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METHODS

Effectiveness of retro walking on knee proprioception after knee injury

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Background: Knee injuries are frequent and can significantly affect a person's functionality and capacity to carry out regular tasks. Only two of the many components that support the equilibrium of the knee joint are ligaments and supporting structures. Direct or indirect trauma can cause ligament injuries that result in instability, and sports and physical activity put the knee joint at a higher risk for injury. Proprioception, the body's ability to recognize its location in space, is crucial for preserving balance and coordinating motions. Walking is a fundamental action that may be employed for rehabilitation, both forward and backward. The aim of the study is to investigate how retro walking after a knee injury affects knee proprioception. Finding out how retro walking impacts knee health is one of the objectives. The objectives include comparing the experimental group's findings to those of a control group and determining how retro walking affects knee proprioception. Retro walking increases knee proprioception as well as the neuromuscular and muscular systems, which may make rehabilitation programs for those with knee injuries more effective.
Objective: The study's objective is to evaluate how retro walking after a knee injury affects knee proprioception. The objectives include comparing the experimental group's findings to those of a control group and determining how retro walking affects knee proprioception. Retro walking increases knee proprioception as well as the neuromuscular and muscular systems, which may make rehabilitation programs for those with knee injuries more effective.
Method: 24 injured individuals (men and women) participated in this experimental investigation. They were split into two groups of 14, the control group, and the experimental group, obtaining everyone's approval after having informed them. The knee injury and osteoarthritis scale (KOOS), star excursion balancing test, and joint position sense are employed as outcome measures. Prior to the intervention, baseline measurements were collected. After 6 weeks of interventions, the final grade was determined. While stationary cycling and strengthening exercises for the quadriceps, calf muscles, and hamstrings are part of traditional therapy among the control group, retro walking was also offered to the experimental group. Results were collected, and the data were examined after 6 weeks.
Result: The experiment group of knee injury patients who performed retro walking demonstrated a substantial increase in knee function and proprioception ratings, according to the study's findings. According to the analysis of the KOOS scale, scores for proprioception and knee function after retro walking were significantly different, with a mean change of −19.833 units. Retro walking's ability to enhance knee proprioception was further supported by the SEBT score, which showed a mean change of −37.167 units. A substantial mean change of −4.583 units was also seen when the JPS score was evaluated, showing the beneficial effects of retro walking on knee proprioception in knee injury patients. These results imply that retro walking is a viable option for enhancing proprioception and knee functionality in knee injury patients.

Conclusion: It has been found that retro walking on a treadmill for 15 min, up to 6 weeks at 3 times each week, with a 10° inclination and a speed of 1–2 m/s, significantly improves knee proprioception following injury. The statistical study supports this observation. Considering the study's results, one may assert that retro walking helps knee injury patients raise their total level of physical activity. It has been demonstrated that retro walking enhances knee function and proprioception. Analysis of differences between both the test and control groups, the joint position awareness, star excursion balance test, and KOOS score all show greater progress. Retro walking is therefore more successful in the rehabilitation of post-knee injury in the current investigation.

Keywords: KOOS – knee injury and osteoarthritis scale, SEBT – star excursion balance test, JPS – joint position sense, ligaments, proprioception

Introduction

The knee is a highly intricate joint consisting of numerous components, rendering it susceptible to various injuries. Traumatic knee injuries are prevalent in both sports at all levels and everyday activities (1). Such injuries have a substantial effect on a person's functionality and capacity for activity, leading to substantial disability and limitations. When any structure within the knee is damaged, it results in symptoms such as pain, stiffness, swelling, instability, and difficulties in performing common daily tasks like walking, squatting, and climbing stairs (2).

The stability of the knee joint is upheld through a combination of factors, including the configuration of the menisci and condyles, as well as passive supporting elements. The cruciate ligaments and collateral ligaments are among the important tissues involved in maintaining knee stability (3). The posteromedial and posterolateral capsular components significantly contribute to the stability of the knee joint, as well as the iliotibial tract. Additionally, dynamic stability is conferred by the muscles that act on the joint (4).

Trauma, whether direct or indirect, can cause ligament damage that results in instability. Cutting, twisting, leaping, and the most common causes of non-contact ligament injury are abrupt decelerations. It is worth noting that the knee joint is frequently cited as the most commonly injured joint among athletes (5). In contact sports, the knee joint is highly susceptible to damage, emphasizing the importance of knee performance in achieving comprehensive and successful rehabilitation. To ensure a stable knee during various activities or sports, it is crucial to focus on factors such as muscle strength, flexibility, balance, and proprioception (6).

Proprioception plays a significant role in the body's awareness of its position in space. Contribution requires meticulous planning, coordinated efforts, and correct planning in addition to coordinated actions. Information about joint angles, movement speed, and tension is conveyed to the brain through proprioceptive sensors found in ligaments, joint capsules, meniscus, and other structures. Consequently, a knee injury affects not just the kinematics of the joint but also the surrounding muscles' neuronal control, proprioception, and general function (7, 8).

Walking is a well-liked, useful, and largely risk-free form of exercise. Humans often pick up forward walking without much difficulty; however, backward walking is sometimes necessary for daily tasks and helps the body with a variety of tasks. In this study, backward walking is used as a kind of therapy to enhance knee proprioception. Retro walking uses atypical motor patterns and visual signals that do not provide the person the visual information they need to forecast the state of the ground. Subjects must reorganize and adjust to the shifting information from their visual, proprioceptive, cutaneous, and vestibular systems as well as increase their movement control in order to maintain dynamic balance. Another straightforward method of rehabilitation is retro walking (9).

