

# Clinical Trial on the Effect of Various Training Program on Biomarkers and other Parameters of Osteoarthritis Knee Joint

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**Abstract** The aim of this pilot study of comparative type was to find the effect and feasibility of various training programs on osteoarthritis of the knee. This included the subjects who visited the outpatient physiotherapy department at the Dr. MGR educational and research institute in Velappanchavadi. Participants aged 45-60 years diagnosed with grades 2 and 3 osteoarthritis of the knee were randomly selected and divided into 3 different groupings: Group A - functional task training; Group B - perturbation training; and Group C - conventional performing for alternative days in a week for a total of 12 weeks. The novelty of the study involves the comparison of various exercise programs and their effect on biomarkers associated with gait and balance parameters. The data were collected by assessing the patients in terms of gait parameters, WOMAC scores, and serum cortisol before and after interventions. The statistical analysis shows a change in the mean value of serum cortisol: Group A (functional task training) from 17.35 to 12.11, Group B (perturbation training) from 17.39 to 7.00, and Group C (conventional exercises) from 17.36 to 11.29; for walking speed, Group A (functional task training): 1.22 to 1.32; Group B (perturbation training): 1.21 to 1.47; Group C (conventional exercises): 1.21 to 1.22; for y-balance, Group A (functional task training) from 73.0 to 81.67,

Group B (perturbation training) from 73.42 to 89.08, Group C (conventional exercises) from 73.17 to 77.33; for the WOMAC questionnaire, Group A (functional task training) from 72.08 to 65.4, Group B (perturbation training) from 72.17 to 60.6; and Group C (conventional exercises) from 72.25 to 69.25. On comparing the mean values of all groups, Group B (perturbation training) shows more significant changes than Group A (functional task training) and Group C (conventional exercises). Also, Group A (functional task training) is better than Group B (perturbation training), and Group A (functional task training) is better than Group C (conventional exercises), and Group B (perturbation training) shows more significant changes. Exercise routines have been utilized in various ways to treat symptoms of arthritis in the knee. The method of functional task training improves people's quality of life and functional abilities. This study concludes that perturbation training is more effective than functional task training and conventional exercise, as perturbation exercises fulfill all the demands necessary to perform daily activities independently.

**Keywords** Osteoarthritis, Perturbation Training, Functional Task Training, Serum Cortisol Level

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## 1. Introduction

Osteoarthritis is a prevalent degenerative condition that primarily affects elderly people. According to reports, osteoarthritis of the knee affects 3.8%–8.1% of the global population, and older people are more likely to develop it [1]. Degenerative changes in the cartilage, synovium, joint surfaces, and other articular components that lead to dysfunctional joints are the hallmarks of osteoarthritis of the knee [2]. Subjects with osteoarthritis of the knee exhibit indications and symptoms that include pain, joint stiffness, crepitus, a restriction in joint range of motion (ROM), abnormalities of the joint, and functional activity limits like walking difficulty or ascending stairs, among others. Reduced joint space, particularly in the medial joint space, due to cartilage deterioration, genu varum, and lipping osteophytes is radiographic characteristic of osteoarthritis of the knee [3]. There are two subgroups of osteoarthritis: 1. Primary osteoarthritis that has an underlying cause; 2. Secondary osteoarthritis, which develops after any other illness or injury [4]. Genetic predisposition, aging, obesity, sedentary lifestyle, metabolic disease, previous injury, and female gender are the modifiable and non-modifiable risk factors of osteoarthritis of the knee [5]. The Indian people are more likely than the general population to have arthritis of the knees because of the frequent squatting seen in Indian practices of using the toilet and other household activities [6]. The Indian Journal of Orthopedics reports that 28.72% of Indians have arthritis in their knees overall, of which 28.1% are males and 31.6% are females [7]. The mechanism of relief from exercise is thought to help with OA knee discomfort by promoting the flow of synovium that feeds the extracellular matrix and keeps it strong [8]. Conditioning with disturbances includes applying direct stresses to shaky surfaces. Stepping and bilateral or unilateral stance perturbation training is provided using a range of tools, such as rockabilly platforms and slider forums. Perturbation training, along with conventional treatment, proves to be effective in improving lower limb function in OA knee subjects [9]. A functional task exercise involves the teamwork of cognition, perception, and motor functions. Functional task exercises improve muscle strength, flexibility, and static and dynamic balance, in turn improving the quality of the activities of daily life [9]. Subjects suffering from osteoarthritis have difficulty performing daily activities, and they demand both balance and task-specific training; hence, it is important to compare perturbation training and functional task training in the functions of the osteoarthritis knee. Joint discomfort from degeneration can last for years. Yet, many therapies that have substantial advantages, such as aerobic exercise or muscular strengthening, are only frequently utilized by individuals for a short time frame (weeks). Short-lived or modest improvements follow, necessitating more action

and medical attention. This is crucial for comprehending various exercises and new techniques, such as perturbation exercises and functional task training exercises, to enhance the protracted effectiveness of such therapies. So, the goal of this study is to evaluate the impact of perturb training, operational activity preparation, and traditional treatment exercise on those suffering from knee osteoarthritis in order to develop a program that would enhance the participants' overall quality of life.

