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Effect of Kinesthetic Exercises versus Agility Exercises in Unilateral Osteoarthritis Knee on Pain, Function and Proprioception - An Interventional Study

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ABSTRACT

Introduction: Due to modernization, obesity, hormonal imbalance and as a response to aging process knee osteoarthritis rate has increased leading to pain, proprioception and physical function deficits. Kinesthetic and agility exercises have shown improvement in joint position sense, physical function and quality of life in knee osteoarthritis patients. Very few studies have been done to study the comparative effect of agility exercises and kinesthetic exercises on Indian population. Hence there was a need to compare the effects of kinesthetic exercises versus agility exercises on knee osteoarthritis.

Materials & Method: After taking written informed consent patients were divided into 3 groups by simple random sampling. Group A received agility plus conventional exercises, Group B received kinesthetic plus conventional exercises and Group C received conventional exercises. Hot pack was given to all 3Groups. All the 3Groups received treatment for 15sessions 4sessions per week for 4 weeks. Pre and post interventional NPRS, Joint position sense error and WOMAC scale were measured.

Results: Baseline data were compared using ANOVA test, within group analysis was done using Wilcoxon test and between group analysis was done using Kruskal Wallis test (between 3groups) and Man-Whitney U test (between 2groups). There was statistically significant difference between and within group for NPRS, joint position sense error and WOMAC scale.

Conclusion: Present study concludes that Agility exercises are more effective than kinesthetic exercises in reducing pain and improving proprioception and physical function in osteoarthritic knee.

Keywords: Knee osteoarthritis, Agility and Kinesthetic Exercises.

INTRODUCTION

Osteoarthritis is a chronic degenerative disorder of multifactorial etiology characterized by loss of articular cartilage, hypertrophy of bone at margins, subchondral sclerosis and range of biochemical and morphological etiologies of synovial membrane and joint capsule.[1] It is hypothesized that knee proprioception is important in coordinating complex movement systems and precise knee joint motions. Osteoarthritis is characterized pathologically by Softening, Ulceration and focal disintegration of articular cartilage, Subchondral bone thickening, Marginal osteophyte.[2] Clinically by Pain, stiffness and progressive limitation of joint range of motion, Joint swelling and coarse crepitations, Muscle atrophy and weakness, Joint deformity, Instability.[3]

Muscle weakness or atrophy may decrease muscle spindle sensitivity, thereby possibly impairing proprioceptive accuracy.[6][14] Proprioceptive reflexes allegedly act to minimize impact on ligaments by reflex contraction of protective muscles.[6]

Kinesthetic exercises are important in motor control, proprioception for anticipation, preparation and response planning which in turn is dependent on joint mechanoreceptors.[5]

Modified agility programs for knee osteoarthritis included performing agility techniques using walking based rather than running based technique.[7] These programs exposed the individual to challenges of motor function encountered in daily activities like quick turns, stops and changes in direction, challenges to balance and negotiating obstacles[7] thereby assisting in returning to higher levels of physical function with less pain.[8] This study had been done to study the comparative effect of agility exercises and kinesthetic exercises on Indian population.

MATERIALS AND METHODOLOGY

Study Design: Interventional study

Study Setting: This study was conducted in outpatient physiotherapy department of a hospital. All the patients were referred from orthopedic outpatient department.

Study Duration: The total duration of the study was 1 year. Each patient was treated for a period of 15sessions.

Sampling Technique: Randomized sampling (chit method)

Sample Size: Total patients: 30 was calculated according to following formula.[27][28]

$N=2SD^2(Z_{a/2}+ Z_B)^2/d^2$ where,

SD= Post SD

d=critical difference

$Z_a/2$= level of significance at 95% confidence interval the value is 1.96.

Z_B= Power of study, at 95% power the value is 1.64.