Objectives of the study

1. To determine if retro walking can improve knee proprioception in patients with a knee injury.
2. To contrast the experimental group's findings with those of the control group.

Need of the study

The knee joint is most susceptible to both direct and indirect harm. Therefore, a good recovery depends greatly on knee performance. According to studies, proprioception is crucial for keeping balance, planning precise and synchronized motions, and regulating body position. Knee proprioception and improved muscular and neural activity are both benefits of retro walking.

Aim

The aim of this study was to investigate the effect of retro walking on knee proprioception following a knee injury.

Hypothesis

Null hypothesis(H_0)

1. There are no significant effects in retro walking on knee proprioception after knee injury

Research hypothesis

1. There are significant effects of retro walking on knee proprioception after knee injuries.

Review of literature

Here is a literature review on retro walking, exploring its kinematics and discussing its benefits in proprioception and balance.

1. Kinematics of backward walking

Backward and forward walking (BW and FW) kinematics were compared in water and on land. In comparison to FW, BW showed a slower rate of walking on land, which might be attributed to inexperience and the challenge of maintaining balance without a forward-looking sense. Under water, however, there was no noticeable difference in the walking speeds of BW and FW, presumably due to the resistance of the water. The vertical ground reaction force (VGRF) force–time curve during free walking (FW) under water had a flat appearance as a result of the decreased walking speed and apparent body weight. Both FW and BW showed lower VGRF under water than on land. In both circumstances, the BW's second ascent during the VGRF was less than the initial high. However, at the end stance, the ankle showed no differences depending on the direction of walking. When walking backward on land, the initial impact indicated a larger dorsiflexed ankle angle than when walking forward (FW). During BW while immersed, subjects changed how they exited the force plate, utilizing either their heels or their toes. The ankle angle waveform was similar on land and under water each for FW and BW, however. The ankle angle was where the kinematics of BW underwater varied the greatest; the hip and knee showed an amplitude-variable reversal pattern. These findings emphasize the differences between the kinematic properties of BW and FW, emphasizing the potential use of underwater BW for those who have balance problems, especially in neurological groups (10).

The motion of walking backward differs from walking forward, and the ways in which the muscles in the lower extremities work are also significantly different. When walking forward, the gastrocnemius muscle speeds up motion at the foot and ankle at first contact, but when walking backward, it slows down motion in the same areas. When the treadmill slope is raised during BW, the gastrocnemius, anterior tibialis, and rectus femoris are among the targeted muscles that are subjected to greater stress. Additionally, a broader range of motion is required of joints. Both forward and retro-ward walking involve a lot of muscular activities during the early loading phase of gait, when muscles cooperate to slow the body down, provide stability, and prepare to accelerate. Because retro walking offers soft tissue adequate time to adapt and strengthen, research has shown that it is an excellent kind of regulated exercise for healing soft tissue. According to research, adding moderate activity to the healing process can help (11).

Repetitive gait training is used to assist stroke patients in restoring their pre-injury motions since gait issues are typical in these individuals. Body weight (BW) training is a significant and practical technique used in stroke therapy to enhance balance and gait. The benefits of BW training on gait speed and step length in stroke patients have been supported by prior studies. The outcomes of this study support these outcomes, demonstrating the value of BW training in enhancing gait and balance. After a stroke, asymmetric weight distribution (WD) is linked to dynamic balance and postural instability. The BWOT group's WD on the afflicted side showed a substantial improvement in the trial, suggesting improved postural stability and independent walking. BWOT is a helpful supplement to regular rehabilitation procedures because it has the potential to improve mobility and equilibrium in stroke patients when incorporated into traditional therapy (12).

2. Benefits of retro walking in proprioception

The intricate system of the knee's proprioception, which consists of ligaments, joint capsule mechanoreceptors, spinal cord, and cerebral cortex-connected nerve fibers, is necessary to maintain joint stability. An important structural element of the knee is the anterior cruciate ligament, which is essential for joint proprioception. Training in BW strengthens the hamstring muscles and activates brain pathways to improve knee proprioception. As opposed to just FW, it uses diverse muscle activation patterns and lessens joint stress. It is a closed kinematic chain workout that increases muscular strength, engages proprioceptive and balance training, and develops hip extensors, lowering aberrant loading on the knee joint. Daily chores and athletic endeavors like getting up from the kitchen sink or playing football, basketball, or tennis all include BW. It has been demonstrated to enhance stride-related muscle activation patterns, lessen adductor moments, and stretch hamstring muscle groups. Additionally, BW engages the brain pathways used in FW and may help those who have suffered neurological impairments recover (8).

Static stability is a critical factor in predicting falls among the elderly population. It has been demonstrated that BW enhances proprioception, pain, static stability, and function in patients with knee osteoarthritis (KOA). BW engages specialized control circuits, activates proprioceptive and vestibular senses, and improves gait characteristics. It has also been effective in reducing pain, increasing muscle strength, enhancing flexibility, and improving physical function in individuals with KOA. Results showed that BW intervention significantly improved static stability, pain relief, and function compared to conventional treatments alone (13).

In a study of 30 cerebral palsy (CP) patients, it was discovered that lower degrees of spasticity (Gross Motor Function Classification System I and II levels) were associated with better gastro-soleus, hamstring, and gastrocnemius spasticity than higher ones. Children at level I performed better on the 3-Meter Back Walk Test (3MBWT), Gillette Functional Assessment Questionnaire (FAQ), and Trunk Control Measurement Scale (TCMS). The 3MBWT did not significantly correlate with either lower extremity proprioception or TCMS, however. The 3MBWT and FAQ showed a negative connection, showing that increased gait function was linked to higher BW ability. Lower extremity muscular strength and the 3MBWT did not substantially correlate. Only the iliopsoas muscle strength and hip extension proprioception showed a significant positive connection. These findings suggest that in cerebral palsy children, proprioception, trunk control, and overall muscular power are not related to the ability to walk backward (14).

