Research Paper

Examining Sensory-motor Training Versus Impairment-based Training on Pain and Function in Subjects With Knee Osteoarthritis

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ABSTRACT

Purpose: Osteoarthritis is a degenerative joint disease affecting synovial joints and damages joints due to stresses caused by an abnormality in any of the synovial joint tissues, including articular cartilage and subchondral bone, ligaments, menisci, periarticular muscles, peripheral nerves, and synovium. To compare the effect of sensory-motor training versus impairment-based training on pain and physical function in subjects with knee osteoarthritis.

Methods: Simple random sampling was used to divide 30 subjects aged 50 and 70 years who met the inclusion and exclusion criteria into two groups (n=15). Group A received sensory-motor training, while Group B received impairment-based training. Before the treatment, the subjects walked for 10 minutes to warm up. For three weeks, each group was treated three times per week. Pre-test; post-test outcomes are noted, the visual analog scale (VAS) was used to assess pain, and the Western Ontario and McMaster Universities osteoarthritis index (WOMAC) was used to assess physical function.

Results: Comparing the post-test pain (VAS) scores between groups showed that the Mean±SD of posttest pain (VAS) score in the sensory-motor training group was 2.707±1.01. The Mean±SD in the impairment-based training group was almost the same, at 2.29±1.13. It was statistically significant at the 5% level. Similarly, the Mean±SD of the posttest function (WOMAC) score in the sensory-motor training group was 16.55±6.92.

Conclusion: Sensory-motor training is superior to impairment-based training on pain and physical function in subjects with knee osteoarthritis.

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Highlights

● OA is a degenerative joint disease primarily affecting the weight bearing joints if left untreated presents with pain and limitation in activities of daily living further leading to joint damage and make the person crippled for life leading to total dependency on the family members.

● Sensory motor training has a significant impact on pain and function in subjects with OA Knee.

● Impairment based training has a task specific impact on pain and function in subjects with OA Knee however complexity of training should not be excluded depending on the age and body mass index.

● Individually both the techniques are effective on pain and function in subjects with OA Knee however sensory motor impairment training is superior in improving the functional outcomes compared to Impairment based training.

Plain Language Summary

Osteoarthritis is a degenerative joint disease that affects synovial joints. The most common cause of pain and disability in older people is a huge problem for them and for society as a whole. In the future, osteoarthritis will be more common because it is more likely to happen and more people get it as they age. For people with knee osteoarthritis, an exercise plan based on their limitations may not be enough to improve their overall physical function as much as possible. Even though these programmes can help reduce the physical problems caused by knee osteoarthritis, they may not be enough to fully improve basic tasks like walking or more complicated tasks like taking part in social role activities (work, recreation). Functional tasks like getting up from a sitting position, climbing stairs, or picking up things off the floor are examples of complex physical tasks that require more than just strength, joint range of motion, and endurance. To do these tasks well, cognitive, perceptual, and motor skills work together with strength, joint range of motion, and endurance. Statistically, there were more positive changes in the sensorimotor group than in the impairment-based exercise group. Standard, traditional exercises have been looked at in many studies to see how they help people with knee osteoarthritis. They were found to reduce pain, build muscle strength, and improve proprioception and functional level. Based on the results of the current study, however, a sensory-motor training programme is a good way to reach optimal levels of functional capacity.

1. Introduction

Osteoarthritis is a degenerative joint disease affecting synovial joints and causes joint damage due to stresses induced by abnormalities in synovial joint tissues, including articular cartilage, subchondral bone, ligaments, menisci, periarticular muscles, peripheral nerves, and synovium. The most common cause of pain and disability among the elderly creates a critical problem for the elderly and society. Longer life expectancy will lead to an increase in osteoarthritis in the future because its incidence and prevalence rise with aging [1, 2].

With aging, advanced glycation end-products (AGEs) accumulate in human articular cartilage and affect the tissue's biomechanical, biochemical, and cellular properties. For example, the accumulation of AGEs increases cartilage stiffness and brittleness while decreasing the synthesis and degradation of cartilage matrix constituents. When AGEs are present in high concentrations, articular cartilage becomes more vulnerable to damage, resulting in osteoarthritis [3].

