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Article

Design and evaluation of comprehensive rehabilitation plan for functional recovery of tennis players' knee joint injuries

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Abstract: Tennis is a popular game among people of all ethnicities. During the game, players work their lower limbs intensively, which leads to their knee joints getting very painful and injured. Many injuries can be sustained during play, including ligament sprains, tears to the meniscus, and pains to the patellar tendon due to sudden stops, changes of direction, and twist running. To understand the mechanics of these injuries, there is an obligatory use of biomechanical techniques that allow one to determine the exact loads and movements that lead to these injuries. The study is to evaluate the efficiency of the complex rehabilitation record aimed at restoring the functions of the injured knee joints in tennis players. One hundred forty-six tennis players with a past of knee joint troubles were included. The subjects were separated into two groups: Group A prescribed a rehabilitation program, while Group B underwent standard treatment. To determine the result of the rehabilitation program on the participants' physical state, data such as joint angles, gait analysis, and force measurements were collected. The treatment program included rehabilitation approaches, such as active range of motion, flexibility exercises, muscle balance, static and dynamic strength training, and others. With respect to statistical analysis, the obtained data were tested by ANOVA, *t*-tests, logistic regression and correlation to assess functional outcome variances within and among the groups. Thus, the data were analyzed using SPSS. In functional outcomes, between Group A and Group B, the treatment outcome was significantly improved due to the intensive comprehensive rehabilitation program. Long-term recovery satisfaction among the athletes improved with time, confirming the benefits of a well-structured rehabilitation provision. The current research report offers substantial perspectives on the improvement of recovery programs drawn for tennis players. It highlights the importance of a tailored sports rehabilitation program in optimizing performance and minimizing the risk of injuries recurring.

Keywords: rehabilitation plan, functional recovery, biomechanical analysis, knee joint injuries, tennis players, statistical analysis

1. Introduction

Tennis is an extensive recreational activity enjoyed by millions of people all over the world. Tennis is a racket sport in which players use a racquet to hit a ball over a net in pairs (doubles) or individually (singles) to score points on a rectangular court. With big events, it is a popular sport around the world because it combines physical agility, strategic thinking, and precision. An athlete who participates in the game of tennis and displays strength, agility, and tactical awareness on the court is known as a tennis player. While participating in regional, national, and worldwide competitions, they frequently undergo intense training to hone their talents in a variety of areas. However, it is quite entertaining, but there is a price to pay for it: one of the most affected parts of tennis is the knees. The linear, lateral, and pivoting actions that are common during a game often lead to knee traumas, such as debilitating knee ligament injuries; meniscus tissue damage and knee pain associated with the patellar region [1]. These injuries not only hinder a player's presentation on the court and also boundary their joint mobility and adversely disturb their long-term joint health. For tennis players, knee injury rehabilitation is vital for a quick return to the sport and safeguarding their future healthy status [2]. The implications of a knee injury to a tennis player are far-reaching and transcend the players' ability to perform their daily activities. When a player hurts an injury on their knee, it can incapacitate their speed, ability to pivot, and balance components that are central to playing well in tennis. These injuries go beyond the immediate need to compete at the highest level and cause issues that last long, such as persistent pain, limited movement, and even the degeneration of joints well previously their time [3]. A tennis player's rehabilitation focuses on using specialized workouts, strength training, and flexibility training to return their body to its pre-injury state. To guarantee a safe return to competitive play, frequently involves a multidisciplinary approach that combines physical treatment, sports-specific training, and psychological support. Rehabilitation is a great factor that is not only aimed at returning one to the athlete level but also enhances the long-term health of the knee by preventing further injuries. Knee injury rehabilitation procedures often rest, use physical therapy, and do basic strength workouts [4]. Even though these approaches alleviate discomfort and enhance mobility, they can not necessarily bring back a tennis player's strength and flexibility attributes that are essential for realistic performance. Moreover, these routine procedures ignore the uniqueness of tennis, hence increasing the chances of re-injury [5]. Biomechanics is responsible for studying the various body movements, and force factors involved in other activities, like tennis. It also makes distributed loads over the joints and muscles, such as those found in the surrounding pelvis, which in turn is associated with physical clearing of the knee joint common knee injury. This is very important information for creating more advanced rehabilitation plans for addressing particular problem areas [6]. A customized program emphasizing pain management, a gradual return to sport-specific activities is part of the rehabilitation process for a tennis player who has had a knee injury. This encompasses the strategy to improve stability restore function, and guard against further injuries. However, the knee is also an important factor in the performance of some sports, especially tennis, which warrants a study of shoulder injuries as well [7,8]. **Figure 1** displays the framework for knee joint injuries in tennis players.

