young and healthy individuals
- It assessed dynamic balance skills after CKC exercise interventions and to make comparisons between both groups, eyes closed and eyes open CKC exercises.
- To explore the impact of the eyes-closed and eyes-open CKC exercise protocols on the power and agility associated with the lower limbs and to compare the magnitude of change between the two groups.

PROPOSED HYPOTHESIS

Null hypothesis: (H0)

- There shall be no significant difference between people practicing CKC exercises with eyes closed and people practicing CKC exercises with eyes open concerning static balance.
- There will not be any significant difference in dynamic balance ability between the eyes-closed group and eyes-open group in CKC exercise.
- There will not be a marked difference in the power and agility of the lower limbs of participants carrying out exercises using the CKC with their eyes shut, and those using their eyes open.

Alternative Hypotheses (H1)

- A marked enhancement in the ability to perform static balance tasks would be observed in participants undertaking eye-closed CKC exercise performances as against those undertaking eye-open CKC exercise performances.
- The performance in dynamic balance will show a remarkable improvement in those participating in eyes-closed CKC exercise training rather than in those in the eyes-open CKC exercise group.
- The power and agility of the lower limbs will demonstrate more enhanced improvement with eyes-closed CKC exercise training compared to eyes-open CKC exercise training.

MATERIALS AND METHODOLOGY

i. Population: - Young healthy individuals

ii. Sampling technique: - Random sampling

iii. Sample size: - 72

iv. Study duration: - 6 months

v. Source of data collection: - P P Savani University students

vi. Inclusion criteria: -

1. Participants must be above 18 years old.
2. Participants must be in good general health without any significant medical conditions that could affect the outcomes.

vii. Exclusion criteria

1. History of any previous injuries, fracture, or surgery of either of lower extremities or spine.
2. History of any cerebral concussions or any other neurological or psychological disorders.
3. History of any vestibular and visual disorders for 3 months before testing.
4. History of any upper respiratory tract infection, urinary tract infection.
5. History of any cardio vascular disease at the time of the study.
6. History of any signs of vertigo, dizziness, headache, migraine, nausea, vomiting, or fever.
7. Participants involved in vigorous regular exercise activity.
8. Body mass index (BMI) higher than 30kg/m.2

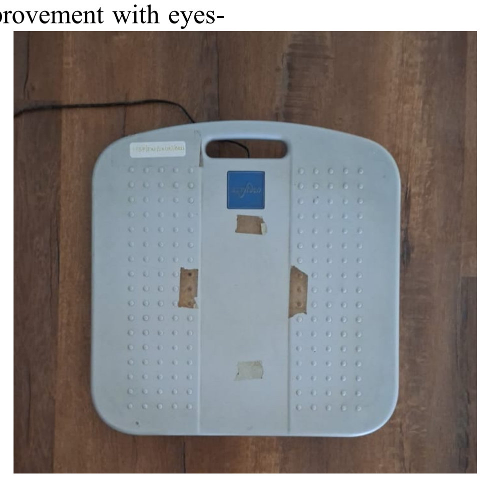


Figure no 3.1 Libra balance board

viii. Outcome measures

1. Frailty and Injuries: Cooperative Studies of Intervention Techniques (FICSIT-4)

2. Stability index registered during a 30-second trial by Libra Dynamic balance board
3. Agility T-Test
4. Single Leg Hop for Distance Test (SLH)

ix. Procedure

Study Setting
The research was carried out in young healthy subjects at P P Savani University campus.

Ethical Considerations and Participant Safety
Written informed consent was obtained from all participants before their inclusion in the study, with the provision of a participant information sheet detailing the study procedures. Participants were instructed to wear loose-fitting and comfortable clothes during the exercise sessions.

Therapists carrying out the exercise protocols received standardized instruction sheets on how to perform the exercises correctly. The exercise session was stopped without delay if a participant expressed excessive fatigue, pain, or a loss of coordination ability.

They were asked to abstain from any other resistance or formal exercise programs beyond activities of daily living during the period under study.

Randomization and Blinding
Participants who met the predetermined criteria of inclusion and exclusion were selected to be randomly assigned. After baseline measurement, participants were randomly assigned to either the treatment group or the control group by simple randomization, with concealment of allocation. Randomization was performed by the external staff member in charge in a concealed manner using opaque, sealed envelopes containing only the code for group allocation: Group A for the treatment group, or Group B for the control group, without any mention of the type of Exercise Intervention.

After finishing baseline measurements, participants were requested to make a selection and open one envelope and thus identify their group assignment. In this research work, a double-blind design was used where both participants and those evaluating the end results were blind to each other's assignment to a particular group.

Blinding of participants was ensured by holding exercise sessions for group A and group B on different days, so that the actual exercise tasks allotted to group A or group B remained unknown to the participants. Blinding of assessors was ensured as there were four independent assessors, and each assessor measured a different parameter (static balance, dynamic balance, agility, or power).

Assessment and intervention
Four independent assessors assessed different parameters one assessor assessed static balance, second dynamic balance, third agility and fourth power. Parameters were assessed three times one baseline assessment was done before the commencement of exercise intervention, thereafter assessment was done at the end of third week and at the end of sixth week.

To conduct this research, we will be using FICSIT-4 (Frailty and Injuries: Cooperative Studies of Intervention Techniques), Libra platform (Easy Tech s. r. l. Borgo San Lorenzo, Italy), Single Leg Hop for Distance Test (SLH), Agility T-Test (AT).