Selection Criteria

1. Inclusion criteria:

1. Patient diagnosed by medical practitioner with osteoarthritis of knee.
2. Patients willing to participate.
3. Both male and female were included.
4. Age group between 45-65 years.[51]
5. Patient were selected as per American College Of Rheumatology criteria
   - Age >50 years
   - Morning stiffness<30 minutes
   - Crepitus on knee motion
   - Bony tenderness
   - Bony enlargement
   - No palpable warmth
6. Patients having symptoms from last 3months.

2. Exclusion Criteria:

1. Any H/O neurological or vestibular disorders.
2. Any H/O musculoskeletal problem of hip and ankle.
3. Any H/O Diabetes.

Withdrawal Criteria

(1) Patient's willing to withdraw.

(2) If the symptoms aggravates due to study intervention.

Materials and Apparatus

- Consent form
- Assessment form
- Examination table
- Paper
- Pencil
- Universal goniometer
- Sand bag
- Hotpack
- WOMAC score sheet
- Double side sticky tape
- Straps
- Camera
- Weight cuff

Figure 1: Materials used

OUTCOME MEASURES:

(1) NPRS (Numeric Pain Rating Scale):

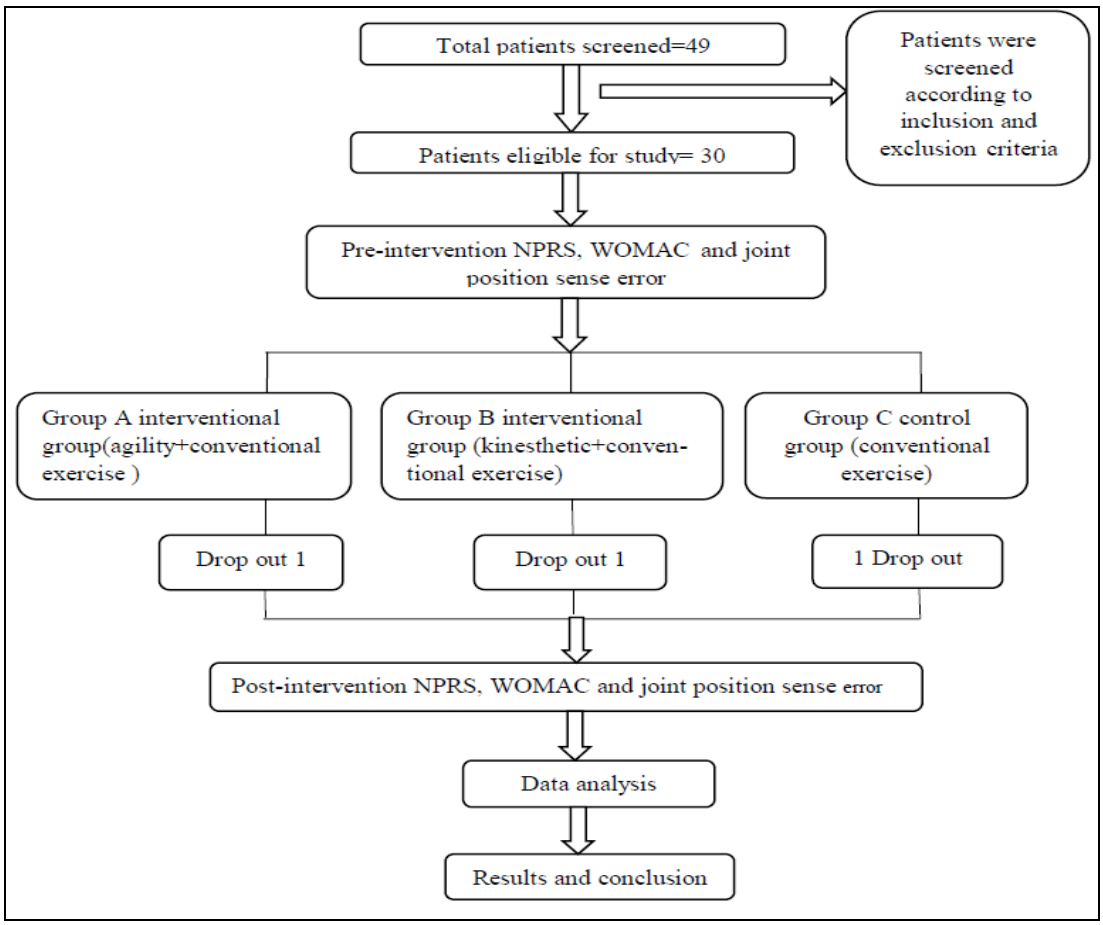
Validity: For construct validity, the NPRS was shown to be highly correlated to the VAS in patients with rheumatic and other chronic pain conditions (pain>6months); correlation range 0.86 to 0.95).[20]
Reliability: Test-retest reliability was r=0.96 and 0.95. [20]