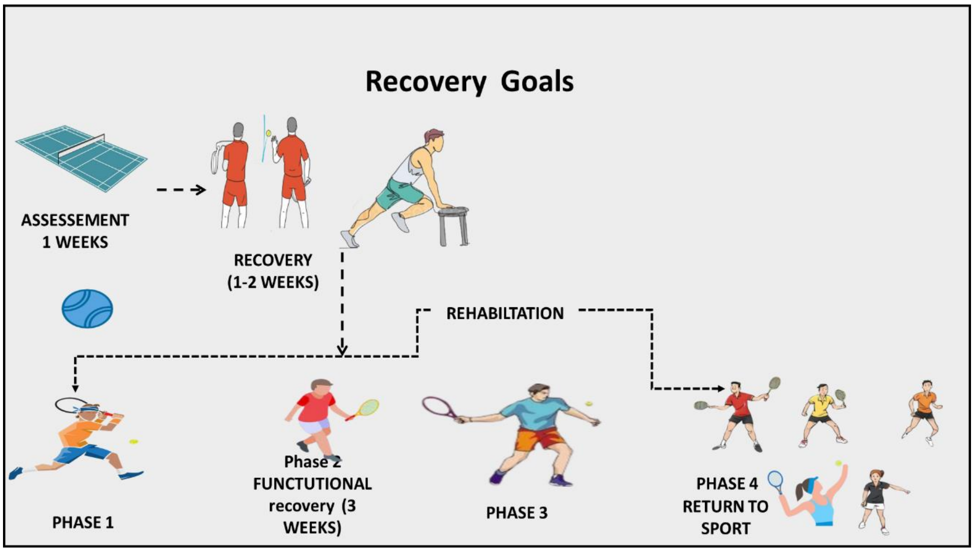

Figure 1. Framework for knee joint injuries in tennis players.

Tennis is a physically demanding activity that puts a lot of stress on the knee joints and lower limbs, because of the numerous sudden stops, quick direction changes, and constant pivoting. High-intensity exercise frequently results in a variety of knee ailments, including meniscus tears, ligament sprains, and patellar tendinitis [9,10]. These injuries can have a detrimental result on one's ability to play sports in the near term as well as long-term joint functionality. Comprehensive rehabilitation methods that address pain and suffering as well as muscle strength, flexibility, and general functional presentation are necessary for an actual recovery from these injuries [11,12]. Comprehending the biomechanical forces implicated in tennis strokes is vital for customizing rehabilitation regimens that foster maximum recuperation. Tennis players frequently have knee injuries as a result of the high intensity motions involved in the game, including abrupt pauses, rapid direction changes, and repeated pivoting. These injuries can have a serious effect on a player's mobility, performance, and long-term joint health [13]. In addition to being crucial for healing, appropriate rehabilitation also ensures a full return to improve competitive performance and lowers the chance of re-harm [14]. The research attempts to assess this plan's efficacy in enhancing functional recovery, muscle strength, pain management, and general long-term happiness by contrasting its outcomes with traditional therapy [15]. This study is to evaluate the efficacy of comprehensive rehabilitation record for tennis players with knee joint problems. It purposes to compare the functional recovery results between a structured rehabilitation plan and traditional therapy.

2. Related work

Yin et al. [16] noticed the recovery and performance of tennis players during their post-injury rehabilitation training. Tennis player underwent a synovectomy, free body excision, and arthroscopic capsulotomy of the left ankle joint. After one month of the operation, there was a substantial decrease in weight and lean mass, a rise in body fat percentage, and a significant rise in heart rate at rest ($P < 0.05$). The athlete's lean mass improved to 43.7 kg three months after surgery; body overweight percentage reduced to 24.5% ($P < 0.05$); albumin, serum iron, entire protein, and haemoglobin all improved; biochemical blood indices were regular during October and blood routine during rehabilitation; recuperation, sustained load, and heart rate dramatically dropped ($P < 0.05$).

Chen and Chen [17] examined how individuals with ligament injuries recover while using nano ligaments in conjunction with tennis. The primary focus is on the construction process of the nano ligament composite Fiber ligament. Second, internal rotation and severe knee deformation can be avoided by employing the nano ligament damage method. As demonstrated by the experimental results, patients with ligament injuries benefit from the combination of tennis and nano ligaments for their rehabilitation training.