1. STATIC BALANCE
Static balance will be assessed by FICSIT-4 (Frailty and Injuries: Cooperative Studies of Intervention Techniques). Evaluator will assess the static balance by filling the questionnaire FISCSIT-4 which is a measures static balance of an individuals in parallel, semi-tandem, tandem, and one- legged stances. It consists of seven tests of increasing difficulty, with a score range of 0-28. Thus, each test is individually scored from 0 (requires assistance to prevent falling) to 4 (fully able to stand for 10 seconds independently).The examinee performs four stances and then repeats three of them with closed eyes (thus, seven tests in total).These stances are standing with their feet side by side, placing the step of one foots o that it is touching the big toe of the other foot, tandem stance (heel-to-toe),and standing on one foot. The last one is performed only with open eyes.

2. DYNAMIC BALANCE
All the participants' dynamic balance will be assessed by using Libra platform (EasyTech s. r. l. Borgo San Lorenzo, Italy). Testing will be performed in a quiet, well-lit, temperature-controlled room to minimize external distractions. Mediolateral (ML) and anteroposterior (AP) dynamic balance will be measured using the stabilometric platform (Libra; EasyTech, Salerno, Italy). The Libra platform is an electronic oscillating balance board that measures mediolateral or anteroposterior tilt from −15° to +15° to an accuracy of 1°. It will be connected to a computer with dedicated software. The participant will stand barefoot on the balance board. Feet will be parallel and the upper limbs rested freely along the trunk. Also, the participants will keep their knees extended throughout the test to exclude the effects of the knee joint on maintaining balance. The task will be to maintain balance on the device for 30 s. In each plane (ML and AP in random order) three trials will be performed after 2 practice trials and the better result will be considered for further analysis. Rest intervals between successive attempts will be set at 60 s. Dynamic balance will be quantified based on the stability index registered during the 30-s trial.

Figure no 3.2 Dynamic balance assessment set up

3. POWER

Single Leg Hop for Distance Test (SLH) :- The SLH is a valid and reliable test useful to assess muscle strength and power deficits (15,16). The subjects started in a standing position on one leg, with the toes positioned at the starting line marked on the therapeutic mat. The subjects had to jump as far as possible, landing on the same leg. The landing had to be maintained stable for three seconds (measured with a stopwatch), otherwise, the attempt was marked as invalid. The following criteria were used to mark invalid attempts: leaving the arms from the hips, a swing of the contralateral leg, using the contralateral leg as a support, loss of balance or multiple jumps at landing. The jumped distance was then measured in centimeters (cm) with a measuring tape, from the starting line marked on the mat (jump take- off) to the heel of the subjects where the landing took place (17).

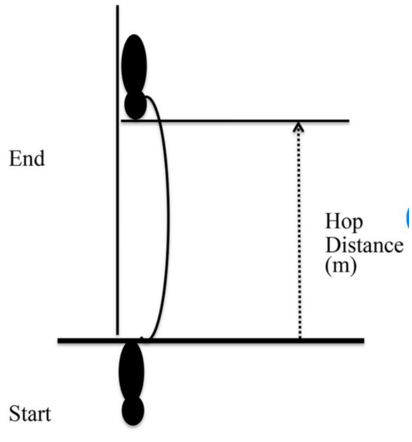


Figure 3.3 Single leg hop test

4. AGILITY

Agility T-Test (AT) :- The AT (3.8) is a valid and reliable test for the measurement of agility and change of direction speed by maximum start, side steps, and running backwards (15, 18, 19, 20, 21). The layout is a combination of four cones in T-shape (5 m × 5 m). Subjects started in a standing position behind the starting point at cone A. After the start signal, subjects sprinted to cone B, touching it with their right hand. Then, they performed a side- shuffle to the left to cone C, touching it with their left hand. Next, they performed a side- shuffle to the right to cone D, touching it with their right hand. Then, they performed a side- shuffle to cone B, touching it with their left hand. After that, they performed a backward run to cone A. Attempts were considered invalid if the subjects did not touch the cones, performed the side-shuffle crossing their legs or did not face forward while sprinting or side- shuffling (15, 18, 19, 20, 21). The execution time was computed in seconds (s) with a stopwatch, from the moment of the first sprint as soon as subjects left cone A to the moment of the last sprint as soon as subjects passed cone A.

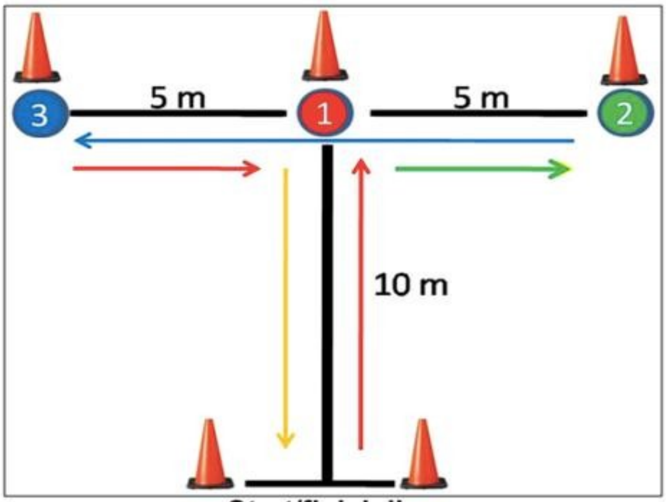


Figure 3.4 T-Test for Agility

The intervention was conducted by ten trained volunteers who were evenly split between treatment and control groups. These volunteers were trained by the principal researcher prior to beginning research. Moreover, they did not have any knowledge of which group served as either experimental or controlled groups. Furthermore, they were not participating in any outcome measures or any knowledge of the exercise program conducted on the other group.