Anatomical abnormalities such as valgus alignment of previous joint trauma, including meniscectomy, anterior cruciate ligament rupture, and common fracture, are also associated with an increased incidence of osteoarthritis. Pain is the main symptom. However, we still have a poor understanding of the cause of pain in osteoarthritis. If a patient aged 45 or older has activity-related joint pain and early morning joint stiffness lasting less than 30 minutes, the diagnosis should be made clinically without further testing. Aerobic exercise and muscle strengthening have improved joint pain and function. Weight loss improves not only joint pain and function but also other health advantages [4].

Several protocols are available for managing knee osteoarthritis to improve patient complaints and overall functional activities. These protocols include traditional exercise programs with various strength training, flexibility exercises, and range of motion exercises [5, 6]. However, the patient's frequent complaints of pain and functional activity levels cannot be entirely relieved and restored. These deficits were associated with various factors influencing balance control, including pain, loss of proprioception, and decreased muscle strength.

Sensory-motor training is often overlooked during the rehabilitation of patients with knee osteoarthritis. The researchers have proposed that improving sensorimotor function can enhance functional performance in patients with a knee injury while also slowing its progression, particularly in the geriatric population [7-9]. Studies have shown that impairment-based therapeutic exercise has effectively reduced knee pain and improved physical function, muscle strength, and gait speed in individuals with knee osteoarthritis [10-12]. However, recent evidence suggests modest improvements in general measures of physical function, with reported effect sizes in the moderate range.

The current study determines whether sensory-motor and impairment-based training effectively improves pain and function in subjects with osteoarthritis and determines which exercise is superior in achieving the outcomes in subjects with osteoarthritis. The main objective of the study is to compare the effect of sensory-motor training on impairment-based training on pain and physical function in subjects with knee osteoarthritis

Study hypotheses

Null Hypothesis (H0)

There will be no significant difference between sensory-motor training and impairment-based training on pain and physical function in subjects with knee osteoarthritis.

Alternate Hypothesis (H1)

There will be a significant difference between sensory-motor training and impairment-based training on pain and physical function in subjects with knee osteoarthritis.

2. Materials and Methods

Data collection

1. Employees State Insurance (ESI) Hospital, Rajajinagar, Bangalore.

2. Padmashree Diagnostic, Vijaynagar, Bangalore.

3. Padmashree Clinic, Nagarbhavi Circle, Bangalore.

Study participants and design

1. Population: Subjects with knee osteoarthritis

2. Sampling: Convenience sampling

3. Sample size: 30

4. Type of study: Comparative Study

5. Research Design: Pre-test; posttest comparative study design

6. Duration of the study: 6 months

Inclusion criteria

1. Subjects diagnosed with knee osteoarthritis by orthopedics,

2. Age group between 50-70 years,

3. Both genders,

4. Bilateral knee osteoarthritis,

5. Within the Kellgren-Lawrence radiographic scale of 1-3.

The subjects with knee deformities, cardiorespiratory diseases (ischemia, arrhythmia, precordial pain, or exercise-induced bronchospasm), rheumatic diseases, vascular impairment, postoperative knee replacement patients, or any knee surgeries and osteoporosis will be excluded.

Study materials

Couch, stopwatch, towel, plastic pylon markers, foam surface, wobble board, weight cuffs, paper, pen, and scale were used to document the study's variables.

Study procedure

After fulfilling the selection criteria and taking the written consent, the subjects were divided into two groups.

Determining the sample size to compare the two means was done according to the following Equation 1:

$$1.\ n=\frac{(Z_{1-\alpha/2}+Z_{1-\beta})^2\times S^2\times 2}{d^2}$$

Z_α=z value for α-level

Z_β=z value for β-level

S=combined standard deviation

d=Effect size (difference between means)

Group A (n=15) (sensory-motor training)

Group B (n=15) (impairment-based exercise training)

The study was approved by the Institutional Ethical Committee, Padmashree Institute of Physiotherapy.