Cigercioglu et al. [18] demonstrated the dominant and non-dominant shoulders differed in terms of range of motion (ROM), strength, and performance in functional tests. It also looked at gender variations in junior tennis players. To compare the differences, the student *t*-test and the paired sample *t*-test were employed. On the dominant shoulder, there was a bigger amount of External Rotation (ER ROM) and a lower amount of Internal Rotation range of motion (IR ROM) and overall ROM (all P values < 0.05).

Liu et al. [19] compared the athletes' performances, based on functional training that affects tennis players' strokes during everyday exercise. In addition to their regular training, the experimental group received functional physical training. The Integrated Training Network (ITN) and functional movement screening techniques were utilized to examine the tennis players' hitting ability both before and after training. The experimental group's mean level and accuracy were significantly greater ($P < 0.05$) after 12 weeks.

Martin et al. [20] examined the knee kinematics and kinetics during three common forward strokes stunned to assess whether the open stance forehand causes higher knee loads and explore its possible association with specific injuries. Findings indicated that the kind of forehand stance has a major impact on the centre of mass's absolute running velocity 163 at the moment the right foot makes contact with the force plate (p 164 < 0.002).

Purushothaman et al. [21] assessed the variations in postural balance and dynamic among expert tennis players who were injured then those who were not, to illustrate the wider effects of knee injured on player performance and stability. Participants in this cross-sectional study were divided into two groups: 40 people in the Non-Injury Group (NIG) and 40 people in knee Injuries Group (IG). These results implied that significant losses in balance control caused by knee injuries can impact both the risk of injury and overall athletic performance.

Lv and Fu [22] demonstrated an empirical investigation of the impact of functional movement system-guided physical exercise on the recovery of sports-related injuries. The screening results provided enough guidance for the three consecutive months of physical training that the individuals received. Torque in the lower limbs was also compared. The measurements of the thigh (from 52.61 cm to 53.26 cm) and calf (from 32.34 cm to 33.16 cm) showed a difference, while the weight and BMI remained unchanged. A significant difference was observed in the flexion, hurdles, squat, and straight knee raise tests ($P < 0.001$).

Liu et al. [23] evaluated the impact of exercise on rotator cuff injuries and the diagnostic value of regular MRIs and MRI shoulder arthrography. The purpose of this is to give male tennis players a resource for shoulder function restoration. This assessed how rehabilitation programs affected the strength and mobilization of the shoulder muscles, posterior deltoid, middle and anterior electromyography (EMG) values significantly increased ($P < 0.05$) in findings for both internal and exterior rotation from surface electromyography (EMG).

Liu [24] examined the injured tennis players and correlated with their location and ethology. As research subjects, tennis players were chosen. Tennis injuries were recorded using a questionnaire. Statistical techniques were used to compile and evaluate tennis players' post-injury rehabilitation programs. Ligament and tendon injured joints, muscles, bursitis, and soft tissue ligament contusions are the most frequent types of fractures. Shoulders, elbows, wrists, ankles, and knees are the joints most frequently affected.

Liang et al. [25] compared the biomechanical performance of female tennis players at various ability levels during the Foot-Up Serve (FUS). Throughout FUS, 3D biomechanical information from tennis players' lower members is collected. To look for variations in the kinematic and kinetic data across the groups, one-way ANOVA was employed. Bilateral lower-limb joints' Range of Motion (ROM) showed substantial variations in biomechanics performance during the landing cushion phase and the preparation phase ($p < 0.05$).

Krueckel et al. [26] demonstrated the tennis injured among league players in Germany, separating acute from chronic injured and focusing on the effects of racquet characteristics and court conditions. Anthropometrics of injury characteristics, equipment uses, and court surface conditions were all addressed in a standardized questionnaire that was used to retrospectively analyze data from 600 tennis players over 1.5 years. Ligaments were most frequently impacted (36.4%) and the lower extreme was the most common site of acute injury (56%), with ankle injuries becoming the most common.

Xiao et al. [27] studied the impact on power and strength of new tennis players. Power and strength were measured using the global tennis association guideline six weeks after the intervention, on baseline and twelve weeks after the intervention. Push-ups, the over-medicine ball throw, the wall squat test, and the standing long jump showed improvement afterward six workweeks of training for both training methods; the results continued to improve as the 12-week mark approached.

Rytelewski et al. [28] aimed to evaluate how physiotherapy training affected the frequency of sports injuries among young tennis players. The survey's next section asked questions regarding the players' health, potential injured, the frequency of micro-injury, and their incidence. Additionally, each respondents supplied information in response to questions regarding the steps taken to prevent injury. Before the commencement of tennis training, both groups' injury rates were comparable.