## 2. Methodology

At the ACS Medical College and Hospital's clinical medical faculty, a pilot study of comparative type was carried out at Velappanchavadi. with approval from the institutional ethical committee to carry out the investigation, Dr. MGR Educational and Research Institute were contacted. A total of 40 people were initially recruited for this study; four people expressed their intention not to participate in the program due to personal circumstances such as shifting of residence, unexpected transfer of spouse's occupation, etc. (fig 1). During the research process were excluded, as were those who did not match the inclusion criteria, making a total of 36 subjects participate up until the research's final stage. All subjects received a thorough explanation of the study's goals and procedures during the initial recruitment. The 36 samples chosen were randomized within blocks, so that the number of people assigned to each therapy was equal (Table 1). All participants have voluntarily given their informed consent. The baseline data were collected from all the participants. Three groups of participants have been formed. 12 participants in group A had perturbation training, whereas 12 subjects in group B underwent functional task training, and 12 subjects in group C received conventional exercise therapy (Table 2, 3, 4), (Figure 1).

**Table 1.** Demonstrates the inclusion and exclusion standards

Inclusion criteria	Exclusion criteria
45 to 60 years old subjects	suffering brought on by past trauma or injuries of any kind
The Kellgren Lawrence scale classifies radiographic severity into grades II and III.	radial severity levels of I and IV On the basis of the Kellgren Lawrence scale
Clinical diagnosis of the patient is OA	prior intra-articular injection using painkillers for the previous three months, Patient involvement in Physiotherapy during the previous six months Bone metabolic disease Patients using assistive technology

**Table 2.** Characteristics of training programme of group A

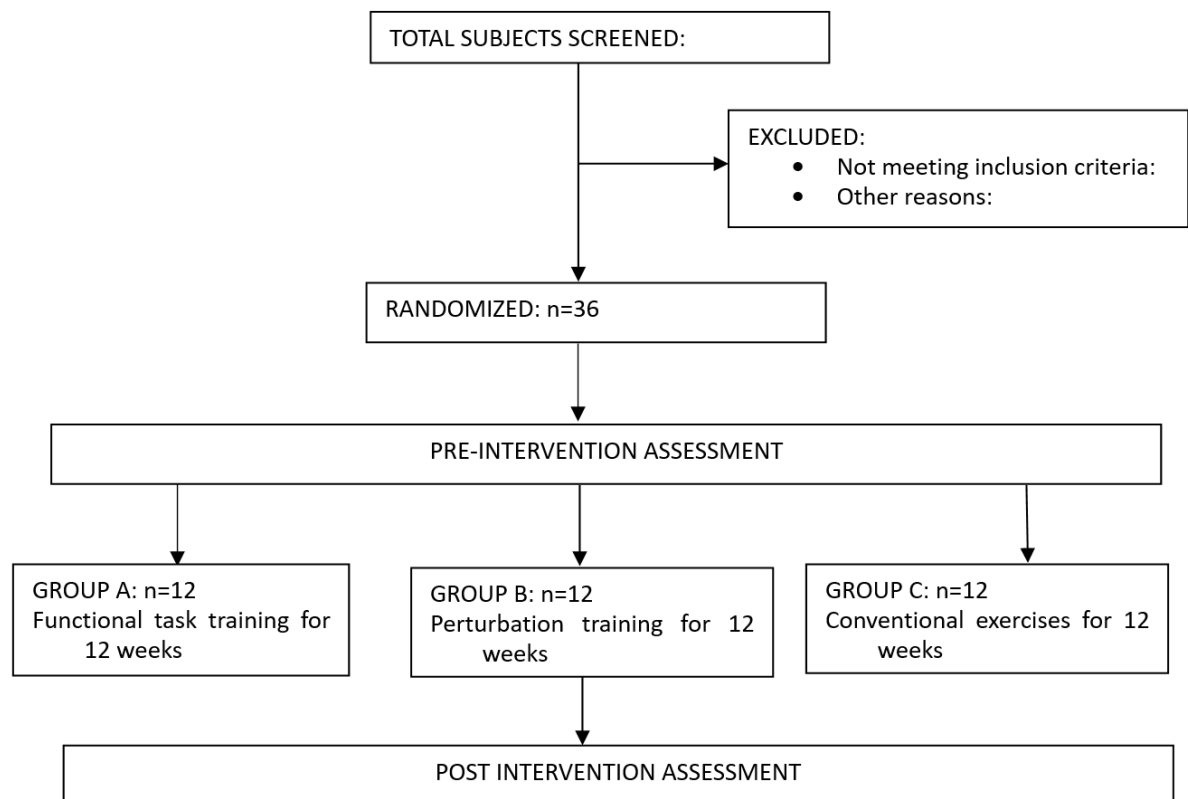
Type of Exercise	Total no of sessions	Duration	Rest(s)	Weight used	Number Of sets
Sit to stand Exercise	36	4 minutes	30s	-	4 sets
Star pattern knee bends	36	4minutes	30s	-	4 sets
Walking up and down on ramp	36	4minutes	30s	250gm	4 sets
Ascending/Descending Stair	36	4minutes	30s	250gms	4 sets
Walking indoor	36	4minutes	30s	250gms	4 sets