Group A (sensory-motor training)

The subjects received three stages of training of static, dynamic, and functional. Each exercise was repeated 3-5 times during a session, with adequate rest periods between each set of exercises. The exercise progressed from easier to more difficult, and the patients were not allowed to progress to a more difficult stage until they completed the easier stage according to the protocol outlined below:

Tandem walking: Walk approximately 10-20 feet and repeat twice in each direction for four times.

Heel walking: Walk approximately 10-20 feet and repeat twice in each direction for four times. Every 1-2 sessions, the step width and step speed increased.

Toe walking: Walk approximately 10-20 feet, repeating twice in each direction for four times. Every 1-2 sessions, the step width and step speed increased.

Side-stepping: Walk approximately 10-20 feet in each direction twice for a total of four times. Every 1-2 sessions, the width and speed of the steps increase. The activity began on a level surface and progressed to side-stepping over low obstacles when subjects successfully side-stepped on level surfaces.

Braiding activities: Walk 10-20 feet and repeat twice in each direction for four times. Every 1-2 sessions, the activity progressed by increasing the width of the steps and the speed of the steps.

Front and back crossover steps during forwarding ambulation: Walk approximately 10-20 feet and repeat twice. Begin with tandem crossover steps and progress to full crossover steps. The width of steps and the speed of steps also progressed after every 1-2 sessions.

Shuttle walking: The activity progressed by increasing the width of the steps and the speed of the steps every 1–2 sessions.

Multiple changes in direction during walking on therapist command: The exercise duration is approximately 30 s, 3 sets.

Double-leg foam balance activity: The duration of the activity is approximately 30 s, 3 sets. The difficulty progressed as the patient progressed to catch the ball with the therapist unbalancing the patient while standing on foam and progressing to single leg support.

Tilt board balance training: Therapist perturbed for approximately 30 s each. If the subjects could tolerate single-limb weight bearing without knee pain, swelling, or buckling, the difficulty of the activity was progressed by adding a ball catch during the perturbations and progressing to single-limb support perturbations. They perform 3 sets.

Group B (impairment-based training)

Participants in this group were given the same standard exercise program, agility, and perturbation training. Side-stepping, braiding (lateral stepping combined with forward and backward crossover steps), front crossover steps during forwarding ambulation, back crossover steps during backward ambulation, shuttle walking (forward and backward walking to and from designated markers), and multiple changes in direction drill in which the therapist provided random hand signals to prompt the individual to change directions while walking were among the agility training techniques used (forward and backward, right and left lateral steps, diagonally backward and forward) [13].

To expose the individual's lower limbs and body to potentially destabilizing forces, perturbation techniques included the use of foam surfaces, tilt boards, and roller boards. During the perturbations, the participant attempted to maintain balance and control of the exercised lower limb.

Measurement of pain

The degree of pain was measured using a visual analog scale (VAS). On a 1 cm chart, the participants were asked to select a number between 0 and 10, with 0 indicating no pain and 10 indicating maximum pain. The participants mark the number that corresponds to the level of pain.

Table 1. Distribution of subjects with knee osteoarthritis according to gender among the groups

Row	Gender	No. (%)	
		A	B
1	Male	6(40.0)	5(33.3)
2	Female	9(60.0)	10(66.7)
		Chi-square value=0.144, df=1, P>0.05, NS	

NS: Not significant (P>0.05).

PHYSICAL TREATMENTS

Measures of function

The physical function subscales of Western Ontario and McMaster Universities osteoarthritis index (WOMAC)-pf were used to collect data on physical function at baseline and follow-up. The WOMAC-pf was used as a disease-specific function measure. The index is intended to reflect the issues faced by people with hip or knee osteoarthritis.

It consists of 17 physical function questions. Individual items are scored ranging from 0 ("no difficulty") to 4 ("high difficulty"). The WOMAC's dependability, validity, and responsiveness have been established [14].