Exercise intervention:

- For the control group, the exercise program will be followed with open eyes and for the treatment group the exercise program will be followed with closed eyes.
- Exercise period: 6 weeks (18 sessions) (22)
- Frequency: 3 time per week
- Repetitions: 3 sets of 10 repetitions (22)
- So, 3 sets of 10 repetitions will be performed in each exercise session and the sessions will be conducted 3 times a week for 6 weeks. (23).
- To prevent muscle fatigue, 2 minutes break time will be given to the subjects at each set (24)
- The exercise protocols of exercise will be performed for 25 minutes, which will be based on a referred study. (22).

The exercise protocol consisted of:

Warm-up exercise for 5 minutes which includes active movement of hip, knee, and ankle joints, marching on place, butt kicks, jogging/ running in place.

1. **Bridging:**
2. **Step-Ups and Step-Downs:**
3. **Partial Squats/Mini-Squats:**
4. **Heel Raises:**
5. **Partial and Full Lunges: (25)**

Cool-down exercise for 5 minutes which will include stretching of hip flexors, extensors, adductors, abductors, external and internal rotators, Quadriceps, Hamstrings, Tensor fascia lata, Iliotibial band, gastrocnemius and soleus.

RESULT AND DATA ANALYSIS

1. **Descriptive statistics**

Parameter	Group	Mean			Median			Std Dev		
		T0	T1	T2	T0	T1	T2	T0	T1	T2
Agility	Experimental	15.92	14.59	13.42	15.68	14.62	13.68	1.46	1.22	1.21
	Control	15.61	14.35	12.37	15.52	14.28	12.40	1.72	1.73	2.33
Power	Experimental	139.0	147.4	172.3	144	150	170	16.00	14.05	13.98
	Control	133.9	143.2	166.0	128	138	168	10.76	14.41	24.22
Static balance	Experimental	24.9	26.7	27.8	25	27	28	0.74	0.67	0.42
	Control	24.8	26.3	27.7	25	27	28	0.79	0.95	0.48

Dynamic balance	Experimental	27.32	21.20	17.01	26.1	20.6	16.7	7.84	4.78	4.07
	Control	29.74	23.20	18.99	29.0	22.8	18.6	5.12	6.44	4.65

Agility: Both groups demonstrated a progressive improvement in agility from T0 to T2, reflected by a consistent reduction in mean agility scores over time. The experimental group showed a steady and uniform improvement with relatively low variability across time points, whereas the control group, although improving overall, exhibited greater variability at T2, suggesting less consistency in post-intervention performance.

Power: Both groups demonstrated a progressive increase in power output from T0 to T2. The experimental group showed a steady and consistent improvement with reduced variability at T2, whereas the Control group exhibited greater variability at post-intervention, indicating less uniform power gains.

Static balance: Both groups demonstrated progressive improvement in static balance from T0 to T2. The experimental group showed slightly higher mean values and lower variability at post-intervention, indicating more consistent balance control.

Dynamic balance: Both groups demonstrated a progressive crease in dynamic balance stability index values from T0 to T2, indicating improved dynamic postural control. The experimental group showed more gradual and controlled improvement, whereas the control group demonstrated higher mean values with comparatively greater variability at mid-intervention.

2. AGILITY

2.1. Testing for Differences within Each Group

Overall, agility performance for the Experimental Group increased significantly throughout the duration of the intervention. At baseline (T0), the average time for performing the agility portion of the test was 15.92 seconds (SD = 1.46). At mid-intervention (T1), the average time was reduced to 14.59 seconds (SD = 1.22) and then further reduced at post-intervention (T2) to 13.42 seconds (SD = 1.21). Thus, the increase in agility performance can be associated with a decrease in the amount of time needed to complete the task. The use of repeated measures ANOVA also indicated that the means of the agility scores at the three time points differ statistically significantly from each other – thus, demonstrating a statistically significant within-group increase in agility performance across time.