Walking is an important activity that is frequently affected by motor control deficits and loss of independence after a stroke. Stroke patients have impaired BW ability, and deficiencies in this ability may increase the chance of falling backward. Increased dependence on proprioception, neuromuscular control, and defense mechanisms is needed when walking backward. The 3MBWT has demonstrated diagnostic efficacy and the ability to differentiate between groups with a history of falls. A moderate link between the Berg Balance Scale, the 3MBWT, and the Timed Up and Go was found by correlation analysis. The 3MBWT is sensitive and has great intrarater reliability in stroke patients. Researchers and medical practitioners can assess significant performance changes in stroke patients using the 3MBWT (15). Additionally, proprioceptive perception in stroke patients can be improved with backward gait training on an underwater treadmill (16).

3. Benefits of backward walking in balance

The study highlights the significance of using accurate and reliable outcome measures when evaluating treatments. The results indicate that TKA patients have progressed to a level where the 3MBWT may be tested for test–retest reliability. For TKA patients, walking speed—including BW—is an essential component of functional mobility and rehabilitation success. Additional difficulties arise while walking backward, which depends on proprioception, neuromuscular control, and defensive reflexes. Measures of BW have been demonstrated to be more sensitive in measuring changes in mobility and balance associated with aging, especially the risk of backward falls. Medical professionals and researchers can employ the 3MBWT, which has been found to have diagnostic accuracy for fall risk, to evaluate functional performance in individuals with primary TKA. The test can be a useful tool in rehabilitation programs for those who have had primary TKA since it is sensitive enough to identify actual variations in patients' performances (17).

Backward walking training (BWT) has been shown to speed up both the backward and forward gaits, suggesting a possible effect on total balance control. Additionally, the study found that members of the BWT category more significantly expanded their self-efficacy in their ability to keep their balance than those in the Standard Balance Training (SBT) group. These findings suggest that improved balance function may be a result of the postural control necessary for BW. Improved balance control may have resulted from enhanced muscular activation and sensory input engagement during BWT. These results emphasize the significance of including BW exercises as a workable intervention for improving balance and general functional abilities in post-stroke patients (18).

Multiple sclerosis patients frequently have mobility issues and are susceptible to dangerous falls. However, it is still difficult to identify fallers in this group using standard methods, which mostly rely on FW and balance tests, which have low sensitivity and predictive value. In order to identify MS patients who fell from those who did not, the study set out to see how effectively forward and backward walking might do so. Traditional fall detection methods that rely on forward movement and balance have limited sensitivity. BW, however, has demonstrated potential in separating fallers from other neurodegenerative conditions. 38 MS individuals' spatiotemporal measurements of forward and backward walking, as well as their fall history, were gathered. After symptom duration, the study found that the strongest individual predictor of those who fall was BW velocity. 76.3% of cases were properly diagnosed using a stepwise model that included the speed of BW and the duration of the symptoms. The models were unaffected greatly by FW measurements. These findings suggest that retro walking velocity is perhaps a helpful treatment tool and efficient fall detection approach in MS patients, providing a more precise means to identify individuals who are most at risk of severe falls (19).

Methodology

Materials used

Treadmill
Paper
Pen
Calculator
Tape
Goniometer

Selection criteria

Inclusion criteria

1. Subjects with all knee injuries
2. Age between 18 and 40
3. Both male and female
4. Subjects having proprioception deficits
5. Patients with or without surgery

Exclusion criteria

1. Patients with non-specific knee pain
2. Fracture
3. Pregnancy
4. Other neurological disorders
5. Other musculoskeletal disorders
6. Psychological disorders
7. Degenerative diseases

Outcome measures

1. KOOS (Knee injury and osteoarthritis outcome score):

It was developed as a comprehensive outcome measure for evaluating the effects on patients following knee injury. This self-administered questionnaire assesses five important factors: knee-related activities of daily living, symptoms, sports performance, QOL (quality of life), pain, and leisure activity. The KOOS's user-friendly style makes it easy for patients to share their opinions on their knee-related experiences. It normally takes 10 min to complete. With scores ranging from 0 (representing no difficulties) to 100 (representing severe problems), each dimension is given a distinct score by adding the replies to its corresponding items. The KOOS offers useful insights into the patient's impression of pain, symptoms, functional restrictions, sports, and leisure activities, and QOL based on calculating the ratings for each dimension in relation to their knee injury. The KOOS is a trustworthy instrument that satisfies the necessary standards for outcome measures and is frequently used to assess knee injury progression and treatment results, allowing medical practitioners to analyze and track patient progress with efficiency. Instructions for scoring:

Each of the KOOS's five patient-related components is given a score. Nine of the items deal with pain, seven deal with symptoms, 17 deal with daily living activities, five deal with sports and entertainment, and four deal with QOL. Each question includes five possible responses, each of which ranges in difficulty from 0 (no issues) to 4 (significant issues), and among the five scores, each is obtained by averaging the scores of the individual items (20).

Pain (P1–P9): This gauges how much discomfort a person is feeling in relation to their knee. Symptoms (S1–S7): This assesses a range of symptoms related to knee issues. The Activities of Everyday Living (ADL) scale (A1–A17) assesses how knee problems affect a person's everyday activities. Sports/Recreation (SP1–SP5): This looks at a person's capacity to engage in sports and leisure activities. Quality of Life (Q1–Q4): This evaluates how well our life is generally going despite your knee issue.