Data analysis

The data were carefully collected, and baseline characteristics and outcomes were measured. SPSS version 20 was used to analyze the data. The level of significance was set at 0.05. The following statistical technique was used:

- The frequency and percentage analysis were used for the subjects' demographic data.
- Mean±SD was used to describe the subjects' age, pre-test; posttest outcome measures of WOMAC, and VAS.
- The Wilcoxon test was used to test the significant difference in pre-test; posttest outcome measures of WOMAC and VAS in each group.
- The Mann-Whitney U test was used to test the significant difference in pre-test; posttest outcome measures in WOMAC and VAS between the two groups.
- The Chi-square test was used to test the significance of gender proportion between groups.

The unpaired t-test was used to test the significant difference between the ages in both groups.

- Microsoft (MS) Excel and MS Word were used to generate the tables and graphs.

3. Results

Table 1 presents the proportion of subjects with knee osteoarthritis according to gender. In Group A, 6 subjects (40.0%) were men, and 9 subjects (60.0%) were

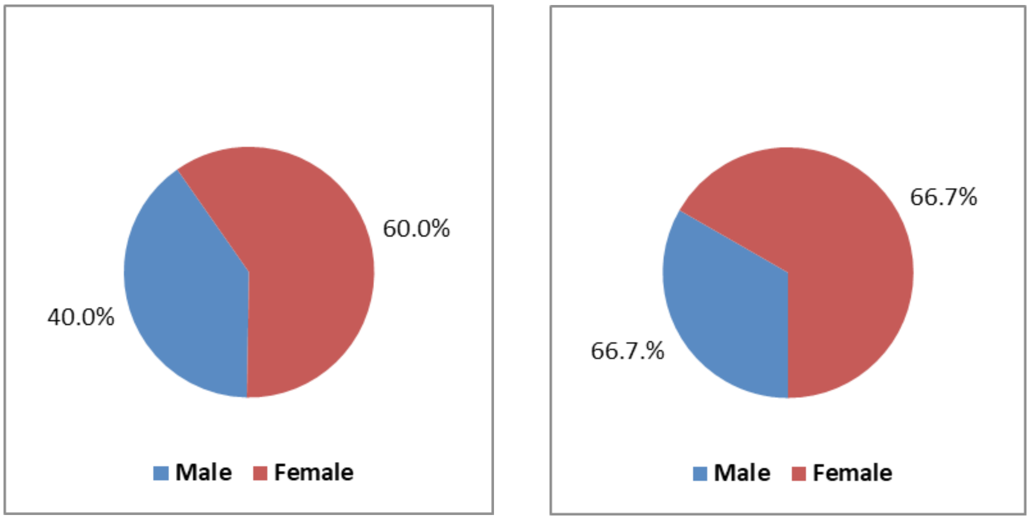

Figure 1. Gender distribution of subjects in group A and B

PHYSICAL TREATMENTS

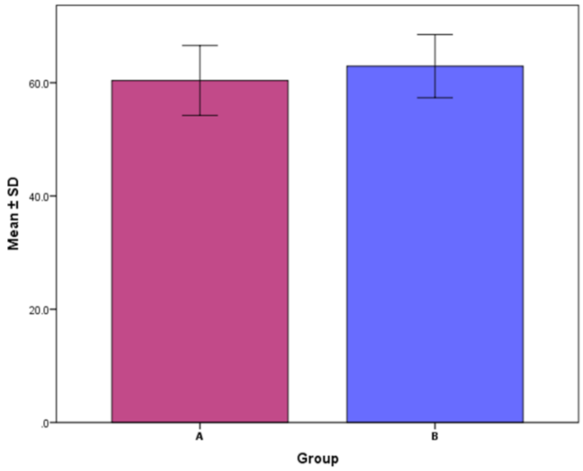

Figure 2. Mean±SD of age of the subjects with knee OA in both groups

PHYSICAL TREATMENTS

women. In group B, 5 subjects (33.3%) were men, and 10 subjects (66.7%) were women. Not much difference was observed between the groups according to gender, and it was not statistically significant (χ^2=0.144, df=1) at the 5% level (P>0.05). Thus, the baseline characteristics of gender are homogeneous in both groups. The following pie chart depicts the proportion of subjects with knee osteoarthritis according to gender (Figures 1-4).