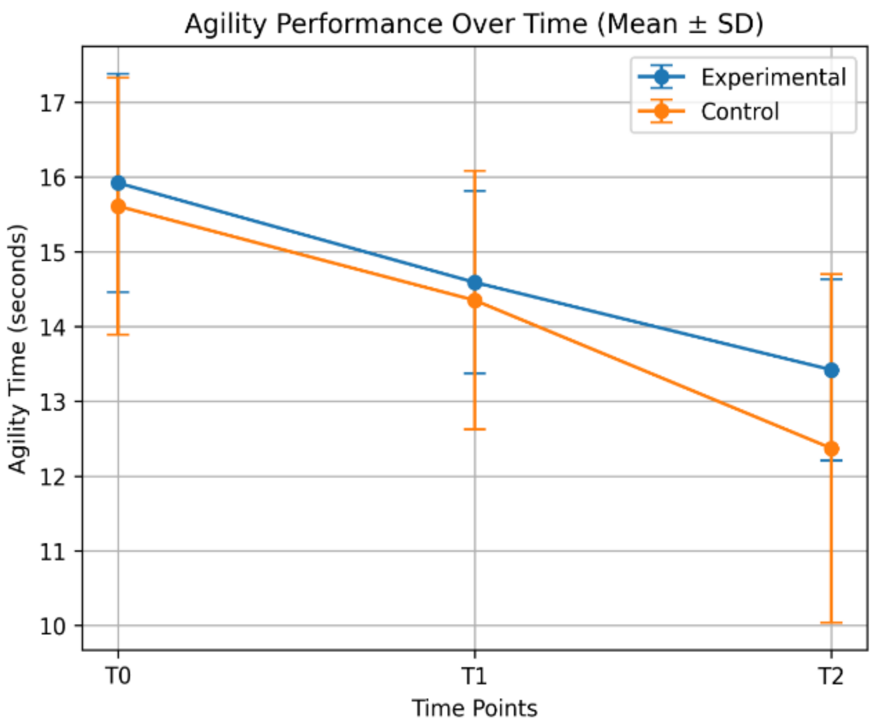
The Control Group also demonstrated significant statistically significant changes in agility performance throughout the study period. At T0, the average time to perform the agility portion of the test for the Control Group was 15.61 seconds (SD = 1.72). The average times for T1 and T2 were 14.35 seconds (SD = 1.73) and 12.37 seconds (SD = 2.33), respectively. Although the Control Group demonstrated improvement in agility performance overall, there was more variability in the patterns of change exhibited by this group than there was for the Experimental Group, as shown by the increased variability at T2. The results of repeated measures analysis indicate that the average time required to perform the agility portion of the test for the Control Group was statistically different between the three times measured.

2.2 Comparing the Statistical data and Making Recommendations

There is evidence that both groups have statistically significantly improved their time and agility, but there was a discrepancy between the two groups in regard to their responses in terms of how they are.

The trail of the experimental group has a more consistent and stable pattern of improvement, but this is evident in their lower standards deviations at all time points compared to the control group. The control group shows greater error variance at T2 compared to the experimental group. This would indicate that the variability in the agility performance post-intervention for the experimental group is less than that of the control group.

Although the mean agility scores of the two groups have shown improvement by T2, the experimental group has had a more consistent level of performance, which would support greater motor control and adaptability in agility outcomes. The results from this study would demonstrate that the experimental intervention for improving agility will provide for stable and reliable increases in agility in comparison to the control group.



Graph 4.1 Comparison between the Experimental and Control Group with respect to Time Points for Agility Performance

3. POWER

3.1 Testing for Within-Group Differences

Changes in Power Performance of the Experimental Group over the Course of the Intervention

The Experimental Group demonstrated an increase in power performance throughout the course of the intervention with a mean score at T0 of 139.0 (SD=16.00), a mid-point increase to 147.4 (SD=14.05) at T1, and a post-intervention increase to 172.3 (SD=13.98) at T2. This increase represents an increase in lower-limb power due to the intervention, and the statistical analysis of repeated measures showed a statistically significant change over time. Therefore, the Experimental Group demonstrated a statistically significant improvement within the group.

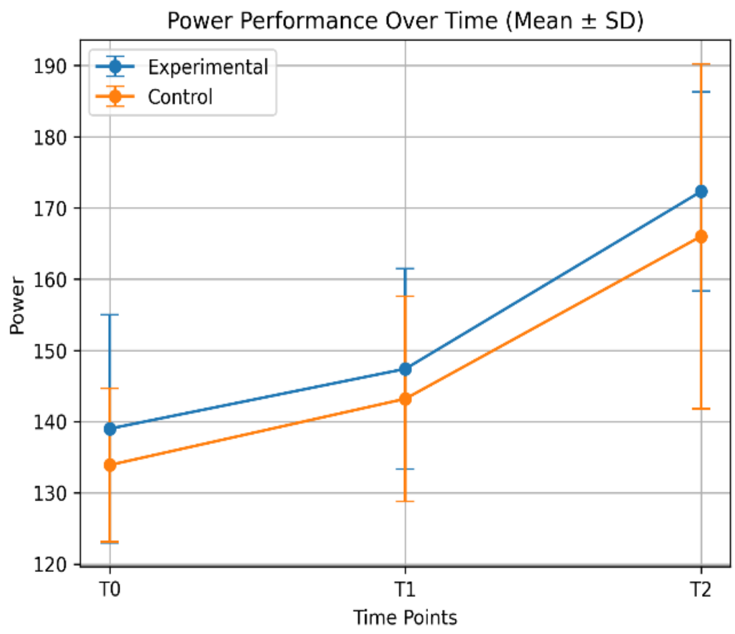
Changes in Power Performance of the Control Group over the Course of the Intervention

Similarly, the Control Group also showed statistically significant improvements in power performance as the mean score at T0 was 133.9 (SD=10.76), the mid-point score increased to 143.2 (SD=14.41) at T1, and post-intervention it had increased to 166.0 (SD=24.22) at T2. The Control Group also showed improvement, but the large standard deviation of power performance at T2 reflects a higher degree of inter-individual variability than was seen when comparing the Experimental Group's scores.

3.2 Comparison Across Groups

While the two groups had similar gains in power over time (all statistical significance, P-value), the experimental group consistently experienced more consistent and stable improvement patterns with their power improvements as demonstrated by the lower standard deviation values at T2 than the Comparison Group. Although the Comparison Group showed considerable mean power improvement, it also had significantly higher variability after the intervention had been completed.