**Table 3.** Characteristics of training programme for Group B

Type of Exercise	Total number of sessions	No of sets	Duration	Rest(s)
Balance perturbation Foam pad	36	4	4 minutes	30s
Balance perturbation for knee flexor and extensor	36	4	4 minutes	30s
Tilt board balance training-Both foot	36	4	4 minutes	30s
Tilt board balance training-single feet	36	4	4 minutes	30s
Swiss ball perturbation training.	36	4	4 minutes	30s

**Table 4.** Characteristics of training programme for Group C

Muscle group	Total no of sessions	Sets for each muscle group	Type of exercise	Duration	Rest(s)
Quadriceps	36	4sets	1.Isometrics 2.Strengthening	40 minutes	30s
Hamstring	36	4sets	1.Strengthening		

**Figure 1.** Study Flow Chart

### 2.1. GROUP A Exercise Protocol Consists of [Table 2]

1. Start by sitting on the chair for this sit-to-stand workout. Take a big breath in and gently raise yourself off the chair by utilizing your legs. Grab onto the chair for support as you lean your chest slightly forward. Take another long breath and stand up straight. Lean over slightly, making sure your legs' backs are in contact with the chair's legs, and then sit back down as you relax. Perform these exercises for approximately one minute, four times with an interval of 30 seconds rest, and continue for alternative days in a week for a total of 12 weeks [10].
2. Star Pattern Step Knee Bends: Begin with a shoulder-width stance. By bending the opposite knee to assist the foot in sliding forward, extend one leg out and place it on the pavement sliding forward, extend one leg out and place it on the pavement. Regain your feet, and then proceed identically. Perform these exercises for approximately one minute, four times with an interval of 30 seconds rest, and continue for alternative days in a week for a total of 12 weeks [11].
3. Ascending and descending a slope while carrying a 250-gram mass in your preferred hand Perform this exercise for 1 minute four times with an interval of 30 seconds rest, and continue for alternative days in a week for a total of 12 weeks [12].
4. Riser climbing and lowering while holding a 250-gram weight in the favored hand perform this exercise for 1 minute four times with an interval of 30 seconds rest, and continue for alternative days in a week for a total of 12 weeks.
5. Walking indoors while passing a weight of 250 grams from hand to hand. Perform this exercise for 1 minute four times with an interval of 30 seconds rest, and continue for alternative days in a week for a total of 12 weeks [13].

All these exercises were supervised by a physiotherapist. Functional Task Training was performed for approximately 30 minutes, including a rest period.

### 2.2. Group B Exercise Protocol Consists of [Table 3]

1. Balancing perturbation on foam pad: During this training, the patient is supported by a single limb while they stand on a 1.3-centimeter expandable foam surface as the therapist attempts to disturb their balance in different ways for approximately one minute. Perform these exercises four times with an interval of 30 seconds of rest, and continue for alternative days in a week for a total of 12 weeks.
2. Balancing perturbation on a foam pad with knee flexion and extension: A single-leg stance is performed with involved limb balancing on a foam pad. Balance drill knee extension and flexion to promote the recruitment of the core and lower extremity muscles for dynamic

stabilization for approximately one minute. Perform these exercises four times with an interval of 30 seconds of rest, and continue for alternative days in a week for a total of 12 weeks [14].

3. A balance board for tilting (both feet): The individual places both of his or her feet firmly on a tilt or balancing board. During around ten minutes, the therapist moves the patient in a right and left, forward and backward motion. Perform these exercises four times with an interval of 30 seconds of rest, and continue for alternate weeks for a total of 12 weeks on different days.
4. A balance board for tilt (single feet): The individual places one foot on a tilt board or balancing board while they stand. Perhaps the clinician has been agitated in medial and lateral directions for approximately one minute. Perform these exercises four times with an interval of 30 seconds of rest, and continue for consecutive weekdays for a maximum of twelve weeks [14].
5. Swiss ball perturbation training: During this training, the patient kneels on a Swiss ball, with hands supporting on hand rails, and the therapist perturbs the anterior-posterior direction for approximately one minute. Perform these exercises four times with an interval of 30 seconds of rest, and continue for alternative days in a week for a total of 12 weeks.