Table 2 presents the age outcomes of subjects with knee osteoarthritis in both groups. In group A, the subjects were in the age range of 51-70 years with a Mean±SD of 60.40±6.17 years. In group B, the subjects were aged 54-70 years with a Mean±SD of 62.93±5.57 years. The unpaired t-test was used to compare the means, which was not significant (P>0.05). It revealed that the baseline characteristic of age was similar in both groups.

Table 3 lists the pre-test; posttest outcomes of VAS and WOMAC among the subjects with knee osteoarthritis in group A. In the pre-test, VAS ranged from 3.7 to 8.3 with a Mean±SD of 6.00±1.44. However, in the posttest, it increased to the range 0.9-4.7 with a Mean±SD of 2.707±1.01. The non-parametric test was used to compare dependent outcomes in order, Wilcoxon test was performed, which was significant (P<0.001).

According to the performance in the pre-test, the WOMAC scores ranged from 22.91 to 67.70 with a Mean±SD of 44.50±15.04. However, in the posttest, the scores were 9.37-31.25, with a Mean±SD of 16.55±6.92. The parametric test was used to compare dependent outcomes in order, and the paired t-test was performed, which was significant at P<0.001. It showed a significant increase in pain score (VAS) and function (WOMAC) among subjects with knee osteoarthritis in group A.

Table 4 lists the pretest; posttest outcomes of VAS and WOMAC among the subjects with knee osteoarthritis in group B. In the pretest, VAS ranged from 2.5-8.4 with a Mean±SD of 4.83±1.76. However, in the posttest, it increased to the range 1.1-5.1 with a Mean±SD of 2.29±1.13. The non-parametric test was used to compare dependent outcomes in order, Wilcoxon test was performed, which was significant (P<0.001).

According to the performance in the pretest, the WOMAC scores ranged from 19.79-76.0 with a Mean±SD of 43.67±17.15. However, in the posttest, the scores were in the range of 7.29-33.33 with a Mean±SD of 19.64±8.31. The parametric test was used to compare dependent outcomes in order, and the paired t-test was performed, which was significant at

Table 2. Range and Mean±SD of the age of the subjects with knee osteoarthritis in both groups

Row	Variable	A		B		Unpaired t-test
		Range	Mean±SD	Range	Mean±SD	
1	Age (y)	51-70	60.40±6.17	54-70	62.93±5.57	t=0.148, P>0.05, NS

NS: Not significant (P>0.05).

PHYSICAL TREATMENTS

Table 3. Range and Mean±SD of outcome measures of subjects with knee osteoarthritis in group A

Row	Outcome Measures	A				Wilcoxon Test	P
		Pretest		Posttest			
		Range	Mean±SD	Range	Mean±SD		
1	Pain (VAS)	3.7-8.3	6.00±1.44	0.9-4.7	2.707±1.01	z=3.410*	P<0.001
2	Function (WOMAC)	22.91-67.70	44.50±15.04	9.37-31.25	16.55±6.92	z=3.408*	P<0.001

PHYSICAL TREATMENTS

VAS: visual analog scale; WOMAC: Western Ontario and McMaster Universities osteoarthritis index. * Significant difference (P<0.05).

P<0.001. It showed a significant increase in pain score (VAS) and function (WOMAC) among subjects with knee osteoarthritis in group B.

Table 5 presents the outcome of a between-group comparison of pretest; posttest pain (VAS) and function (WOMAC) among subjects with knee osteoarthritis. The pretest pain score was 6.00±1.44 in group A and 4.83±1.76 in group B, which were more or less the same and not significant (P>0.05). Similarly, the functions 44.50±15.04 in group A and 43.67±17.15 in group B were not statistically significant (P>0.05). It showed that before the intervention, the subjects with knee osteoarthritis were similar in pain (VAS) and function (WOMAC) in both groups.

However, in the comparison of posttest scores of pain (VAS) between the groups, the Mean±SD of posttest pain (VAS) of the subjects with knee osteoarthritis in group A was 2.707±1.01. The Mean±SD of subjects with knee osteoarthritis in group B was 2.29±1.13. The non-parametric test was used to compare the independent outcomes of two groups; when the scores were ordinal, the Mann-Whitney U test was applied, and it was statistically significant (P>0.05). Similarly, the Mean±SD of the posttest function of the subjects with knee osteoarthritis in group A was 16.55±6.92. The amount was comparably more than the Mean±SD of subjects with knee osteoarthritis treated in group B, 19.64±8.31. The non-parametric test was used to compare the independent outcomes of two groups; when the scores were ordinal, the Mann-Whitney U test was applied, and it was statistically significant (P<0.001).