Calculations

1. KOOS Pain: The mean score of items P1 to P9 is multiplied by 100 and then divided by 4.
2. KOOS Symptoms: The mean score of items S1 to S7 is multiplied by 100 and then divided by 4.
3. KOOS ADL: The mean score of items A1 to A17 is multiplied by 100 and then divided by 4.
4. KOOS Sports/Rec: The mean score of items SP1 to SP5 is multiplied by 100 and then divided by 4.
5. KOOS QOL: The mean score of items Q1 to Q4 is multiplied by 100 and then divided by 4. Each situation has a possible score between 0 and 100 points. When it comes to constraints brought on by the damaged knee, 100 points means there are not any at all, while 0 points means there are many (21).

Joint position sense test

To assess a person's proprioceptive ability, the joint position sense (JPS) test is employed, especially their capacity to detect and replicate the position of their joints without the use of visual signals. Motor control, movement coordination, balance, and joint stability depend heavily on proprioception. As a result, evaluating JPS offers useful data for several. The individual was asked to complete the exam while standing with their feet shoulder-width apart. The untested limb's foot was raised off the ground, and the knee was in a straight, 0-degree posture from the outset. The individual began the test by following directions and going through a practice run while keeping their eyes open. The participant was then instructed to close their eyes as they:

Take off the untested limb's foot from the ground. When ordered to halt at a specified angle, such as 30 degrees, slowly flex the weight-bearing leg. Holding the test posture isometrically for about 5 s, sense or identify the location of the knee. For 7 s, return to your weight-bearing position in the upright position. Recreate the previously achieved flexed position of the weight-bearing limb while concentrating on the knee. The time spent in each posture throughout the test was identical to that in other research. A goniometer was used to calculate the angles between the initial point and the duplicated position. After measuring the feeling of the knee joint position three times, the average result was gathered for each leg. By deducting the initial point and duplicated position, the absolute angular error (AAE), which symbolizes the difference between the intended and actual joint positions, was calculated as a dependent variable (22).

Star excursion balance test

The participant of the SEBT stands in the center of an eight-line grid that is 6 to 8 feet wide and angles outward at 45 degrees, **Figure 1**. The competitor must maintain a single-leg stance with the other leg in the grid's center while reaching as far as they can along each of the eight lines, lightly touching the line, and returning to the center with the reaching leg. With the most distal portion of the reaching leg, the participant is urged to lightly touch the ground before returning to a double-leg stance without allowing the contact to compromise balance. The distance from the star's center to the furthest point reached in each direction is used to calculate the size of the SEBTs (**Figure 2**). The burden on the balance and neuromuscular-control systems increases with excursion distance. Participants must extend behind the stance leg to accomplish the challenge while reaching laterally and posterolaterally (**Figure 3**). To reduce the learning effect, participants should be given six opportunities to practice reaching in each of the eight directions. Starting at the front of the grid, one should work their way clockwise around it. The test should then be completed with a left stance leg following the completion of the three trials in each of the eight directions and a 5 min rest period. The distance from the grid's center to the reach the leg's point of greatest excursion should be noted for each reach distance by the investigator on the tape (23).

FIGURE 1 | Joint position sense (JPS) in standing (22).

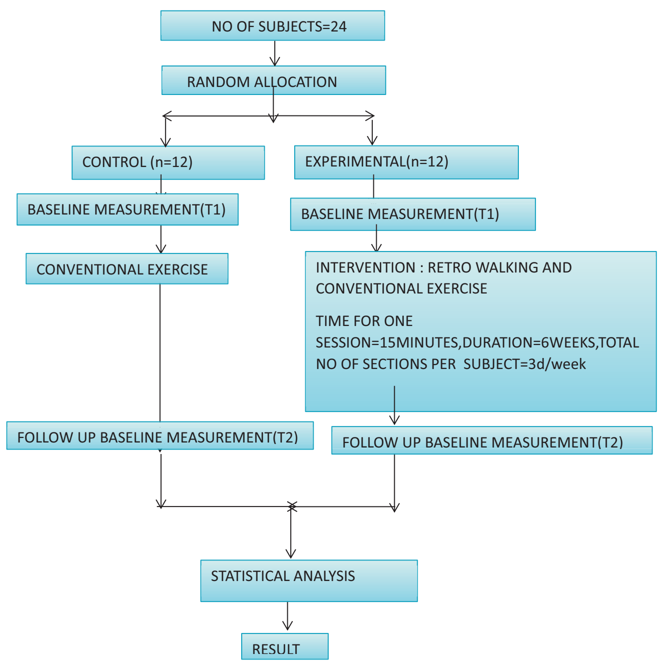
Note: The trial is not deemed finished if the subject makes a heavy impact on the ground or stops at the touchdown point and elevates or moves any part of the stance limb's foot or must make touch with the ground with the reaching foot to maintain balance.

Scoring method

The average distance in each direction (measured in centimeters) is calculated using the formula "Reach 1 + Reach 2 + Reach 3/3". This average is divided by the leg length, multiplied by 100, to get the relative (normalized) distance in each direction. This results in the normalized distance expressed as a proportion of leg length of leg length (%).

Study Procedure

Flow chart



Flow chart describing the methodology

It is a randomized control experiment that lasted 3 months and had 24 patients who matched the inclusion and exclusion requirements. Randomly chosen from the KIMS ALSHIFA Hospital, participants for the experimental and control groups gave their assent before participating in the trial.