All these exercises were supervised by a physiotherapist. Perturbation Training was performed for approximately 30 minutes, including a rest period.

### 2.3. Group C Exercise Protocol Consists of [Table 4]

- Quadriceps isometrics [15]
- Quadriceps strengthening [16]
- Hamstring strengthening [17]

All these exercises were performed for approximately one minute, four times with an interval of 30 seconds rest, which was continued for alternative days in a week for a total of 12 weeks.

### 2.4. Outcome Measures

1. Serum cortisol, WOMAC Questionnaire
2. Y-Balance Test
3. The 10-Meter Walk Test

### 2.5. Statistical Analysis

The data were analyzed using the post-HOC test, one-way ANOVA test, NPar test, Kruskal-Wallis test, turkey HSD test, t-test, and Wilcoxon signal rank test. The standard deviation and mean were used to express the data. Statistics were judged to be significant for probability values under 0.05. The version of the software was unknown because the statistics were performed by the statistician.

### 3. Results

A total of 41 OA knee patients were enrolled in the study. Among them, 36 patients completed the study, (5 Subjects dropped out: 3 subjects due to shifting of Residential address, 2 subjects due to change of spouse office address.), out of which 12 were in Group A (functional task training), 12 were in Group B (perturbation training), and 12 were in Group C (conventional exercises). The demographic characteristics of the patients are shown in Table 5. There were no discernible variations among the categories on any outcome metrics before intervention, and there was a significant difference after interventions [Tables 6, 7].

When contrasting Groups A's mean values, -functional task training, Group B- perturbation training, Group C- conventional exercises as of all outcome measures [Table 6], it exhibits a significant drop in the comment arithmetic mean of serum cortisol morning level in all three groups. But Group B shows mean value of 7.008 which is lower than group A -12.117 and group C-14.592 at ( $P<0.05$ ) [Table 6,7]. It also shows significantly increasing mean values in the following assessment of walking speed in all three groups. But Group B shows mean value of 1.470000 which is greater than group A -1.322500 and group C-1.227500 at ( $P<0.05$ ) [Table 6].

The article overall average reveals a notable rise in Y balance test in all three groups, but Group B shows mean value of 89.08 which is greater than group A -81.67 and group C-77.33 at ( $P<0.05$ ) [Table 6]. It also demonstrates a substantial decline in the blog average scores of WOMAC questionnaire score in all three groups, but Group B shows

mean value of 60.67 which is lower than group A -65.42 and group C-69.25 at ( $P<0.05$ ) [Table 6]. All these mean that perturbation training results in a decrease in the serum cortisol level, improves walking speed, increases balance and improves quality of life compared to the Group A and Group C.

The serum cortisol level is a biomarker that relates to the amount of pain experienced by the patient, and this study introduces the use of serum cortisol to evaluate the changes in pain in OA knee patients. The morning serum cortisol levels of the three groups are contrasted in Figure 2 before and after the intervention. As seen by a significant decrease in post-test blood cortisol measurements, it is concluded that Group B benefits from perturbation training. The results of a walking speed test performed before and after the intervention are shown in Figure 3 for each of the three groups. The results of the walking speed test in the B group are significantly greater than those of Groups B and C, thus supporting the conclusion that perturbation training increases performance in Group B.

The WOMMAC questionnaire findings for each group's intervention before and after are shown in Figure 4. By showing that Group B's post-intervention findings have significantly decreased when compared to Group A's and Group C's, it is concluded that perturbation training enhances Group B. The results of the Y balance exam done before and after each group's intervention are compared in Figure 5. The pre-test - post-test values of Group B relative to Group A and Group C show a substantial increase, indicating that perturbation training enhances Group B.