The result showed that sensory-motor training improved pain and function significantly more than impairment-based training among subjects with knee osteoarthritis.

4. Discussion

The study's objective is to compare sensory-motor training versus impairment-based training on pain and physical function in subjects with osteoarthritis. Sensory-motor training is a special program to restore motor control via maximizing sensory input from different parts of the body to improve the patient's pain, balance, and overall function level, and impairment-based exercise improves the deficiencies in the knee joint.

The study showed no gender difference between the groups, which was insignificant at the 5% level (χ^2= 0.144, df=1). As a result, the baseline gender characteristic is similar in both groups.

In our study, we found significant effects between the groups; in the results relating to the VAS and WOMAC

Table 4. Range and Mean±SD of outcome measures of subjects with knee osteoarthritis in group B

Row	Outcome Measures	B				Wilcoxon Test	P
		Pre-test		Post-test			
		Range	Mean±SD	Range	Mean±SD		
1	Pain (VAS)	2.5-8.4	4.83±1.76	1.1-5.1	2.29±1.13	z=3.411*	P<0.001
2	Function (WOMAC)	19.79-75.0	43.67±17.15	7.29-33.33	19.64±8.31	z=3..410*	P<0.001

PHYSICAL TREATMENTS

VAS: visual analog scale; WOMAC: Western Ontario and McMaster Universities osteoarthritis index. * Significant difference (P<0.05).

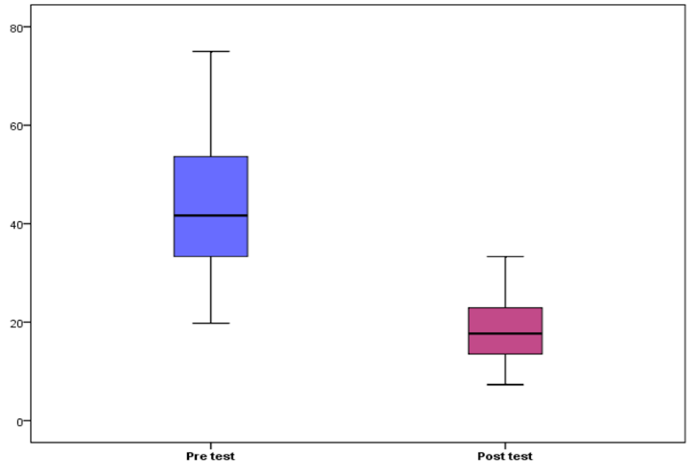

Figure 3. Pre and posttest function (WOMAC) of subjects with knee OA in between the group B

PHYSICAL TREATMENTS

questionnaire, we observed improvements in pain and physical function in both types of intervention used in the groups.

Group A variables were significant (P<0.001). Sensory-motor training progresses the patient via exercises in various postures, bases of support, and challenges to their center of gravity. As a result, each exercise induces automatic and reflexive muscular stabilization, challenging the patient to maintain postural control in various situations [15, 16]. Fitzgerald et al. compared a group of patients with knee osteoarthritis who underwent a traditional training program (muscle strengthening of the lower limbs associated with stretching exercises and joint range of motion) with a group who performed the traditional program along with sensory training (agility and coordination). Although the groups with additional sensory-motor training improved, the authors found no significant differences compared to the traditional rehabilitation program.

Also, in Group B, the outcome variables were significant (P<0.001). Task-specific exercise is not a new concept. Literature reports that this approach can help improve the performance of a functional task in the elderly [17, 18]. Alexander et al. [17] described a task-specific training program for elderly people living in congregate housing that emphasized getting out of bed and out of a chair. The program consisted of breaking down the functional tasks into the components that the participants practiced.