In summary, the Experimental Group achieved significantly more uniform improvements in power production than the Comparison Group. This indicates that the intervention was effective in producing a significantly better consistency and control of power development.



Graph 4.2 Comparison between the Experimental and Control Group with respect to Time Point for Power Performance

4. STATIC BALANCE

4.1 Testing for Differences within Groups

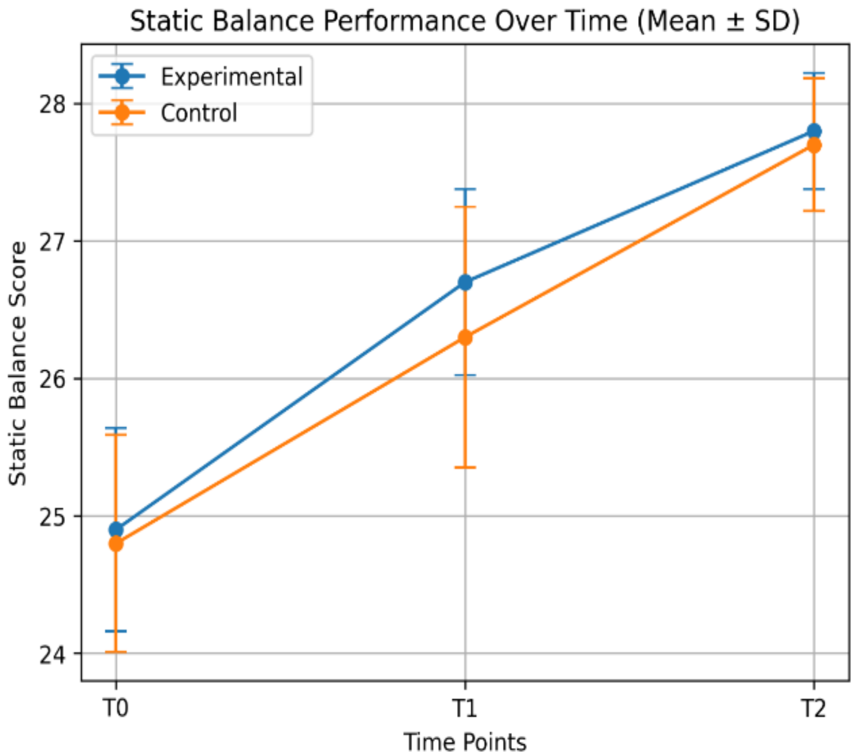
The Experimental Group demonstrated increased performance in static balance over time during the intervention period; mean static balance score increased from 24.9 (SD=0.74) prior to the intervention at T0, to 26.7 (SD=0.67) in the middle of the intervention at T1, and ultimately to 27.8 (SD=0.42) after completing the intervention at T2. The continual rise in average static balance score suggests that static postural stability has improved from baseline levels because of the intervention performed. Statistical tests using repeated measures analysis confirmed that there were statistically significant differences between the time points assessed.

The Control Group also had statistically significant differences within the group. The mean static balance score increased from 24.8 (SD=0.79) prior to the intervention at T0, to 26.3 (SD=0.95) in the middle of the intervention at T1, to eventually 27.7 (SD=0.48) after finishing the intervention at T2. The statistical data presented significant evidence of a change in the mean static balance score from T0 to T1; however, the noticeable degree of variability in the scores at T1 indicates that the adaptation response to the mid-intervention level of intervention was not as consistent as it was for the Experimental Group.

4.2 Group Comparisons

When comparing improvements in static balance statistically significant improvements were found for both groups over the time period. However, when looking at the Experimental Group's improvements at T2, the expected marginally better performance at T1 will additionally provide for more consistency in their improvements (lower standard deviations). Less Variance was found for the Experimental Group, when compared to the Control Group, as indicated by the range of means at the various time periods examined.

The results indicate that the Experimental Group performed at a higher level of improvement compared to the Control Group, due to the consistent nature of improvements experienced by the Experimental Group in terms of gain in static balance.



Graph 4.3 Comparison between the Experimental and Control Group with respect to Time Point for Static Balance Performance

5. DYNAMIC BALANCE

5.1 Testing for Within-Group Differences

Dynamic balance was assessed on three occasions (T0, T1, and T2) for both the Experimental and Control groups. The Experimental group demonstrated substantial and significant improvements in dynamic balance performance throughout the study period with a corresponding decrease in the stabilization index value over time. For example, mean stabilization index values were 27.32 (SD=7.84) at T0, 21.20 (SD=4.78) at T1, and 17.01 (SD=4.07) at T2, indicating a significant improvement in dynamic postural control ability. Repeated measures analyses revealed a significant difference in dynamic balance ability due to the time that participants spent in Experimental Group training.

Likewise, to the Experimental Group, members of the Control Group improved significantly in their dynamic balance ability during the entire duration of the study. In particular, participants' average stabilization index value decreased from 29.74 (SD=5.12) at T0 to 23.20 (SD=6.44) at T1 to 18.99 (SD=4.65) to T2. Thus, although there was marked improvement for this group during the study, the increased variability seen for the Control Group at T1 may indicate the possibility of changes in their dynamic balance performance being impacted by non-stable factors including transient effects of mental state, exertion, and remedial/compensatory techniques of each individual.