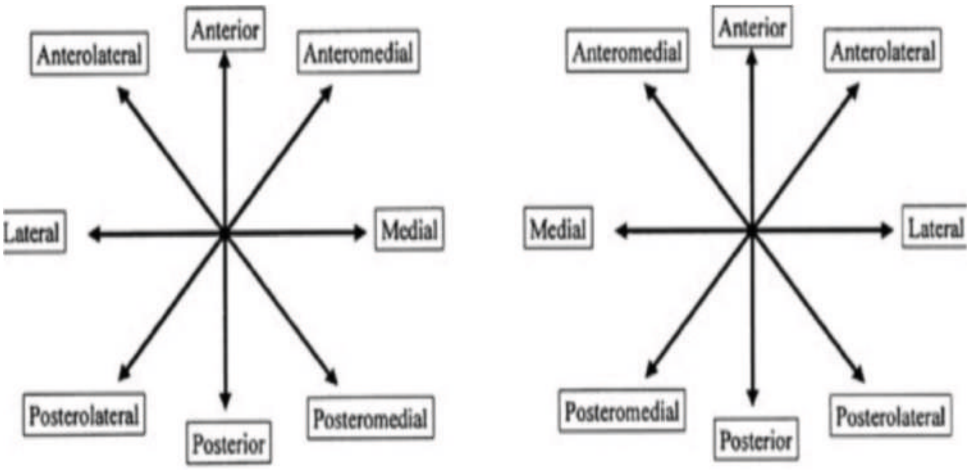


FIGURE 2 | Reaching directions for the star excursion balance test (SEBT) (23).

Before the research began, the volunteers received a thorough explanation of the methods. The 24 patients were split into two groups: the experimental group A (n = 12) and the control group B (n = 12). Prior to the intervention, baseline measures were collected.

Experimental group (group A)

The experimental group consisted of 12 subjects who underwent retro walking as part of the conventional rehabilitation protocol. The protocol included exercises such as static quadriceps, static hamstring, straight leg raise (SLR), and various strengthening exercises using weight cuffs, active resistance, and resistance bands. As improvement was observed, additional exercises such as squats, leg presses, ankle pumps, static cycling, quadriceps table exercises, and stair climbing were introduced. Subjects in group A performed BW (retro walking) on a treadmill for 15 min, three times a week, every other day, for a total of 6 weeks, at a speed ranging from 1 to 2 m/s with a 10° incline (9).

Safety precautions were taken during retro walking, including attaching a safety stop device to the shirt or pants to automatically stop the treadmill belt if the body gets too far from the front of the treadmill. Subjects held onto the side rails of the treadmill and initiated BW by reaching one leg backward and landing on their toes, gradually rolling onto the heel as the knee straightened. The toe-to-heel walking pattern was repeated, and the speed of the treadmill was gradually increased. After completion, the treadmill belt was stopped, and subjects were instructed to continue walking backward until the belt came to a complete stop.

Control group (group B)

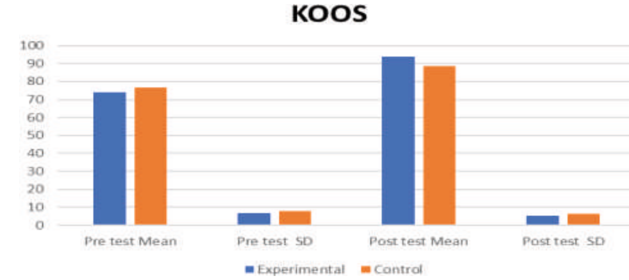
The 12 individuals in the control group were told to adhere to the typical knee injury recovery guidelines. This included exercises such as static quadriceps, static hamstring, SLR, and various strengthening exercises using weight cuffs, active resistance, and resistance bands. Similar to group A, as improvement was observed, additional exercises such as squats, leg presses, ankle pumps, static cycling, quadriceps table exercises, and stair climbing were gradually introduced. Overall, the interventions and measurements were carried out as per the established protocols and instructions provided to each group.

FIGURE 3 | Performance of star excursion balance test (SEBT) in the posterolateral direction.

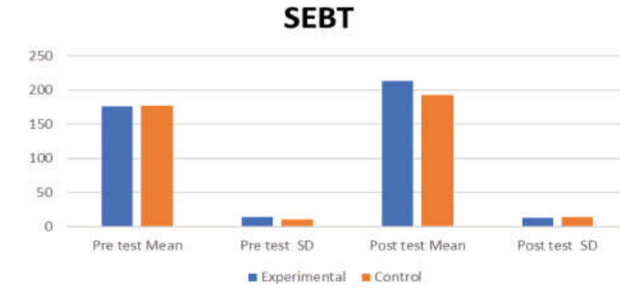
TABLE 1 | Pre- and post-test knee injury and osteoarthritis scale (KOOS) values of groups A and B.

Group	Pre-test mean	Standard deviation	Post-test mean	Standard deviation
Group A	74.08	6.653	93.92	5.368
Group B	76.75	8.103	88.50	6.571

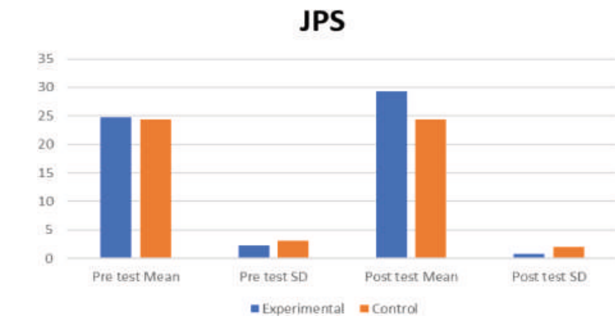
FIGURE 4 | Retro walking (9).