For people with knee osteoarthritis, an impairment-based exercise approach may be insufficient to maximize overall improvement in physical function. Although such programs can help reduce the physical impairments associated with knee osteoarthritis, they may be insufficient to fully influence basic functional tasks such as walking or more complex tasks such as participating in social role activities (work, recreation). Functional tasks such as standing up from a sitting position, climbing stairs, or picking up objects from the floor are examples of complex physical tasks

Table 5. Mean±SD of pre-test/posttest outcome measure of subjects with knee osteoarthritis in the groups

Row	Outcome Measures	Mean±SD			
		Pre-test		Post-test	
		Group A	Group B	Group A	Group B
1	Pain (VAS)	6.00±1.44	4.83±1.76	2.707±1.01	2.29±1.13
2	Function (WOMAC)	44.50±15.04	43.67±17.15	16.55±6.92	19.64±8.31
Between-group comparison Mann-Whitney U test		VAS: z=1.669, P>0.05, NS WOMAC, z=1.104, P>0.05, NS		VAS: z=1.978, P<0.05, S WOMAC, z=2.621, P<0.05, S	

PHYSICAL TREATMENTS

VAS: visual analog scale; WOMAC: Western Ontario and McMaster Universities osteoarthritis index.
S-Significant difference (P<0.05); NS-Not significant difference (P>0.05).

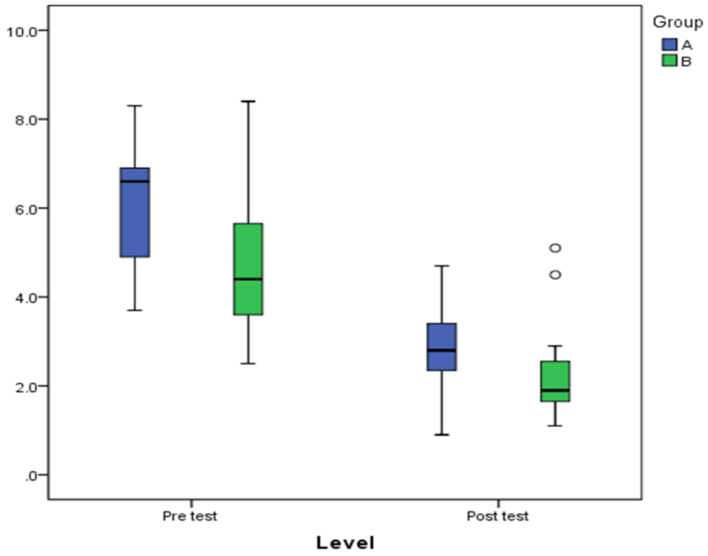

Figure 4. Pre and post test pain (VAS of subjects with knee OA in between the groups

PHYSICAL TREATMENTS

in which, in addition to the minimum requirements of strength, joint range of motion, and endurance, other factors such as cognitive, perceptual, and motor skills interact to achieve the best performance [19].

A task-specific approach would allow patients to practice and learn problem-solving skills for the task that is most difficult for them. Also, it may provide the therapist with a better evaluation tool to determine the types of impairments or physical deficits influencing the performance of the problematic task. This information, in turn, can help therapists design impairment-based exercise components in the rehabilitation program correctly.

Constructive variations were statistically significant in the sensorimotor group compared to the impairment-based exercise group. Many studies have investigated the effect of standard traditional exercises on the management of knee osteoarthritis and found that they reduced pain and increased muscle power, improving proprioception and functional level [20]. However, based on the findings of the current study, a sensory-motor training program is effective in achieving optimal functional capacity levels. Exercises targeting neuromuscular components should be included.

5. Conclusion

Sensory-motor training improves pain and physical function compared to impairment-based training; however, impairment-based training improves specific physical functional tasks and components depending on the task used for the training and the age factor; these exercises need to be imparted.

Study limitations

The training frequency and sessions received in both groups differ, affecting the results. The second limitation of the study is the type of training received in Group B that few subjects could not complete the entire session.

Ethical Considerations

Compliance with ethical guidelines

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Funding

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Authors' contributions

All authors equally contributed to preparing this article.

Conflict of interest

The authors declared no conflict of interest.

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