2.2 Comparing the Two Groups

Both groups had statistically significant improvements in dynamic balance over time. However, the Experimental Group demonstrated a level of improvement that was far more consistent and controlled than that of the Control Group, especially from T1 to T2, where improvements were shown by the larger reductions in stability index values and decreased variability in the Experimental Group's performance when compared with the Control Group. The higher stability index values and increased variability from the Control Group indicate that they were relying on compensatory balance strategies to maintain dynamic balance.

In summary, the experimental group was able to develop a better dynamic balance adaptation than the control group.

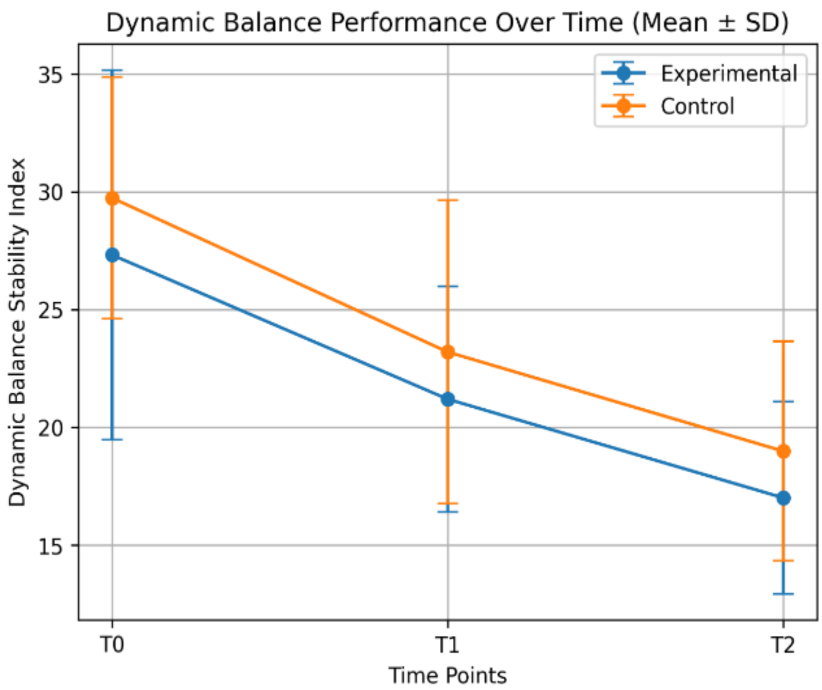


Table 4.8 Averages of Performance on Dynamic Balance at Each Time Point (T0, T1, T2) by Group: Experimental Group and Control Group

Graph 4.4 Comparison Between the Experimental Group and Control Group with respect to Time Point for Index of Dynamic Balance Stability.

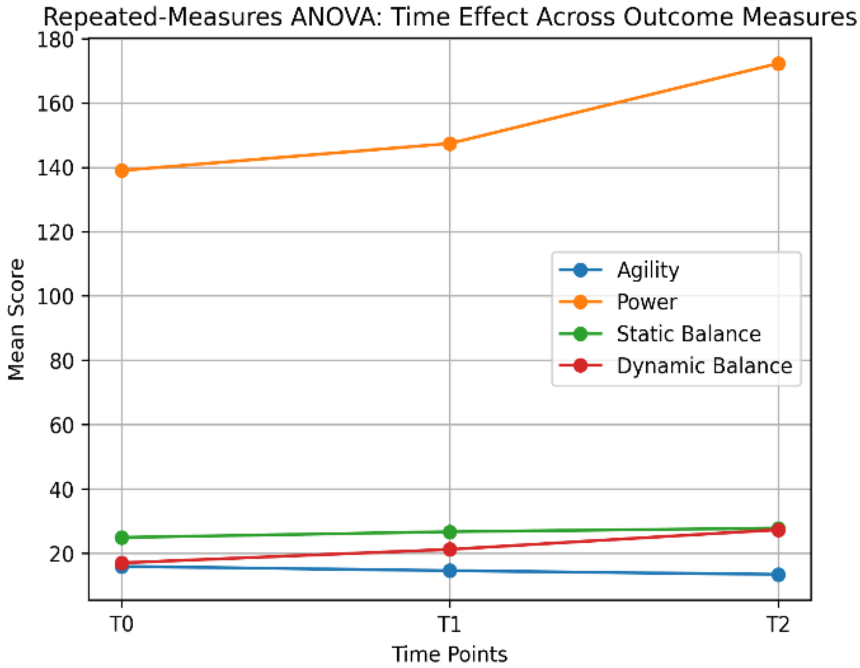
Repeated-Measures ANOVA: Time's Overall Impact

The use of repeated-measures ANOVA demonstrated that all indicators (outcome variables) from both groups (Experimental vs Control) exhibited statistically significant time effects. A summary of the F-value and p-value results from ANOVA can be seen in Table X.

Table 4.9 Results from repeated-measures ANOVA conducted to compare mean scores obtained across three time points in both experimental and control groups.

Test	Group	F-value	p-value	Interpretation
Agility	Experimental	70.01	<0.001	Highly significant change across time
Agility	Control	34.89	<0.001	Highly significant change across time
Power	Experimental	42.07	<0.001	Highly significant improvement
Power	Control	1974	<0.001	Highly significant improvement
Static Balance	Experimental	86.37	<0.001	Highly significant incremental gains
Static Balance	Control	115.90	<0.001	Highly significant incremental gains
Dynamic Balance	Experimental	15.33	0.00013	Significant improvement across time (Reduction in stability index)
Dynamic Balance	Control	55.55	<0.001	Significant improvement across time (Reduction in stability index)

In these results, it was confirmed that the Experimental Group experienced a statistically significant Time effect in all areas measured; whereas the Control Group also demonstrated statistically significant Time effects in Agility, Power, Static Balance and Dynamic Balance.