(2)Western Ontario and McMaster University Scale (WOMAC scale):
Validity: Cronbach's alphas for Likert scale format of the WOMAC were 0.86-0.89, 0.90-0.91 and 0.95 for the pain, stiffness and function subscales respectively.
Reliability: The test-retest reliability (interclass correlation coefficients: ICC) were 0.74, 0.58 and 0.92 for pain, stiffness and physical function subscales respectively. [21]

(3) Joint Position Sense Error:

The shadow goniometer was found to be a good reliable with Intraclass correlation of 0.993(p value<0.0001) and valid tool with correlation coefficient 0.996 (p-value<0.0001) in measuring knee flexion range of motion.[23][24]

Flow Chart of Procedure



Procedure:

Patients were included as per selection criteria after taking written informed consent. Then divided into 3groups by simple random sampling (chit method). Treatment was given for 15sessions in 4weeks.

Group A: Interventional group (Agility exercise)

Patients in this group were given hot pack, agility and conventional exercises. Agility exercises included the following: [15]

(1) **Wedding march**: Step forward and slighty to one side with leading foot, bring trailing foot together with the leading foot; alternate leading foot.

Step 1 Step 2

Figure 2: Wedding march

(2) **Backward wedding march**: Step backward and slighty to one side with the leading foot, bring trailing foot together with the leading foot; alternate leading foot.

Step 1 Step 2

Figure 3: backward wedding march

(3) **High knees march**: Walk forward while flexing hip about 90 degrees.

Figure 4: High knees march

(4) **Side stepping**: Stand with feet together, step to side with leading foot, bring trailing foot back to leading foot; repeat for prescribed number of steps, then repeat in opposite direction.

Step 1 Step 2

Figure 5: Side-stepping

(5) **Semi-tandem walk**: Walk heel-to-toe with heel landing just in front of and medial to great toe of opposite foot.

Figure 6: Semi-tandem walk

(6) **Tandem walk**: Advanced version of above, heel lands directly in front of opposite foot.

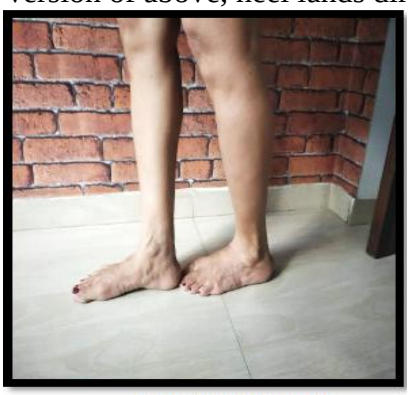


Figure 7: Tandem walk

(7) **Cross-over walk**: Walk forward bringing each foot across midline of body.

Figure 8: Cross-over walk

(8) **Modified grapevine**: Step to side with right foot, bring the left foot behind the right, step to side with right, bring left in front of right; repeat for prescribed number of steps ; change leading foot and repeat in opposite direction.

Figure 9: Modified Grapevine

(9) **Toe walking**: Walk forward on toes.

Figure 10: Toe-walking

(10) **Heel walking:** Walk forward on heels.