GRAPH 1 |



GRAPH 2 |



GRAPH 3 |

Statistical analysis

Analysis of the koos scale

Table 1 shows the average and standard deviations of the pre-test and post-test findings for group A and group B are shown in the table. In the experimental group (A), the pre-test mean was 74.08 (SD = 6.653) and rose to 93.92 (SD = 5.368) after the test. The control group (B) pre-test mean was 76.75 (SD = 8.103), and the post-test mean was 88.50 (SD = 6.571). These numbers shed light on how the knee function of both groups changed during pre-and post-test assessments.

The pre-test mean for knee function on the KOOS in the experimental group was 74.08 (SD = 6.653), whereas the post-test mean rose to 93.92 (SD = 5.368) (Table 2). For the patients in the experimental group (A), pre-and post-test KOOS mean scores are displayed in the mean column. SD stands for the pre- and post-balance score SDs. The pre-test versus post-test distinction (74.08 and 93.92 units) represents a mean change of −19.833 units. In the pre- and post-test KOOS ratings for knee injury patients in group A, there is a significant change (p-value 0.0001). This demonstrates how retro walking helps knee proprioception recover from damage.

Table 3 shows the pre-test mean for knee function on the KOOS in the control group was 76.75 (SD = 8.103), while the post-test mean rose to 88.50 (SD = 6.571). The average KOOS before and after the test scores for individuals with knee injuries in the control group are shown in the mean column. The pre-test versus post-test difference (76.75 and 88.50 units) is −11.750 units on average. In the control group of knee injury patients, the pre- and post-test KOOS scores differ significantly ($p = 0.0001$) from one another.

Therefore, we can see that patients with knee injuries in the experimental group show a substantial change in their KOOS score, but patients with knee injuries in the control group do not. Retro walking is therefore a very effective way to enhance knee proprioception following a knee injury.

Now let us examine the post-test KOOS scores to see if the pre-test KOOS scores of groups A and B were similar.

The variation between the means of the two groups (74.08 and 76.75 units) is displayed as a difference of 2.667 units less than 0.001 p-values (Table 4). Both group pre-test KOOS scores significantly differ from one another. So, at the baseline level, we may regard the groupings as homogeneous.

TABLE 2 | Analysis of pre- and post-test knee injury and osteoarthritis scale (KOOS) values of the experimental group (A) using paired *t*-test.

Test	Mean	Standard deviation (SD)	Mean shift	No.	Table value	*p*-value
Pre-test	74.08	6.653	−19.833	12	2.201	0.0001
Post-test	93.92	5.368				

TABLE 3 | Analysis of pre- and post-test knee injury and osteoarthritis scale (KOOS) values of the control group (B) using paired *t*-test.

Test	Mean	Standard deviation	Mean shift	No.	Table value	*p*-value
Pre-test	76.75	8.103	−11.750	12	2.201	0.0001
Post-test	88.50	6.571				

TABLE 4 | The pre-test knee injury and osteoarthritis scale (KOOS) scores for groups A and B are analyzed using a *t*-test, which uses mean, standard deviation, and *t*-value.

Group	Pre-test mean	Standard deviation	Mean difference	No.	Table value	*p*-value
Group A	74.08	6.653	2.667	12	2.201	< 0.001
Group B	76.75	8.103				

TABLE 5 | Using a *t*-test, which uses the mean, standard deviation, and table value, the post-test knee injury and osteoarthritis scale (KOOS) scores for groups A and B are analyzed.

Group	Mean	Standard deviation	Mean difference	No.	Table value	*p*-value
Group A	93.92	5.368	5.417	12	2.201	< 0.001
Group B	88.50	6.571				

Table 5 shows the mean post-test KOOS scores for groups A and B are shown in the mean column of the *t*-test table. The variation between the means of group A and group B (93.92 and 88.50 units) is displayed by the difference (5.417 units). With a *p*-value of 0.001, the post-test KOOS ratings between group A and group B differ significantly. Retro walking, therefore, helped patients with knee proprioception following knee injuries.

Statistical analysis of star excursion balance test score

The variation between the pre- and post-tests (37.167 and 16.083 units) is the mean change (−2.405 units) (Tables 6, 7). In the experimental group of knee injury patients, the difference between the pre-test and post-test SEBT scores is statistically significant ($p = 0.001$).

The difference between the means of the two groups (177 and 193.08 units) is represented by the number (−16.083) (Table 8). The *p*-value of less than 0.001 indicates that there is a statistically significant variance in the post-test SEBT scores in the control groups. This demonstrates how knee proprioception is affected by retro walking. Both groups show statistically significant results when compared, although the experimental group's results are more highly significant.

Checking for homogeneity between group A and group B, pre-test knee function scores is the next step and therefore demonstrates how retro walking affects people with knee injuries by comparing the post-test SEBT scores between group A and group B.

Table 9 shows the mean pre-test SEBT scores for group A and group B are shown in the mean column of the *t*-test table. The variation between the averages of group A and group B (176.25 and 1770 units) is represented by the units (−0.750). Between group A and group B, there is no obvious difference in pre-test SEBT scores (*p*-value > 0.05). Therefore, we may see the groups as homogeneous at the base level.

TABLE 6 | Pre- and post-test star excursion balance test (SEBTs) of group A and group B are compared.