Kazemi et al. [29] developed and assessed the screening tool's validity and reliability for tennis functional movements as an injury prediction. Using samples of 20 tennis players, the test-retest approach was used to measure the tool's dependability at two-week intervals. 21 out of 27 tests had a content validity ratio of more than 0.62, according to the findings of the material validity ratio calculation; the remaining tests were eliminated.

Mainer-Pardos et al. [30] aimed to evaluate the influence of neuromuscular training on junior tennis players' abilities receiving a lot of guidance. The Experimental Group (EG) received neuromuscular training for 10 weeks, which included twice-weekly sessions for strength, speed, throws, agility, leaps, and coordination. Consequences indicated an important improvement in the EG, explosive power, especially in the bilateral leaps (vertical and horizontal) and speed. Equally, the Control Group (CG) non exhibit comparable gains. Also, the number of asymmetries did not increase.

3. Materials and methods

An evaluation for knee joint injuries, 146 participants were chosen based on predetermined criteria and placed in two groups: Group B received normal care, and Group A underwent a complete rehabilitation program. To assess the success of the recovery process, information on joint angles, force measurements, and gait analysis was gathered. Statistical techniques, such as *t*-tests, ANOVA, correlation, and logistic regression, were performed via SPSS.

3.1. Data collection

In this study, a rehabilitation plan was developed for the functional recovery of injured knee joints in tennis players in this study. Initially, this dataset comprised of 300 tennis players based on comprehensive clinical evaluations and extensive injury histories. 146 players were selected as participants from this bigger pool after meeting certain requirements for collection through an online survey: A documented history of knee joint disturbances related to tennis activities, an age range among 18 and 34 years old to signify active players, a confirmed clinical diagnosis of knee joint injuries, including ligament sprains, meniscus tears, or patellar tendon pain; and a willingness to involve in the rehabilitation program and follow-up evaluations. The purpose of this selection procedure is enabling a useful comparison of the therapy outcomes and the suggested rehabilitation program's overall effectiveness. Then, the participant's demographic table is shown in **Table 1**.

Table 1. Demographic table.

Demographic Variable	**Group A (*n* = 73)**	**Group B (*n* = 73)**
Gender		
Male	44 (60.3%)	46 (63.0%)
Female	29 (39.7%)	27 (37.0%)
Age [years]		
Mean [SD]	28.4 [3.2]	27.9 [3.5]
Range	21–35	22–34
Injury Type		
Ligament Sprain	25 (34.2%)	24 (32.9%)
Meniscus Tear	20 (27.4%)	21 (28.8%)
Patellar Tendinitis	28 (38.4%)	28 (38.4%)

Table 1. (*Continued*).

Demographic Variable	Group A (*n* = 73)	Group B (*n* = 73)
Injury Duration		
Less than 1 month	30 (41.1%)	28 (38.4%)
1-3 months	33 (45.2%)	34 (46.6%)
More than 3 months	10 (13.7%)	11 (15.0%)

Study's participant demographics show both the parallels and contrasts between the two groups. The mean age of Group A was 28.4 years (SD = 3.2), and the mean age of Group B was 27.9 years (SD = 3.5). Both groups' age ranges were similar, ranging from 21 to 35 years and 22 to 34 years, respectively. The proportion of genders was likewise similar, with men making up 60.3% of Group A and 63.0% of Group B, and women 39.7% and 37.0% of each group, respectively. Ligament sprains, meniscus tears, and patellar tendinitis were reported in both groups (34.2%, 27.4%, and 38.4% in Group A, and 32.9%, 28.8%, and 38.4% in Group B). The distribution of injury types was similar. In terms of the length of the injury, most individuals said they had group A at 45.2% and group B at 46.6% for injuries lasting one to three months, respectively, followed by group A at 41.1% and group B at 38.4% for injuries lasting less than a month and group A and B at 13.7% and 15.0% for injuries lasting more than three months. These demographic factors collectively show that the member profiles of the two groups are generally well-matched, contribution a strong basis for assessing the efficacy of the rehabilitation database of the tennis players.