Figure 11: Heel-walking

Participants began with approximately 15steps of each exercise and progressed to a maximum of approximately 75 steps.[15]

Group B: Interventional group (Kinesthetic exercise)

Patients in this group were given hot pack, kinesthetic and conventional exercises.

Kinesthetic exercises included [17]

(1) **One leg balance**: It involved standing on affected foot with relaxed, upright posture and the other leg flexed at knee, hip and ankle. This position was held for one minute, followed by rest for 10-20 seconds, and was repeated twice more. After a brief rest, three similar repetitions were carried with the unaffected leg.

Figure 12: One Leg Balance

(2) **Blind advanced one leg**: It involved standing on affected foot with relaxed, upright posture and the other leg flexed at knee, hip and ankle with eyes closed. This position was held for one minute, followed by rest for 10-20 seconds, and was repeated twice more. After a brief rest, three similar repetitions were carried with the unaffected leg.

Figure 13: blind advanced one leg balance

(3) **Toe walking**: Here the participant was made to walk 20 meter distance up on the toes pointing straight ahead, then walk with toes pointing forward. After a short rest, the procedure was repeated once again.

Figure 14 : Toe-walking

(4) **Heel walking:** Walking for 20 meters on heel with toes pointing out and then toes pointing in after a short rest, the procedure was completed once more.

Figure 15: Heel walking

(5) **Cross body leg swings**: Leaning slighty forward with hands on a wall for support and weight on affected leg, other leg was swing in front of the body. This was repeated for 15 times and after a brief rest, 15 similar repetitions with unaffected leg as weight-bearing limb were performed.

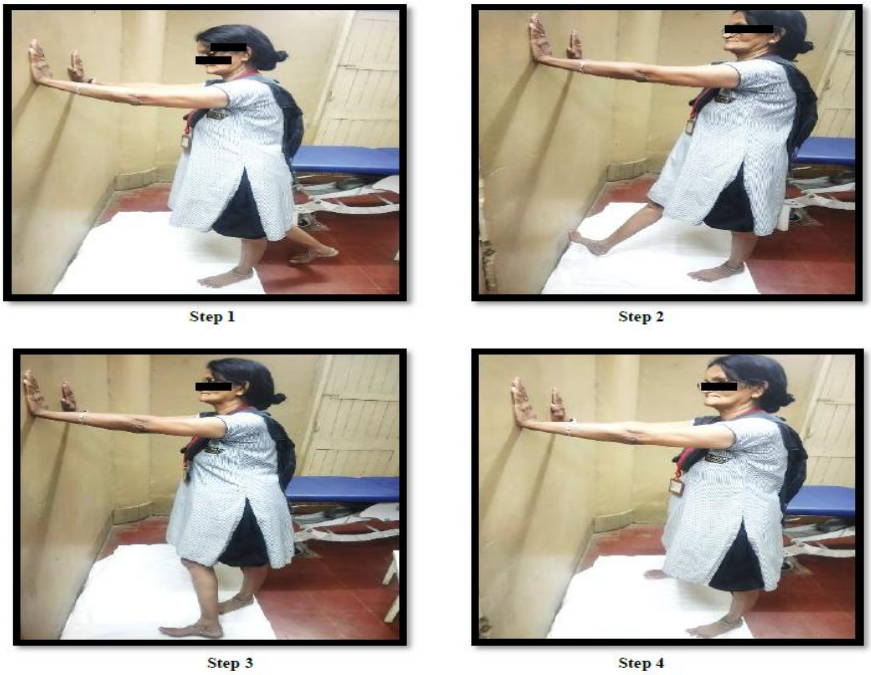


Figure 16: cross over leg swings

Group C: Control group

Both control and interventional groups were given progressive muscular strengthening program. All exercises are performed thrice daily and 10 repetition of each exercise. Exercise are performed once in department once in department and twice at home.[26]

Patients in this group were given hot pack and conventional exercises. Conventional treatment included: [31]

(1) Hot pack at knee joint for 10minutes.[29]

Figure 17 Hot Pack

(2) **Static quadriceps exercises:** Position of the patient: Supine or long sitting with knee extended (or flexed a few degrees) and towel underneath.