**Table 5.** The demographic characteristics of the patients

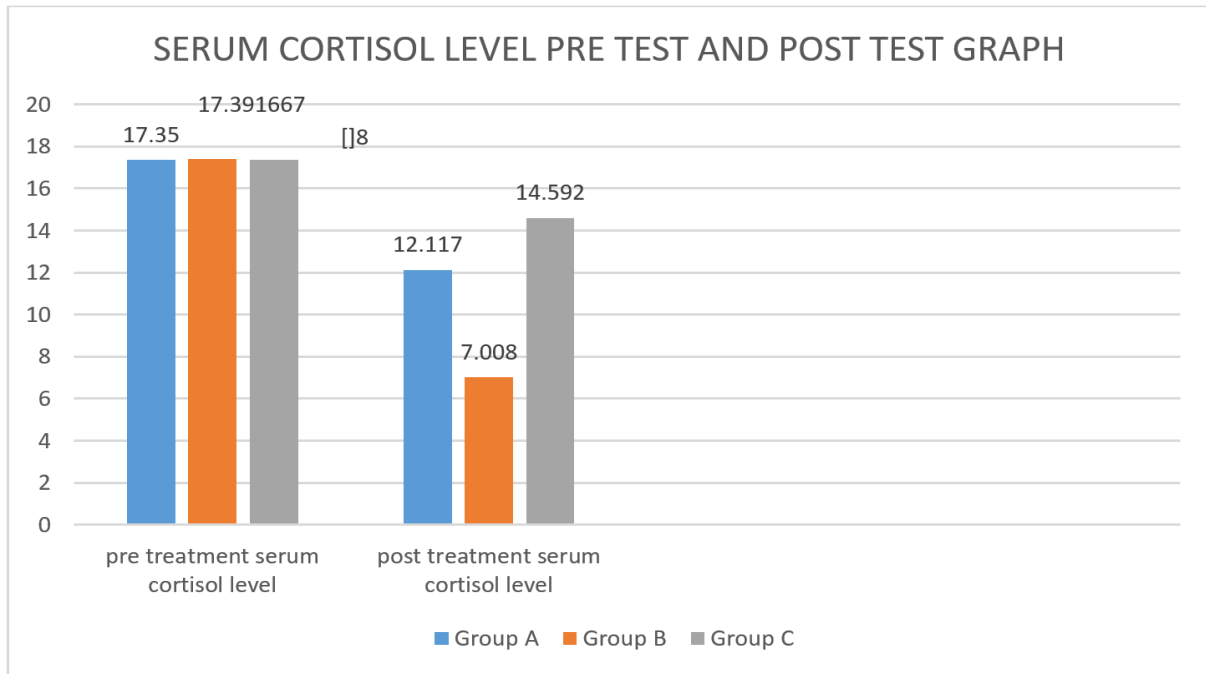
DEMOGRAPHIC DETAILS	MEN		WOMEN		TOTAL	
Number of patients	18		18		36	
Age	Forty-five- sixty		Forty-five- sixty		Forty-five- sixty	
Kellgren Lawrence scale	Grade II 10	Grade III 8	Grade II 12	Grade III 6	Grade II 22	Grade III 14

**Table 6.** Evaluation of outcome measures

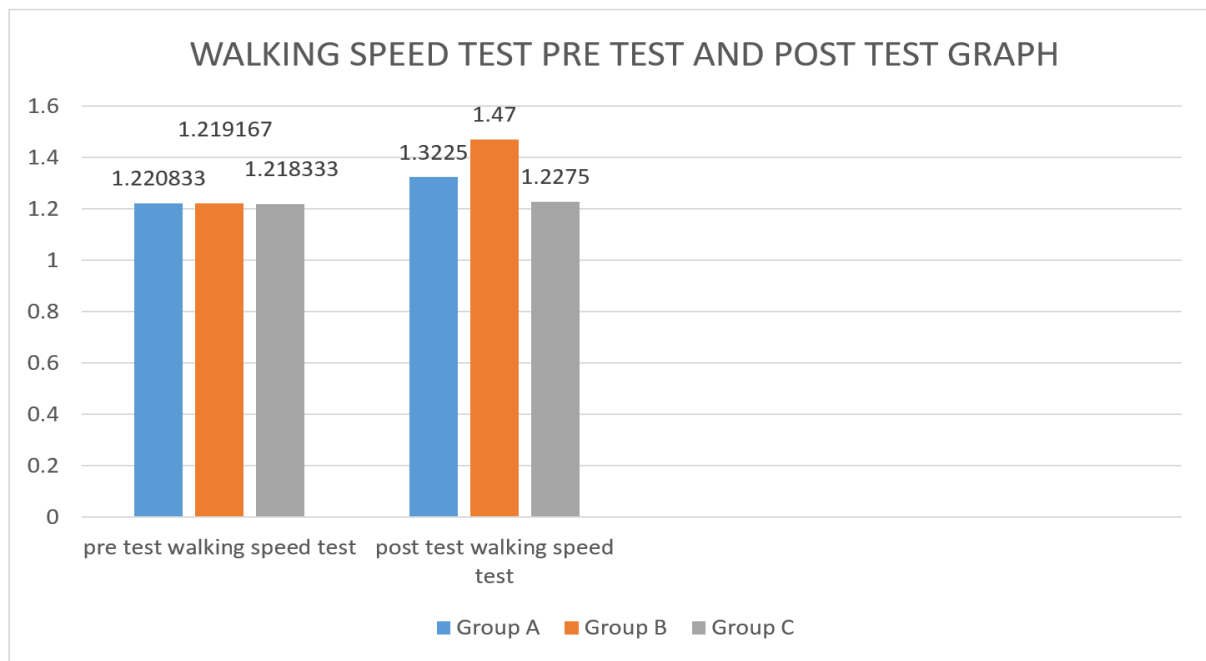
Subjects	Serum cortisol morning		Walking speed test		Y balance test		WOMAC questionnaire	
	first test	After evaluation	first test	After evaluation	first test	After evaluation	first test	After evaluation
Group A	17.35000	12.117	1.220833	1.322500	73.00	81.67	72.08	65.42
Group B	17.391667	7.008	1.2119167	1.470000	73.42	89.08	72.17	60.67
Group C	17.366667	14.592	1.2183333	1.227500	73.17	77.33	72.25	69.25
Total	17.369444	11.239	1.2194444	1.340000	73.19	82.69	72.17	65.11