3.2. Splitting of group

In the study, the two groups were considered to compare the effectiveness of different rehabilitation methods for tennis players with knee joint injuries:

Group A (comprehensive rehabilitation plan): Group A followed a specific rehabilitation program created with tennis players. Based on their clinical diagnosis and injury history, each participant was given a customized rehabilitation plan that addressed their unique injuries and recovery objectives. Exercises that were designed to improve range of motion, strength, stability, and flexibility were included of the program. Range-of-motion exercises were designed to increase knee joint mobility, while static and dynamic strength training was used to improve knee joint muscle balance and stability. Furthermore, sense of balance and muscle coordination were the focus of particular stability training activities, which are essential for the rapid direction changes that characterize tennis. Exercises for flexibility were included to increase muscular suppleness generally and help prevent injuries.

Group B (Traditional therapy): In contrast, Group B received normal or conventional therapy, which stressed general therapeutic procedures rather than a sport-specific approach. This group received therapy using techniques like passive stretching, fundamental strengthening exercises, and general pain management techniques. Group B's development was monitored less closely, and the rehabilitation plan saw fewer data-driven modifications. This group mainly focus on general recovery and symptom relief; it did not prioritize optimizing athletic performance or preventing tennis-specific injuries, instead concentrating on pain management and increased mobility.

3.2.1. Variables

Study focused on factors that are essential for assessing knee injury recovery in tennis players, including muscular strength, pain and discomfort, functional outcomes, gait analysis, functional performance, and long-term satisfaction. To compare the efficacy of the complete rehabilitation program with conventional therapy, several characteristics were examined. The variables are Functional Outcomes, which evaluate joint function following rehabilitation and overall healing.

Muscle Strength: Muscle strength is a vital sign of healing and function that represents the force produced by the surrounding muscles of the knee. Participants' muscle strength is measured using dynamometry to track recovery process and quantify changes.

Pain and Discomfort: The participants' stated pain levels during the recovery process are reflected in Pain & Discomfort. Standardized pain scales were used to measure this, and data were collected at various intervals during the research to monitor changes and relate them to efforts made toward rehabilitation.

Gait analysis: The timing of particular actions is recorded in seconds by gait analysis, which sheds light on the mechanics and operation of the lower limbs. Gait data were captured using motion capture technology to assess the subjects' return to normal gait patterns after their injury.

Functional Performance: Functional Performance evaluates the entire performance of the knee joint in sports-related activities. The way the knee functioned in motions unique to tennis was assessed using organized physical activity evaluations, such as agility and endurance tests.

Long-term satisfaction: Long-term Satisfaction measures how satisfied participants are overall with their recovery, taking into account things like mobility, pain alleviation, and quality of life after rehabilitation. Survey information was gathered during follow-up evaluations to get insight into the athletes' perceptions of their recuperation process and to help evaluate the overall efficacy of the rehabilitation program. **Figure 2** shows the key factors influencing knee injury.

Figure 2. Key factors influencing knee injury recovery in tennis players.

3.2.2. Statistical analysis

The study is to evaluate the efficacy of complete rehabilitation plan for tennis players' knee joint injuries in terms of their functional recovery. To compare the results of tailored rehabilitation database against traditional therapy in terms of several variables. Statistical techniques are used to analyze the effectiveness of different rehabilitation methods for tennis players with knee joint injuries. The SPSS statistical tool is employed in this research. This study utilizes *t*-test, ANOVA, correlation analysis and logistic regression to assess and evaluate the effectiveness of a comprehensive rehabilitation plan for the functional recovery of knee joint injuries in participants. The *t*-test is used to compare the mean variations in functional outcomes between the two groups. ANOVA assessed differences in recovery outcomes between rehabilitation and traditional therapy groups, determining the statistical significance of functional improvements across variables. Correlation analysis assessed relationships between rehabilitation variables, helping identify associations between treatment effects and functional recovery outcomes in players. A statistical technique called logistic regression is used to model the relationship between one or more independent factors and a binary dependent variable to forecast the likelihood for a particular result of tennis players.

4. Result

Study evaluated the effectiveness of a comprehensive rehabilitation plan for tennis players with knee joint problems. The significant results of the ANOVA, *T*-test, correlation analysis and Logistic Regression are assessed. It means differences in functional outcomes among the two groups are compared by the *t*-test. By comparing the recovery results of groups receiving rehabilitation against traditional care, an ANOVA determined the statistical significance of functional improvements across variables. To determine correlations between treatment effects and functional recovery outcomes in athletes, correlation analysis evaluated links between rehabilitation variables. Binary outcomes are predicted by logistic regression using the relationships between the variables of tennis players.