Procedure: Ask patient to contract the quadriceps isometrically, causing the patella to glide proximally, then hold for count 10, and repeat. Have the patient dorsiflex the ankle while holding the isometric contraction of the quadriceps.

Figure 18: Static Quadriceps Exercise

(3) Short arc terminal knee extension: Position of the patient: Supine or long sitting. Place a rolled towel or bolster under the knee to support it in flexion.

Procedure: Ask the patient to extend the knee. Initially have the patient extend the knee only against the resistance of the gravity. Later, add cuff weights around the

ankle to increase the resistance if the patient does not feel the pain or crepitation.

Figure 19: terminal knee extension

(4) Strengthening in Straight leg raise:
Patient's position: Supine with knee extended. Foot is placed flat on the exercise table. Opposite hip and knee are flexed to stabilize the pelvis and low back.
Procedure: Instruct the patient to set the quadriceps muscle and then lift the leg to about 45^0 of hip flexion while keeping the knee extended. Hold the position for a count of 10 and then repeat.

Figure 20: Straight leg raise

(5) Hip abductor strengthening in side-lying:
Patient's position: Side lying with affected leg upward. Hip and knee of the lower leg flexed for pelvis stability.
Procedure: Ask the patient to lift the leg while keeping the knee extended. Resistance can be added with weights.

Figure 21: Side-lying hip abductor strengthening

(6) **Hamstrings strengthening in prone position**:
Patient's position: Prone lying with a small towel roll or form rubber under the femur joint proximal to the patella to avoid the compression of the patella between the treatment table and femur.
Procedure: Weight cuff is tied around the ankle. Patient is asked to flex the knee only upto

Figure 22: Hamstring strengthening

(7) **Hamstring muscle stretching:**
Patient's position: Supine lying, with the patient's knee fully extended, support the patient's lower leg with your arm and shoulder. Stabilize the opposite extremity along the anterior aspect of the thigh with your outer hand or belt or with the assistance of another person.
Procedure: With the knee at 0^0 extension, and the hip in neutral rotation, flex the hip as far as possible. (3 repetition with 30 second).

Figure 23: Hamstring Stretching

(8) **Gastrocnemius stretching**:
Patient's position: Supine lying.
Procedure: Grasp the patient's heel (calcaneus) with one hand, maintain the subtalar joint in neutral position, and place your forearm along the planter surface of your foot. Stabilize the anterior aspect of the tibia with the other hand. Dorsiflex the talocrural joint of the ankle by applying pressure in a superior direction just proximal to the heads of the metatarsals with your forearm. (3 repetitions with 30 second hold)

Figure 24: gastrocnemius stretching

(9) **Quadriceps strengthening in high sitting position**:
Patient's position: High sitting
Procedure: Ask the patient to extend the knee from 90^0 to full extension. Apply resistance to the motion as tolerated.

Figure 25: Quadriceps strengthening

(10) **Closed chain exercise- partial squats.**
Patient's position: Standing with back against the wall.
Procedure: Ask the patient to flex the hip and knee and slide the back down and then up the wall, lowering and lifting the body. As the control improves, have the patient into greater knee flexion, up to a maximum of 60^0.

Figure 25: Closed Chain squats

RESULTS

Total 27patients were included in the study, based on the inclusion and exclusion criteria. After taking informed, written consent subjects were randomly allocated into 3 groups. Group A (interventional group), Group B(interventional group) and Group C(control group). Statistical analysis was done by using SPSS version 16. All outcome measures (NPRS, WOMAC and joint position sense) were analyzed at baseline and after 15sessions treatment. Confidence interval was kept at 95% and level of significance was kept at 0.05.

Kolmogorov-Simonov test and Shapiro-Wilk test were applied and the data were not normally distributed. (Ordinal scale WOMAC is used)

Baseline data was calculated by using one way-analysis of variance (ANOVA) test which showed that data were similar at baseline.