**Table 7.** ANOVA, Test of significance: Between Group A, B, C and Within Groups A, B, C

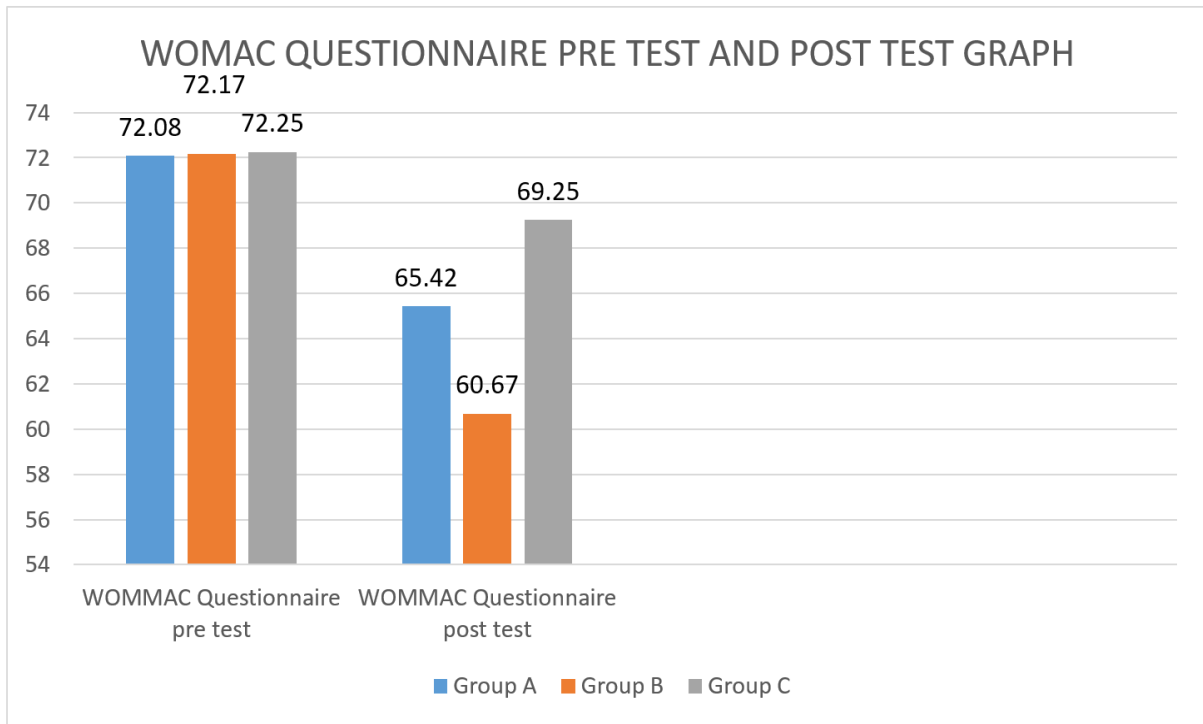
Serum cortisol morning level test		Walking speed test		Quadriceps thickness		WOMAC questionnaire		Y balance test	
Test prior to actually	After trial	Test prior to actually	After trial	Test prior to actually	After trial	Test prior to actually	After trial	Test prior to actually	After trial
.984	.000	.995	.000	.906	.000	.992	.000	.793	.000