4.1. *T*-Test

The means of important variables were compared between Group B (conventional therapy) and Group A (rehabilitation plan) using the *T*-test. Significant changes were found in muscle strength, pain and discomfort, functional performance, gait analysis, and long-term satisfaction in addition to functional results. The efficacy of the comprehensive rehabilitation approach for treating knee joint problems in tennis players is highlighted by *T*-Test this analysis results (**Table 2** and **Figure 3**).

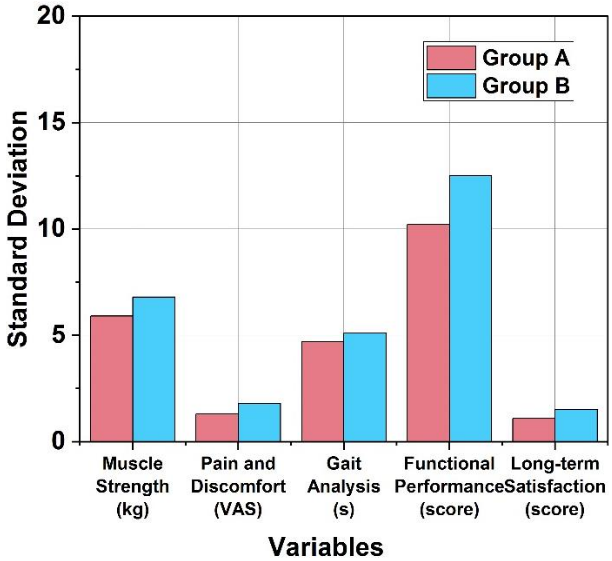

Figure 3. Outcomes of standard deviation.

Table 2. Result of *T*-Test.

Variable	Group A (Mean ± SD)	Group B (Mean ± SD)	*t*-value	*p*-value
Muscle Strength (kg)	78.4 ± 5.9	70.1 ± 6.8	4.14	< 0.001
Pain and Discomfort (VAS)	2.1 ± 1.3	4.5 ± 1.8	−6.92	< 0.001
Gait Analysis (s)	35.2 ± 4.7	29.8 ± 5.1	4.88	< 0.001
Functional Performance (score)	75.0 ± 10.2	60.4 ± 12.5	5.32	< 0.001
Long-Term Satisfaction (score)	8.3 ± 1.1	5.2 ± 1.5	7.58	< 0.001

A comparison of the two groups' rehabilitation results shows notable variations in a number of performance indicators. With a *t*-value of 4.14 ($p < 0.001$), Group A, which received the full rehabilitation program, showed a mean muscle strength of 78.4 kg, far higher than Group B's mean of 70.1 kg. Group A reported an average of 2.1 on the Visual Analog Scale (VAS), much lower than Group B's 4.5 (*t*-value: −6.92, $p < 0.001$), suggesting a significant decrease in discomfort among participants undergoing the organized therapy. Furthermore, based on gait analysis, Group A's average time was 35.2 s, whereas Group B's was 29.8 s (*t*-value: 4.88, $p < 0.001$), indicating better mobility. Operational effectiveness Moreover, Group A's mean score of 75.0 is considerably higher than Group B's 60.4 (*t*-value: 5.32, $p < 0.001$), indicating a preference for Group A. Lastly, with a *t*-value of 7.58 ($p < 0.001$), long-term satisfaction scores stayed much further along in Group A (8.3) compared to Group B (5.2). Indicating overall efficacy for the comprehensive rehabilitation method in improving tennis players' recovery and contentment.

4.2. ANOVA

ANOVA was used extensively to identify differences significant between the two groups for a number of recovery outcomes, by means of muscle strength and functional performance. Significant variations between the two groups are found for a number of recovery outcomes, including muscle strength and functional performance, in large part to the use of ANOVA. This statistical analysis provided strong support for the study's findings by confirming that the comprehensive rehabilitation strategy was more effective than standard therapy according to **Table 3** ANOVA results.

Table 3. ANOVA results.

Variable	**Sum of squares**	**df**	**Mean square**	***F*-value**	***p*-value**
Muscle Strength (kg)	298.2	1	298.2	17.67	< 0.001
Pain and Discomfort (VAS)	346.5	1	346.5	57.14	< 0.001
Gait Analysis (s)	128.9	1	128.9	22.54	< 0.001
Functional Performance (score)	456.0	1	456.0	32.25	< 0.001
Long-Term Satisfaction (score)	210.7	1	210.7	18.90	< 0.001