Table: 1 Baseline Characteristics

Variable/outcome measures	Total (n=30)	Group A	Group B	Group C	F value	P value
	Mean±SD	Mean±SD	Mean±SD	Mean±SD		
Age	55.59±6.92	55.4±9.08	55±8.65	52.90±7.68	0.250	0.310
NPRS	5.74±0.71	5.88±0.78	5.77±0.83	5.55±0.52	0.491	0.50
WOMAC	39.92±6.93	41.88±8.69	40±6.43	37±4.92	1.275	0.29
Joint position sense	17.79±4.19	17.65±4.26	15.73±8.24	19.99±3.90	2.625	0.70

Table 2: Gender distribution of the patients in all the 3groups

Gender	Group A	Group B	Group C
Male count %	3	5	4
Female count%	7	5	6
Total	**10**	**10**	**10**

Table 3: statistical tests used for analysis of each outcome measures

ANALYSIS	NPRS	WOMAC	JOINT POSITION ERROR
Within group analysis of group A,B and C	Wilcoxon signed rank test	Wilcoxon signed rank test	Wilcoxon signed rank test
Between groups A,B and C	Kruskal-wallis H test	Kruskal-wallis H test	Kruskal-wallis H test
Between Group A and B, Group A and C and Group B and C	Man whitney U test	Man whitney U test	Man whitney U test

Table 4: Analysis of NPRS within group A, B and C was done using Wilcoxon test showed significant difference between pre and post intervention pain in all 3 groups.(p<0.05)

Groups	Pre treatment	Post treatment	z value	p value
	Mean±SD	Mean±SD		
Group A	5.88±0.78	2.55±0.72	2.762	<0.05
Group B	5.77±0.83	3.44±1.01	2.762	<0.05
Group C	5.55±0.52	4.22±0.97	2.585	<0.05

Between 3 groups analysis for NPRS was done by using Kruskal-wallis H test. Statistically significant difference was found between three groups.(p<0.05) (chi-square value=19.31)

Table 5: Man-whitney U test for between groups analysis of NPRS

Man-whitney U test	Between group A and B	Between group A and C	Between group B and C
z value	3.04	3.69	2.78
p value	<0.05	<0.05	<0.05

Table: 6 Analysis of WOMAC within group A,B and C was done using wilcoxon test. which showed statistically significance difference in three groups(p<0.05)

Groups	Pre treatment	Post treatment	z value	p value
	Mean±SD	Mean±SD		
Group A	41.88±8.69	23.22±7.69	2.714	<0.05
Group B	40.88±6.93	26.88±6.25	2.680	<0.05
Group C	37.00±4.92	27.33±5.76	2.677	<0.05

Analysis of **WOMAC** score between groups was done with **kruskal-wallis H test**. Which showed statistically significance difference between three groups(p<0.05)

Table 7: Man-whitney U test for WOMAC score between groups showed significant difference.

Man-whitney U test	Between group A and B	Between group A and C	Between group B and C
z value	3.69	3.31	3.19
p value	<0.05	<0.05	<0.05

Table 8: Within group analysis of joint position sense error was done by using wilcoxon test which showed statistically significant difference between pre and pre intervention.(p<0.05)

Group	Pre treatment	Post treatment	z value	p value
	Mean±SD	Mean±SD		
Group A	17.65±4.26	8.59±3.15	2.67	<0.05
Group B	15.73±8.24	8.24±2.38	2.66	<0.05
Group C	19.99±3.90	14.17±3.47	2.67	<0.05

Table 9: Man-whitney U test between groups A,B and C for Joint position sense error showed significant difference.