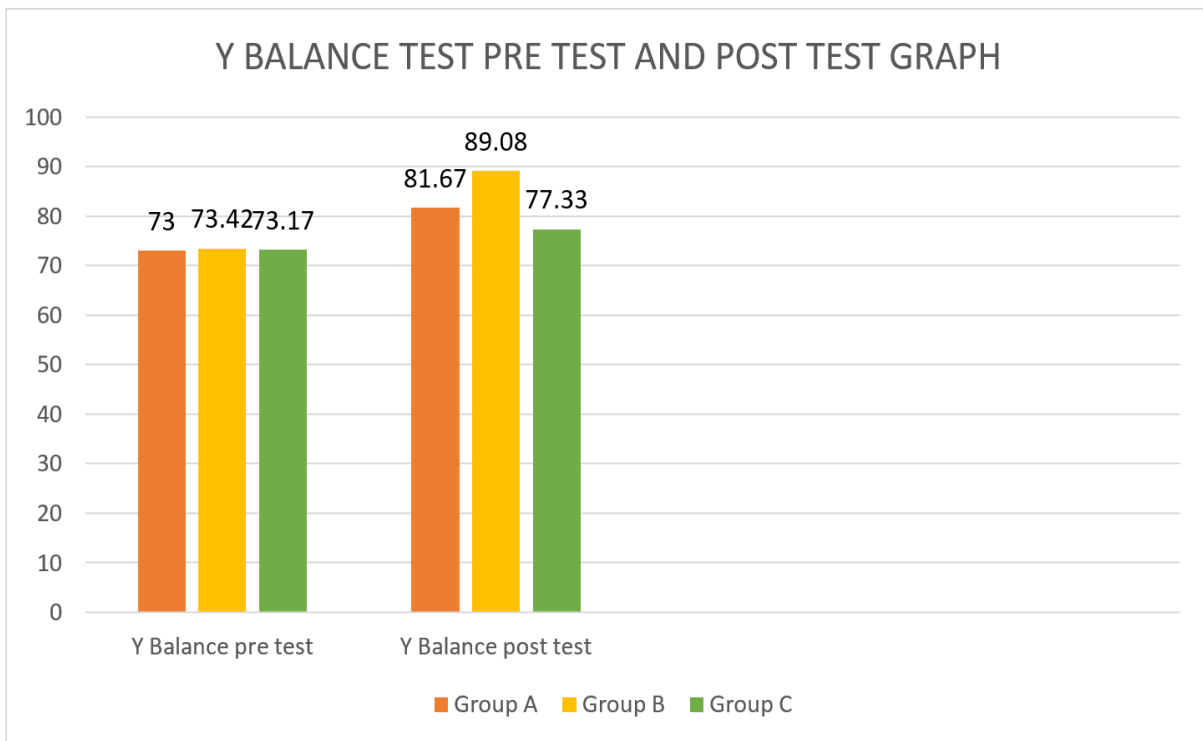
**Figure 2.** The morning serum cortisol levels of the three groups prior to and subsequent to the intervention. It concludes that perturbation training improves in Group B as evidenced by a considerable drop in post-test blood cortisol readings



**Figure 3.** The outcomes of a walking speed test conducted preceding and following the intervention for each of the three groups. It concludes that perturbation training improves in Group B as evidenced by the significantly higher post-test results of the walking speed test in Cluster B stood in contrast to groupings B and C



**Figure 4.** The WOMAC questionnaire results for each group's intervention before and after. It concludes that perturbation training improves Group B by demonstrating a significant decline in the postintervention findings of Group B compare to Group A and Group C



**Figure 5.** The Y balancing exam's findings conducted before furthermore after each group's intervention. It concludes that perturbation training improves Group B by demonstrating a significant rise in the pre-test - post-test values of Group B relative to Group A and Group C

## 4. Discussion

The purpose of the whole inquiry was to assess the efficacy of disturbance training, adaptive demand coaching, and conventional exercises to alleviate the symptoms of OA knees. The study started with Table 1 and proceeds as described in Tables 2, 3 and 4 and Figure 1. From the results, we can know that perturbation training is better than functional task exercises for pain reduction, muscle thickness, walking speed, steadiness, and autonomous functioning in arthritic knee sufferers. Similarly, incidence of Osteoarthritis increases globally Osteoarthritis, representing up to 2 percent of total of all Working - age adults internationally in 2019, as well as the 15th most prevalent trigger for years of disability globally between 1990 and 2019[18]. Osteoarthritis poses to be primary contributor to impairment in elders, primarily because of ageing population and increasing obesity [19]. Emrani et al. [20] stated that subjects with osteoarthritis of the knee often show muscle weakness and functional loss in the kneecap. Hip and quad muscle weakness affects the stability of the knee, so the patient changes his gait pattern to maintain balance while walking. This demands more energy, while at the same time, the patient's walking speed is reduced. This affects independence in activities of daily life, resulting in poor quality of life [21]. Exercises given to osteoarthritis knee patients should also promote daily living activities like using the toilet, getting up from a bed, getting in a car, and so on. In this study, functional task training improved neuromuscular control and equilibrium, along with a considerable improvement in the participants' exercise skills. Repetitive movements, which are used in daily life and exercises, improve the dynamic stabilization provided by the muscles. As a result, the poundage leg chain's forces and moments are enhanced [22]. A training program for OA knees containing perturbation training challenges the stability of the knee, which is compromised in osteoarthritis knees due to the various reasons cited above. In perturbation training, when a body is perturbed, the CNS uses reflexive, automatic, and voluntary movements to regain balance. In forward perturbation, there is reflex activation of the lower limb muscles such as the gastrocnemius, hamstring, paraspinals, tibialis anterior, quadriceps, and abdominals. In mediolateral perturbation, the hip abductors and hip adductors, ankle invertors, and evertors are activated. This activation of muscle improves the dynamic stability of the knee, improves the walking speed of patients, reduces their risk of falls, reduces pain, and makes them functionally independent [23]. Conditioning with regulated and unpredictable forces applied to an elevated platform for the lower extremities increases the effectiveness of the sustaining muscles throughout stride and gait [24]. The secretion of cortisol is considered to be the mechanism causing stress-induced suppression of immune function. Some studies have shown that serum cortisol levels decrease after meditation. Sezer Efe et al. [25] reported a decrease in the serum cortisol level