The rehabilitation outcome measures show statistically significant differences, according to the analysis of variance (ANOVA) results. A sum of squares for muscle strength of 298.2 had a significant influence from the rehabilitation treatment (F-value of 17.67, $p < 0.001$). Pain and Discomfort results showed a sum of squares of 346.5 and an exceptionally high F-value of 57.14 ($p < 0.001$). Regarding gait analysis, the participants' gait analysis was highlighted by the F-value of 22.54 ($p < 0.001$), which was obtained from a sum of squares of 128.9. With a total of 456.0 and an F-value of 32.25 ($p < 0.001$), functional performance scores also showed significant improvements, demonstrating improved functional performance after the extensive recuperation. Ultimately, long-term satisfaction scores showed an F-value of 18.90 ($p < 0.001$) and a sum of squares of 210.7, further confirming the beneficial effects of the organized rehabilitation program on player contentment. All things considered; these results show the efficacy of the comprehensive rehabilitation method in aiding in the recuperation of injured knees in tennis players.

4.3. Correlation

Understanding the links between the variables in a study depends heavily on correlation. It measures the relationship between changes in one variable and changes in another, such as the relationship between pain relief or improved functional performance and muscle strength gains. It facilitates the identification of the elements that have the greatest influence on results by displaying positive or negative correlations. This helps to improve rehabilitation plans by taking these relationships in **Table 4** and **Figure 4** as a correlation matrix with result.

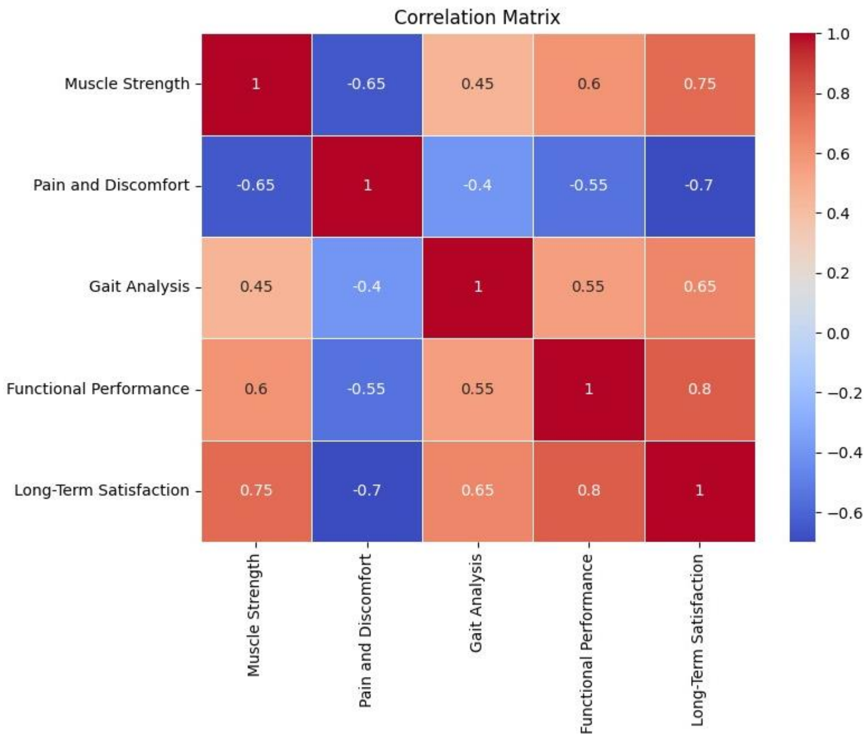

Figure 4. Output of correlation matrix.

Table 4. Correlation results.

Variable	Muscle strength	Pain and discomfort	Gait analysis	Functional performance	Long-term satisfaction
Muscle strength (kg)	1.00	−0.65	0.45	0.60	0.75
Pain and discomfort (VAS)	−0.65	1.00	−0.40	−0.55	−0.70
Gait analysis (s)	0.45	−0.40	1.00	0.55	0.65
Functional performance (score)	0.60	−0.55	0.55	1.00	0.80
Long-term satisfaction (score)	0.75	−0.70	0.65	0.80	1.00

Significant correlations exist between the different rehabilitation results in tennis players, according to the correlation analysis. There was a significant positive association (0.75) between muscle strength and long-term satisfaction, suggesting that higher levels of satisfaction following rehabilitation are linked to stronger muscles. There was a negative association (−0.65) between muscle strength and pain and discomfort, indicating that higher levels of muscle strength are associated with lower levels of pain. Furthermore, a favourable connection was seen between muscle strength and both functional performance (0.60) and gait analysis (0.45), highlighting the role that strength plays in improving overall functional performance and mobility. The idea that less discomfort leads to higher satisfaction with recovery results is supported by the substantial negative connection between pain and discomfort and long-term satisfaction (−0.70). There were shown to be positive relationships between functional performance and gait analysis (0.55) and long-term satisfaction (0.65), underscoring the interdependence of these factors even further. Overall, the results highlight how important muscle strength is for reducing pain and improving function, which eventually improves long-term pleasure for tennis players recuperating from knee injuries.