Man-whitney U test	Between group A and B	Between group A and C	Between group B and C
z value	2.93	2.88	2.65
P value	<0.05	<0.05	<0.05

Table 10: Post Mean difference between groups for NPRS,JPSE and WOMAC

Variable	Group A(pre-post difference) Mean±SD	Group B(pre-post difference) Mean±SD	Group C(pre-post difference) Mean±SD	Chi-square value between three groups	p value
NPRS	3.33±0.5	2.33±0.5	1.33±0.70	19.31	<0.05
Joint position sense error	9.05±1.48	6.86±1.23	5.81±2.4	11.81	<0.05
WOMAC	18.11±1.36	14.33±1.58	12.66±2.5	21.15	<0.05

Between group analysis of joint position error was done with Kruskal-Wallis H test. Which showed statistically significant difference between three groups. ($p>0.05$)(chi-square value=11.818)

Multiple comparisons of NPRS, WOMAC score and Joint position sense error was done by using Kruskal-Wallis test and Man-Whitney U test between groups. The p value for group A and B was <0.05, for group A and C was <0.05 and for group B and C was <0.05. So there was statistically significant difference between group A and B, group A and C as well as between group B and C.

So alternate hypothesis $H_1$1, $H_1$2, $H_1$3 are accepted and Null hypothesis $H_0$1, $H_0$2, $H_0$3 are rejected. There is significant difference between effect of agility and kinesthetic exercises on pain, function and proprioception.

DISCUSSION

At the end of 15 sessions, patients in all the three groups showed improvement in pain, proprioception and physical function (WOMAC score) between and within group on statistical analysis by using SPSS16.

The mean differences of NPRS, proprioception and physical function was higher in group A as compared to other two groups. So agility exercises along with conventional exercises are more effective in improving pain, function and proprioception in knee osteoarthritis.

As per the result of the study statistically significant effect of agility exercises can be due to modified walking based exercises that simulated various activities of daily activities exposing the individual to quick turns, changes in direction and negotiating obstacles in the environment focusing on motor deficits, muscle weakness. It included various components of stability, balance, weight-bearing closed chain exercises and retrowalking. All these components increase the stability and co-contraction which simulates various muscle work activities of daily living like walking, changing directions, quick turns, getting up from sitting[11] thereby improving physical function. Exercises included in agility activate agonists as well as antagonists at hip, knee and ankle simultaneously, and are similar to activities in daily living. Weight-bearing promotes synovial diffusion which promotes increased healing capacity, joint lubrication and also stimulates mechanoreceptors thereby enhancing the joint position sense there by providing proper input and motor output in turn providing sensorimotor control.[11][12] Thereby improving joint position sense error. All these components of agility reduce the risk of fall and increases physical function and reduce pain. Results of present study are similar to those done by Matthew W. Rogers et al in 2011 who concluded that kinesthesia, balance and agility exercises showed earlier improvement in pain and physical functional as compared to conventional exercises. Results of the study showed that there was 70 significant improvement in knee stability and symptomatic relief and maximal functional capacity for community based physical activity in both groups which led to improvement in Outcome measures WOMAC scale, KOOS scale, get up and go

test(GUG), timed 10-stair climbed and descent time but kinesthesia, balance and agility exercises showed earlier improvement in physical function in WOMAC scale. [30] Results of the present study are similar to the study done by Dr. Mounika Jupudi et al (2017), "Effects of Mulligan's Mobilization Adjunct to Agility and Perturbation Exercises in Subjects with Knee Osteoarthritis". They concluded that Mulligan's technique with Agility and perturbation exercises is a better treatment approach than Mulligan's with conventional treatment in improving NPRS, ROM and WOMAC score.[31] The addition of mobilization with movement leads to correct tracking of joint movements led to improved joint position sense, pain and in turn physical function. The results of present study were similar to those done by Oleksandr Krasilshchikov et al (2018), to study effects of Perturbation and Functional Task Training on elderly 45 osteoarthritis patients. Improvements in daily function and physical function were seen due to exercise resembling the daily activity. The exercises with modifications which included performing agility techniques using stepping-based rather than walking-based activities and combining double-limb support with than single-limb support showed significant improvement in training groups with significantly better scores in outcome measures WOMAC, Timed "Up and Go" (TUG), Berg Balance Scale (BBS) test, Six minutes walking distance test than the subjects from the control group. [16] Results of the present study were supported by study done by Fitzgerald GK et al (2002), did a case study "Agility and perturbation training for a physically active individual with knee osteoarthritis" on a 73-year-old woman with bilateral knee OA. The rehabilitation program consisted of lower-extremity stretching, strengthening and endurance exercises that were supplemented with a variety of walking-based agility training techniques, and perturbation training techniques for 6 weeks 2times per week. At the completion of rehabilitation, the patient was able to walk on level surfaces and stairs and return to playing golf and tennis without episodes of instability and with reduced pain due to Supplementation of rehabilitation programs for people with knee OA with a modified agility and perturbation training program may assist them in returning to higher levels of physical activity with less pain and instability following rehabilitation.[5]