Graph 4.6 Repeated Measures ANOVA: Time effect across outcome measures.

DISCUSSION

In our study, we evaluated the effects of the 2 exercise protocols one with closed eye and one with open eye on static balance, dynamic balance, agility and power. Despite the fact that the pre-post comparison within each group indicated that all 4 parameters are improved after 6 weeks of intervention, we found that all parameters showed significantly greater improvement then control group. The main finding of this study show that after closed chain exercise performed with closed eye has shown significant improvement in their ability to control static balance, dynamic balance, agility and power compared to control group.

Table no 5.1 Summary of changes in Agility, Power, Static balance and Dynamic balance across time

Outcome measures	Experimental group	Control group	Overall interpretation
Agility	Progressive improvement across time with reduced variability at T2	Progressive improvement with increase variability at T2	Both groups improved; experimental group showed more consistent performance and better retention
Power	Consisten and steady improvement across all time points with lower variabilitu at T2	Significant improvement with higher variability at post-intervention	Both groups improved; Experimental group demonstrated more uniform power gains
Static balance	Gradual and consistent improvement across time with lower variability at T2	Progressive improvement with comparatively higher variability at mid-intervention	Both groups improved; Experimental group showed slightly superior stability and consistency
Dynamic balance	Significant improvement indicated by progressive reduction in stability index with controlled variability	Significant improvement with greater variability, particularlt at mid-intervention	Both groups improved; Experimental group demonstrated more controlled and consistent dynamic balance adaptation

This study's significant findings indicate that both Experimental and Control Groups displayed different amounts of time-dependent improvement regarding Agility, Power, Static Balance, and Dynamic Balance; however, the nature (direction) of that change was distinct for each measure. Both groups improved significantly in Agility; however, the Experimental group had a greater capacity to maintain their improved Agility. Experimental group showed better performance in power also. Furthermore, during the intervention period, both groups had a marked decline in stability index which shows experimental group had shown better improvement in their Dynamic Balance performance from pre- to post-testing.

Agility is an essential skill for many sports; thus, the marked improvement seen in both Experimental and

Control Groups throughout this study indicates that consistent exposure to an organized method of Physical Activity can improve Agility as it relates to the ability to change direction quickly for healthy, young adults. The Experimental Group had a greater capacity to maintain their newly acquired Agility after the completion of the intervention likely due to the secondary effects of using closed-eyes, closed-chain exercise on performing Agility tasks. The closed-eye condition decreased the dependence on visual input; therefore, increasing the use of proprioception and vestibular senses when performing the tasks, which suggest improved sensorimotor integration. This reweighting of input from several stimuli supports the improved Neuromuscular Coordination and Efficiency of Movement gained by the Experimental group, which resulted in sustained Agility Gains.

In contrast, the tendency of the Control Group hovering at the plateauing level suggests that most forms of conventional/ unrestricted training may provide some level of immediacy in improvement without providing adequate support or opportunity for further consolidation. Power demonstrated statistically significant growth over time for both groups. This suggests repeated loading of the body produces large responses in power output for healthy, young individuals. The experimental group showed more uniform power gain compare to control group.

Both groups showed results indicative of improvements in the ability to maintain static balance, indicating how well postural control systems adapted to the effects of continued practice and use of closed-chain exercises. Although both groups had improvements, individuals in the Experimental group demonstrated greater amounts of improvement when measured using a statistically significant measure. The ability to improve one's balance without the use of visual stimuli may force athletes to rely more on somatosensory feedback and vestibular system inputs for postural control and to improve their ability to sense the position of body parts and maintain postural alignment. The increased demand for of sensory input over time led to better-developed strategies for maintaining postural control for a longer period of time, thereby allowing this group to perform better on tests of static balance than did the Control Group. One study was conducted by MI Kyoung Kim et all and found that closed kinetic chain improved statis and dynamic balance however improvement was mush significant in dynamic balance which is similar to our study. (26)

These increases in performance align with previous studies that have found that improvements in the static balance adaptation over time are gradual and varying depending on the specific types of sensory input and tasks used during training. The study shows that both the control and experimental groups made significant gains from not only dynamic balance, as shown through decreased scores in dynamic balance stability index (DBSI), but for the experimental group, these gains were significantly greater than for the control group, indicating that they achieved superior results from closed-chain exercises with the eyes closed.

Dynamic balance involves continuous integration of multisensory input, preparatory postural adjustments, and rapid neuromuscular responses to maintain stability while performing movements. Increased proprioceptive processing and improved neuromuscular coordination due to training under visual deprivation were likely responsible for the improvement in DBSI achieved by the experimental group. Closed-chain exercises performed with the eyes closed resulted in increased reliance on somatosensory and vestibular input, which facilitated sensorimotor reweighting and the ability to control the centre of mass better while performing dynamic tasks.