Group	Pre-test mean	Standard deviation	Post-test mean	Standard deviation
Experimental	176.25	14.079	213.42	13.365
Control	193.08	11.070	193.08	14.551

Table 10 shows the mean post-test SEBT scores for group A and group B are shown in the mean column of the *t*-test table. The variation (20.33) depicts the variance in the means of the two groups (213.42 and 193.08 units). The *t*-value (4.318 units) is greater than the table value (2.467 units), demonstrating a significant variance between the two groups in the post-test knee function ratings (p 0.001). As a result, retro walking helps knee damage patients with their proprioception.

Statistical analysis of joint position sense score using *t*-tests

For the patients in group A, the mean JPS score before and after the test is displayed in the mean column. The variation between JPS scores before and after the test (24.75 and 29.33 units) is a mean change of −4.583 units. In the experimental group of knee injury patients, the difference between JPS scores before and after the test is significant statistically ($p = 0.0001$). This demonstrates how retro walking helps knee proprioception recover from damage (**Tables 11**, **12**).

The average JPS scores before and after the test for patients with knee injuries in group B are shown in the mean column. The mean change, which is −0.667 units, is the variation between before and after the test (29 and 29.67 units). With a *p*-value of 1.000, it was determined that the JPS ratings for patients with knee injuries in the control group did not alter between the pre- and post-tests (**Table 13**). As a result, we can conclude that patients with knee injuries in the experimental group's JPS scores have changed significantly, but patients with knee injuries in the control group's JPS scores have not changed much. Retro walking is therefore a very effective way to enhance knee proprioception following a knee injury.

Let us compare the JPS scores from the pre- and post-tests to see if there was homogeneity between both group's pre-test results.

Table 14 shows mean JPS score for group A was 24.75 (SD = 2.340), whereas the mean JPS score for group B was 24.42 (SD = 3.118). The calculated difference between the mean JPS scores of the two groups was 0.333. The *t*-test, which had a sample size of 12, had a *t*-value of 0.296. The critical *t*-value at a certain level of significance, based on the pertinent table value, was 2.201. The pre-test JPS scores of the two groups did not differ significantly on a statistical basis, as indicated by the analysis's *p*-value, which was determined to be 0.770.

The difference of 4.67 units illustrates the difference between the two groups' means (29.67 and 25 units). The post-test JPS results show significant variations between group A and group B (*p*-value 0.001). Therefore, after knee injuries, retro walking assisted patients with knee proprioception (**Table 15**).

Results

Experimental group (A)

Evaluation of koos scale

The mean change is −19.833 units, which is the variation between the pre- and post-test values of 74.08 and 93.92 units for knee injury patients in the experimental group. For knee injury patients in the experimental group, there is a statistically significant difference (*p*-value 0.0001) between group A and group B knee function and proprioception ratings. This shows how knee proprioception and function are impacted by retro walking in knee injury patients.

Evaluation of SEBT score

Pre- and post-test findings for individuals with knee injuries in Group A were compared, and the mean change (−37.167 units) was found to be the variation between the two (pre-test: 176.25 units, post-test: 213.42 units). In the experimental group of knee injury patients, the difference between the SEBT pre- and post-scores is statistically significant ($p = 0.001$). This demonstrates how retro walking helps injured individuals' knee proprioception.

Evaluation of JPS score

The mean change (−4.583 units) represents the variation between the pre- and post-tests (29.33 and 24.75 units) for patients with knee injuries in group A. In the experimental group of knee injury patients, there is a substantial difference between the JPS scores obtained before and after the test (*p*-value 0.001). This demonstrates the value of retro walking for people with injured knee proprioception.

Control group (B)

Koos scale

By contrasting the knee function scores of patients with knee injuries in group B, before and after the test, an average of 11.5 units is lost between before and after the test (76.75

TABLE 7 | To compare the pre- and post-tests of star excursion balance test (SEBT) in group A, using mean, standard deviation (SD), and *t*-value.

Test	Mean	Standard deviation	Mean change	No.	Table value	*p*-value
Pre-test	37.167	8.332	−2.405	12	2.467	< 0.001
Post-test	16.083	9.718				

TABLE 8 | *t*-value, SD, and mean comparison scores from the star excursion balance test (SEBT) pre- and post-tests in group B.

Test	Mean	Standard deviation	Mean change	No.	Table value	*p*-value
Pre-test	177	11.070	−16.083	12	2.467	< 0.001
Post-test	193.08	14.551				

TABLE 9 | Analysis of the pre-test star excursion balance test (SEBT) scores between group A and group B.

Group	Pre-test mean	Standard deviation	Mean difference	n	Table value	*p*-value
Group A	176.25	14.079	−0.750	12	2.624	< 0.11
Group B	177.00	11.070				

TABLE 10 | Using a *t*-test, the post-test star excursion balance test (SEBT) scores are analyzed between group A and group B.

Group	Mean	Standard deviation	Mean difference	No.	Table value	*p*-value
Group A	213.42	13.365	20.333	12	4.318	< 0.001
Group B	193.08	14.551				

TABLE 11 | Pre- and post-test comparisons for the joint position sense (JPS) in Group A and Group B.

Group	Pre-test mean	Standard deviation	Post-test mean	Standard deviation
Group A	24.75	2.340	29.33	0.778
Group B	24.42	3.118	24.42	1.975

and 88.50 units). In group B of knee injury patients, the assessments of knee function before and after the test show a significant difference (*p*-value 0.0001).

SEBT score

The difference between the means of the two groups (177 and 193.08 units) may be seen in the mean variation (−16.083) between pre- and post-test scores for knee injury patients in the control group. The *t*-value is significantly greater than the table value with a value of −5.733 units, of 2.467 units, p 0.001, indicating that there are significant differences in the post-test proprioception ratings between group A and group B.