The effect in Group B could be due to stimulation of mechanoreceptors and developing sensorimotor control. Kinesthetic physical awareness refers to the knowledge of your surroundings that you receive via the sensory receptors in your joints, muscles and skin. Kinesthesia is described as the ability to sense the motion and its direction.[9] Addition of kinesthetic exercises that help neuromuscular restoration along with standard strengthening exercises provides dynamic muscle strength increase with significant recoveries in the functional status of the patients. When your mechanoreceptors that is your afferent receptors are stimulated a proper feedforward mechanism, preparation and response planning enhance the task execution.[10] Thereby reducing risk of fall and joint position sense error leading to proper refinement of movements, increases the readiness of knee joint and decreases the chances of re-injury upon return to daily activities.[4][5] All these leads to improvement in physical function, pain and proprioception. The results are supported by Peeyoosha Gurudut et al in 2018 who did a comparative study the effect of Calisthenic and proprioceptive exercises on Pain, Proprioception, Balance and Function in Chronic Osteoarthritis of Knee. Results showed that Proprioceptive exercises are more effective than Calisthenic exercise group in improving pain, proprioception deficit, balance and functional disability. The improvement in proprioception due to the reason that the proprioceptive exercises include unpredictable movements which teach our body to control the position of the joints. Since proprioceptive exercises bring

about synchronous activities of knee muscle and mechanoreceptors that might have led to better improvement in balance, proprioception and function. The results of present study are supported by Iltekin Duman et al in 2012 did a study to find out the effect of proprioceptive exercise on balance and proprioception in patients with knee osteoarthritis and concluded that. Outcome measures were WOMAC scale, VAS, stabilometric evaluation for balance and CYBEX-NORM test for proprioception improved significantly after giving proprioceptive exercises.[32]

The effect in group C could be attributed to strengthening exercises which were included in all groups. Resisted isolated muscle contractions normalize the firing pattern and joint biomechanics leading to reduction in joint pain and cartilage degradation.[26] Resisted exercises increases bone mineral density , reduces stress on joints, ligaments , increases the capacity to repair and heal damaged tissue , improves balance thereby improving physical function and pain. The results were similar to the systemic review done by Angela K. Lange et al in 2008"strength training for treatment of osteoarthritis of the knee: A systematic review" which showed significant improvement in pain, stiffness, physical disability, quality of life, self-efficacy, depression, muscle function, strength, walking endurance, gait speed, stair climb and sit-to stand.[19]

Hot pack application used in all the three groups Vasodilation of the vessels produces an influx of blood to that area superficial muscle layers are heated resulting in relaxation of affected tissues and reduction in pain. In areas with low amounts of overlying adipose tissue, blood flow can be affected upto 3cm deep. [18]

CONCLUSION

Present study concludes that agility exercises are more effective than kinesthetic exercises in reducing pain and improving proprioception and physical function in osteoarthritic knee.

Clinical Implications:

From the above study it can be stated that agility exercises are a better choice of treatment than kinesthetic exercises for knee osteoarthritis patients.

Future Scope: Study can be done with bilateral knee osteoarthritis patients.

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