The greater improvement observed in the DBSI for the experimental group supports the notion that closed-chain exercises performed with restricted sensory input challenge the postural control system more than performing these exercises with unrestricted sensory input, enabling individuals to perform dynamic balance tasks with greater efficiency. The smaller reduction in the DBSI for the control group suggests that they achieved less adaptation of the neuromuscular system following closed-chain exercises, while the greater reduction for the experimental group indicates a greater level of adaptation of the neuromuscular system. Results suggest that performing closed-eye closed-chain exercises may help increase dynamic balance in young and healthy people. Study was conducted by Shima Jandaghi, Nahid Tahan etc. They did study on improvements in balance in stroke patients in response to visual restriction exercise. They found that experimental group who has given balance training with visual restrictions have shown greater improvements compare to control group who were given balance training with open eyes. (27) Some more previous studies found that the exercise training with visual restriction by stroke parent affected their gait dynamic stability (28), knee joint proprioception (29), balance and concentration ability (30), gait velocity and balance (31). It has been hypothesized by the researcher that in comparison with free vision conditions, the vestibular and proprioceptive inputs are weighted more heavily in the conditions that extrinsic feedback system is removed (Visual deprivation condition). (28) another study was conducted by Yong Wook Kim and Sung Jun Moon in which they evaluated the effect of treadmill walking with the eyes closed and open on the gait and balance ability of chronic stroke patients and found that the walking and balance abilities of the closed eye group has showed more improvement compare to open group. (28)

Based on the results obtained from this study, the findings suggest that performing CKC (closed kinetic chain) exercises with closed eyes has a statistically significant impact on improving dynamic balance, static balance, agility, and power. This improvement is evident at both the 3- week and 6-week post-intervention assessments. Our result is contradictory to the result obtained by David Rodr´ıguez-Sanz et al in their study (32). They conducted study included performing and comparing eyes-open (EO) versus eyes-closed (EC) balance training on professional soccer players with chronic ankle instability (CAI) using a controlled cohort design of the same subjects (n = 14), during which both groups (EO versus EC) completed the same exercise program consisting of balance and strengthening exercises on unstable surfaces. The results did not support the overall hypothesis of this study as there were no significant differences observed between the EO and EC training groups for any of the outcome measures evaluated. One more study was conducted by Kim et al. (2016) (30) who investigated the combined effects of visual restriction and unstable dual-task base training (VUDT). Their result was similar to our study and demonstrated the superior results through the use of VUDT training provide strong evidence that integrating visual deprivation with unstable dual-task balance training is a more effective intervention to enhance the balance and attention of chronic stroke survivors than traditional dual-task training methods. Kwon et al. (11) investigated the effects of open kinetic chain (OKC) and closed kinetic chain (CKC) exercises on dynamic balance in healthy young adults. The authors concluded that closed kinetic chain exercises are more effective than open kinetic chain exercises for improving dynamic balance in healthy individuals within a six-week training period. This results match with the result obtained through our study. One more study was conducted by Kim et al. (2016) (30) who investigated the combined effects of visual restriction and unstable dual-task base training (VUDT). Their result was similar to our study and demonstrated the superior results through the use of VUDT training provide strong evidence that integrating visual deprivation with unstable dual-task balance training is a more effective intervention to enhance the balance and attention of chronic stroke survivors than traditional dual-task training methods.

Ulbricht investigated whether postural control training performed with eyes closed produces different effects on static and dynamic postural control compared to eyes-open training in healthy collegiate athletes. Despite the absence of significant results, the observed trends support the hypothesis that visual deprivation may enhance sensory reweighting, particularly proprioceptive and vestibular reliance, when adequate training volume and progression are applied. (33)

CONCLUSION

The findings of this study indicate that a 6-week closed eyes, closed chain exercise program resulted in statistically significant improvements in agility, power, static balance and dynamic balance in young healthy individuals. Repeated measures analysis demonstrated a significant effect of time across outcome measures in both experimental and control groups, confirming meaningful neuromuscular and postural adaptations over the intervention period. Experimental group exhibited more consistent and controlled improvements, particularly in balance related parameters, as reflected by reduced variability and progressive reductions in dynamic balance stability index values.

LIMITATIONS

Though the results were beneficial, there are some limitations. One limitation is sample size which may result in results not being representative of the general population. The participants were limited to young, healthy individuals so results cannot be used to make conclusions about clinical populations, older adults or those with balance disorders. Lastly, the study lasted for only six weeks; retention of any positive strategies has not been evaluated following the end of the programs.

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COMPLIANCE WITH ETHICAL STANDARDS CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this paper. The study was conducted independently without any influence from commercial, financial, or personal affiliations that could affect the objectivity or integrity of the research.

ETHICS STATEMENT

The study was approved by the Institutional Ethics Committee of P P Savani University PERC/PPSU/23/3A/15 dated 27/03/2024. All procedures performed in this study were in accordance with the ethical standards of the institutional research committee

INFORMED CONSENT

Informed consent was obtained from all individual participants included in the study. Participants were informed about the study objectives, procedures, and their right to withdraw at any time without any consequence.

The confidentiality and privacy of all participants were strictly maintained.

AUTHOR'S CONTRIBUTION

Dr. Bindesh Patel was responsible for the conceptualization, study design, data collection, statistical analysis, interpretation of results, manuscript drafting, and final approval of the version to be published. Dr. Neeta Vyas provided primary supervision, conceptual guidance, critical review, and expert inputs during the design and interpretation stages of the study. Dr. Anila Paul contributed through co-supervision, assistance in data interpretation, methodological guidance, and review of the manuscript. All authors have read and approved the final version of the manuscript and agree to be accountable for the integrity and accuracy of the work.

DATA AVAILABILITY STATEMENT

All data generated or analyzed during this study are included in this published article and its supplementary files.

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