JPS score

For knee injury patients in group B, the mean variation (−0.000) between the pre- and post-test scores illustrates the difference between the means of the two groups (24.42 and 24.42 units). The *t*-value is higher than the 2.201 unit value in the table, indicating that there is no statistically significant difference between group A and group B post-test proprioception ratings ($p > 0.05$).

According to the findings, the experimental group's knee injury patients significantly improved their proprioception and knee function ratings, but the control group showed no discernible difference. According to these results, retro walking is very successful in improving proprioception and knee function in those with knee problems.

Discussion

This study sought to better understand how retro walking affected knee proprioception in those with knee injuries. Following a full description of the processes and based on a set of inclusion and exclusion criteria, patients who wanted to

TABLE 12 | Analysis of joint position sense (JPS) pre- and post-tests in group A (paired *t*-test).

Test	Mean	Standard deviation	Mean change	No.	table value	*p*-value
Pre-test	24.75	2.340	−4.583	12	2.201	0.0001
Post-test	29.33	0.778				

TABLE 13 | Pre- and post-test knee joint position sense (JPS) comparison in the control group using mean, standard deviation, and *t*-value.

Test	Mean	Standard deviation	Mean change	No.	Table value	*p*-value
Pre-test	24.42	3.118	−0.000	12	1.796	1.000
Post-test	24.42	1.975				

TABLE 14 | Analysis of pre-test joint position sense (JPS) scores between group A and group B.

Group	Pre-test mean	Standard deviation	Difference in Mean	No.	Table value	*p*-value
Group A	24.75	2.340	0.333	12	2.201	= 0.770
Group B	24.42	3.118				

TABLE 15 | Using a *t*-test, the post-test joint position sense (JPS) scores for group A and group B were compared.

Group	Mean	Standard deviation	Mean difference	No.	Table value	*p*-value
Group A	29.33	0.778	4.917	12	2.201	< 0.001
Group B	24.42	1.975				

take part in the research were accepted. The participants were divided into two groups at random, one of which served as the experimental group and the other as group B (control). While the control group received standard rehabilitation care, group A (experimental) also engaged in retro walking.

For 15 min, participants underwent a retro walking intervention that involved walking backward on a treadmill set to a speed between 1 and 2 m/s with a 10° incline. Over the course of 6 weeks, the retro walking sessions were held three times each week, with sessions planned every other day. These criteria were based on earlier research that looked at retro-walking therapies (9).

Retro walking needs more brain activation than FW, according to research by Godde et al. (24). The supplementary motor area, the thalamus, the caudate, the parietal cortex, the putamen, and the primary motor cortex are some of these areas. Additionally, while BW, there were higher levels of oxygenated hemoglobin in the pre-central gyrus, supplementary motor area, and superior parietal lobule. These results suggest that retro walking stimulates different brain networks and may have specific physiological effects (24).

The results of the research concur with those of Sedhom (9), who claimed that walking backward poses special difficulties because it throws off people's normal visual cues and necessitates that they modify their motor patterns and rely on data from several sensory systems to stay balanced. It was discovered that training in both forward and backward walking increased muscular strength, with BW producing the most improvements in knee proprioception (9).

The statistical analysis's data indicate that the experimental group, which performed retro walking in addition to conventional rehabilitation, saw better rehabilitation outcomes than the control group. This finding is supported by the higher scores obtained by the experimental group in the SEBT, KOOS, and JPS. The investigation using independent sample *t*-tests revealed that the experimental group's KOOS, SEBT, and JPS scores substantially increased from pre-test to post-test measurements (p 0.005 and p 0.0001, respectively). The resulting *p*-values demonstrate high levels of significance (90 and 95.9%, respectively), confirming the advantages of retro walking in enhancing knee proprioception. Particularly when comparing the pre-test and post-test scores for knee injury patients in the experimental group, there was a mean decline of −4.583 units in joint position sense between the pre-test score (29.33 units) and post-test score (24.75 units). A considerable drop in JPS scores between pre- and post-tests in the experimental group as compared to the control group is indicated by the derived *p*-value of less than 0.001. This study demonstrates once more how effective retro walking is at enhancing knee proprioception in knee injury patients.

Overall, the results of this study point to the possibility that including retro walking in the rehabilitation process might significantly enhance knee proprioception and functional outcomes for those who have had knee injuries. Retro walking is a useful supplement to conventional rehabilitation methods since it presents distinct difficulties and utilizes various brain networks.

Conclusion

After an injury, retro walking on a treadmill for 15 min, three times each week for up to 6 weeks, at 1–2 m/s and an inclination of 10°, is found to significantly enhance knee proprioception. Statistical study backs up this observation. Retro walking is useful in treating knee injury patients, and this boosts general physical activity in those who have been wounded, according to the study's findings.

It has been demonstrated that retro walking improves proprioception and the knee's general functionality. The experimental group's KOOS score has improved more than that of the control group, by comparing the JPS test and the SEBT. Retro walking is therefore more beneficial in the current study's rehabilitation of individuals with knee injuries.

Summary

The study sought to determine participants' subjective perceptions of the "effectiveness of retro walking on knee proprioception after a knee injury." A comparison of 12 subjects from each of the two groups of 24 participants—experimental and control—was conducted. The control group had typical physiotherapy interventions including isometrics and strength training, whereas the experimental group underwent retro walking along with standard rehabilitation for a period of 6 weeks. The KOOS, SEBT, and JPS scores among those in the experimental group revealed that both stages of the test have a significant difference. This study came to the conclusion that retro walking can be incorporated into a proprioception-improving rehabilitation regimen.

Limitations

1. The study cannot be generalized since there were not enough female patients.
2. A small sample size.

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