and a positive effect on the preservation of bone mineral density in preterm infants. In this study, the serum cortisol level decreased after exercises in all three groups, with perturbation training showing an efficient decrease in the serum cortisol level [Table 7, Figure 2]. This study is the first to demonstrate the effects of perturbation and cognitive activity conditions on individuals' blood cortisol levels with OA knees. Studies show that subjects with osteoarthritis knee walk with slow velocity, slow cadence, increased stance duration, and a small stride length [26]. They have a small flexion moment during the early stance. On this treadmill desk, exercise with more disturbances resulted in a small, huge rise in regional rail gait parameters and a decrease in loco motor instability in Parkinsonism disease [27]. In this study, perturbation training proved to increase the walking speed of the subjects with OA knees [Table 6, Figure 3]. Studies show that subjects with OA knees' poor quadriceps' power capacity and motor constriction, or the muscle's refusal to properly contract, are two factors that may contribute to muscle wasting. A lack of quadriceps prevents the functioning physical activities of patients with OA knee [28]. Soul Cheon et al. [29] concluded that the thickness of the quadriceps femoris and vastus located at different locations improved after open kinematic and closed kinematic chain exercises. To our knowledge, there was no previous research showing that perturbation training or functional task exercises decrease serum cortisol in individuals. This research reveals that perturbation training seems more powerful than functional task workouts and conventional exercises [Table 7, Figure 2].

G.K. Fitzgerald et al. [30] reported a positive outcome in the WOMAAC score after agility and perturbation training in OA knee patients. Another article also supports the idea that perturbation training improves the living values of individuals with OA knee. As per research, perturbation training is more efficient in rising one's standard of living and shows an increase in the WOMAC score [Table 6, 7, Figure 4]. The values of Group B are considered to be greater when compared to Group A and Group C [Table 6]. Perturbation training acts as an effective tool for improving balance and fall reduction in elders. Rafi Mohammed et al. [31] concluded that functional task training enhanced balance in elderly subjects. In this study, an increased mean value in the y balance score was seen following perturbation training in subjects with OA knees [Table 7, Figure 5]. Since there is no literature exploring the effectiveness of perturbation training over functional task exercises in the management of grade II and grade III OA knees, these findings may be used in physiotherapy practice to assist in the creation or implementation of interventions for OA knees and improve their quality of life. There is strong evidence for the effectiveness of perturbation task training performed for 12 weeks. Though, functional and conventional task training and conventional exercise were shown to be effective. The pre-test and post-test values of serum cortisol in the morning were



17.391667 and 7.008. The pre-test and post-test values of walking speed test were 1.2119167 and 1.470000. Both for the before and after evaluation of the WOMAC questionnaire were 72.17 and 60.67, and the prior and subsequent test results for the balance test were 73.42 and 89.08 [Table 7].

### Perspective

Based on the present results, the perturbation exercise appears to be effective in improving pain, increasing the thickness of the quadriceps muscle, walking speed, and balance, and improving the efficiency of stabilizing muscles during stance and gait. From a practical point of view, the perturbation exercises are easy to understand. However, the only drawback is that the exercise cannot be performed independently as it deals with balance. In addition, the present protocol has proven to give tremendous results. Frequent falls can be avoided with perturbation training exercises.

## 5. Conclusions

All these observations lead to our conclusion that preparation for everyday activities and for perturbations both reduces serum cortisol level i.e. pain, walking speed, balance and quality of life. Collectively our findings strengthen the conclusion that perturbation training is significantly better than functional task exercises on pain reduction, muscle thickness, walking speed, balance and functional independence in patients with OA Knee.

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