4.4. Logistic regression

Logistic regression is used to examine the difference between a number of separate variables and a binary outcome, such as the success of a patient's rehabilitation. It aids in figuring out how variables like pain thresholds and muscular strength affect the possibility of an athlete's functional recovery. **Table 5** is the logistic regression result.

Table 5. Logistic regression results.

Variable	**Coefficient (*β*)**	**Standard error**	**Wald statistic**	***p*-value**	**Odds ratio**
Muscle strength (kg)	0.25	0.10	6.25	< 0.001	1.29
Pain and discomfort (vas)	−0.30	0.12	5.00	0.025	0.74
Gait analysis (s)	0.15	0.09	3.00	0.083	1.16
Functional performance (score)	0.40	0.11	12.00	< 0.001	1.49
Long-term satisfaction (score)	0.35	0.10	10.00	< 0.001	1.42

The impact of several rehabilitation outcome variables on tennis players' recovery is better understood due to the significant information provided by the logistic regression analysis. Muscle strength showed an important positive coefficient ($p < 0.001$, $\beta = 0.25$), meaning that the odds of a good recovery increase by 29% (Odds Ratio = 1.29) for every unit increase in muscle strength. An odds ratio of 0.74 indicates a 26% reduction in odds for each unit increase in discomfort. Pain and discomfort showed a significant negative coefficient ($p = 0.025$, $\beta = -0.30$), suggesting that higher pain levels decrease the likelihood of successful recovery outcomes. Improved gait can aid in recovery, although despite the positive coefficient ($\beta = 0.15$) in gait analysis, it did not approach statistical significance ($p = 0.083$). It has a less definite effect. The probabilities of positive recovery outcomes are increased by 49% (probabilities Ratio = 1.49) when functional performance scores are improved, as indicated by the strong positive coefficient ($p < 0.001$, $\beta = 0.40$). The significance of the satisfaction in recovery success was highlighted by the long-term satisfaction scores, which again produced an important positive coefficient ($p < 0.001$, $\beta = 0.35$) then an odds ratio of 1.42. These results highlight how important it is for tennis players to have pain management, functional performance, muscular strength, and overall pleasure during the rehabilitation process after knee injuries.

5. Discussion

According to the study, a customized rehabilitation program can greatly enhance knee joint healing and improve tennis players' long-term functional outcomes while lowering their chance of reinjure. The comparisons exhibiting *p*-values less than 0.001, the *T*-test results indicated that Group A outperformed Group B in terms of muscle strength, pain and discomfort reduction, improved functional performance, and longer-term satisfaction. With *p*-values less than 0.001, the ANOVA findings show significant differences in all recovery outcomes. Muscle strength had the lowest *F*-value (17.67), while pain and discomfort had the highest *F*-value (57.14). Significant correlations were found by correlation analysis, with muscle strength and long-term satisfaction having the strongest positive association (0.75) and the lowest correlation

(0.45) with gait analysis. The logistic regression results demonstrated substantial positive impacts of muscle strength (β = 0.25) and functional performance (β = 0.40) on recovery likelihood, whereas gait analysis (β = 0.15) had the least impact and was not statistically significant (p = 0.083) of tennis players.

6. Conclusion

This study compares a thorough rehabilitation program to standard treatment to determine which is more beneficial for knee joint recovery in tennis players. Tennis players with knee joint injuries found that Group A, which adhered to the comprehensive rehabilitation plan, was more successful in enhancing functional recovery and long-term happiness. Its customized method met particular biomechanical requirements, maximizing recovery and lowering the chance of repeat injuries, making it the better choice than Group B's conventional therapy. A potential constraint of this research is the very small sample size of 146 individuals, which could potentially impact the applicability of the results to a wider tennis playing population. The limitation is only included 146 participants, a tiny sample size that could not accurately reflect the overall tennis playing population. Furthermore, the lack of data from long-term follow-up restricts our capacity to understand how recovery outcomes are sustainable. The research's future focus is on optimizing sophisticated biomechanical approaches in sport-specific rehabilitation programs to improve tennis players' performance, healing, and injury prevention.

Ethical approval: Not applicable.

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