



Exploring the efficacy of isometric strength exercises in knee rehabilitation among football players

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Abstract

Background and study aim. Isometric strength exercises engage the intricate knee joint, including the femur, tibia, and patella, along with multiple muscles and ligaments, aiding in the rehabilitation of knee injuries while supporting movement and injury prevention. The specific objective of this research is to investigate the effectiveness of isometric strength exercises in rehabilitating the knee injuries among football players, assessing their impact on recovery and performance.

Material and methods. Thirty male ACL Knee injured football players were randomly assigned to isometric strength exercise group (ISEG) (N=15) (Age; 20 ± 1.9 , Height; 171 ± 4.5 , Weight; 60 ± 6.0) and control group (Age; 21 ± 1.3 , Height; 173 ± 4.4 , Weight; 63 ± 8.2) and their age ranged between 18 and 23. Subjects were randomly selected from various football academies in Coimbatore, Tamil Nadu, India. Thirty subjects who will diagnosed by a physiotherapist and help of orthopaedician as having knee injuries in football players and who showed a typical restriction of Range of motion (ROM). Fifteen subjects underwent rehabilitation (Isometric Strength exercise Group) and the other 15 underwent cryotreatment (Control Group). Analysis was based on the active and passive flexion Range of motion (ROM) were measured by kinovea-0.9.5 software. Means and standard deviations (\pm) described all data, with Shapiro-Wilk tests checking for normality ($p < 0.05$). A dependent 't' test determined significant mean differences between experimental and control groups ($p < 0.05$).

Results. The participants who underwent a regimen of Isometric strengthening exercises exhibited notable enhancements in their range of motion (ROM), highlighting the effectiveness of this comprehensive approach significantly improved in active and passive flexion Range of motion ($p < 0.05$).

Conclusion. Isometric strength exercises demonstrate promise in enhancing knee rehabilitation outcomes among football players, warranting further exploration and implementation compared to control group.

Key words: isometric strength exercises, Knee rehabilitation, Kinovea software and football players.

Анотація

Дослідження ефективності ізометричних силових вправ у реабілітації колінного суглоба футболістів

Маріяппан Раджкумар, Суббрамані Логесваран, Селварадж Сурьярадж, Муругесан Равін, Гунасекан Вінот каннан, Деварадж Суджінрадж, Етіраж Баладжі

Передумови та мета дослідження. Ізометричні силові вправи задіюють складний колінний суглоб, включаючи стегнову кістку, великогомілкову кістку та надколінник, а також безліч м'язів і зв'язок, допомагаючи в реабілітації травм коліна, одночасно підтримуючи рух та запобігаючи травмам. Мета цього дослідження – вивчити ефективність ізометричних силових вправ у реабілітації травм коліна у футболістів, оцінивши їхній вплив на відновлення та продуктивність.

Матеріал та методи. Тридцять чоловіків-футболістів з травмою коліна були випадковим чином розподілені на 2 групи: групу ізометричних силових вправ (ISEG) (N=15) (вік: $20 \pm 1,9$, зріст: $171 \pm 4,5$, вага: $60 \pm 6,0$) та контрольну групу (вік: $21 \pm 1,3$, зріст: $173 \pm 4,4$, вага: $63 \pm 8,2$), а їх вік варіювався від 18 до 23 років. Випробувані були випадково обрані з різних футбольних академій у Коїмбаторі, Таміл Наду, Індія. Тридцять





спортсменів, яким фізіотерапевт та ортопед поставили діагноз травми коліна, та у яких спостерігалось типове обмеження діапазону рухів (ROM). П'ятнадцять спортсменів пройшли реабілітацію (група ізометричних силових вправ), інші 15 пройшли кріотерапію (контрольна група). Аналіз був заснований на активному та пасивному згинанні. Діапазон руху (ROM) вимірювався за допомогою програмного забезпечення Kīnovea-0.9.5. Середні значення та стандартні відхилення (\pm) описували всі дані з тестами Шапіро-Вілк для перевірки нормальності ($p < 0,05$). Залежний t-тест визначив суттєві відмінності середніх значень між експериментальними та контрольними групами при ($p < 0,05$).

Результати. Учасники, які пройшли курс ізометричних силових вправ, продемонстрували помітні покращення в діапазоні рухів (ROM), що підкреслює ефективність цього комплексного підходу, значно покращивши результати в активному та пасивному згинанні ($p < 0,05$).

Висновки. Ізометричні силові вправи демонструють перспективність покращення результатів реабілітації коліна у футболістів порівняно з контрольною групою, що потребує подальшого вивчення та впровадження.

Ключові слова: ізометричні силові вправи, реабілітація коліна, програмне забезпечення Kīnovea та футболісти.

Introduction

A study suggests that quadriceps strengthening exercises during early anterior cruciate ligament (ACL) rehabilitation should aim to limit anterior tibial translation near full knee extension to prevent excessive strain on healing tissue. Knee-flexion exercises with voluntary quadriceps contraction effectively activate the rectus femoris, vastus medialis, and vastus lateralis muscles while preventing anterior tibial translation, potentially making them a suitable intervention for early ACL rehabilitation [1].

The utilization of isometric Knee Strength assessment to evaluate muscle imbalances presents potential for injury prediction in professional soccer players. Notably reliable due to fixed positions, further research is needed despite observational limitations [2].

The study conducted a meta-analysis and systematic evaluation of epidemiological data related to injuries. Male professional football players are at a significant risk of injury, particularly during games [3].

This research article is to review the current literature regarding conservative treatment options for the three most common knee injuries in runners including patellofemoral pain syndrome (PFPS), iliotibial band friction syndrome (ITBFS), and patellar tendinopathy (PT). Result is a comprehensive overview of each diagnosis and a research-based approach to effectively evaluate and treat each condition for best outcomes [4].

Single-joint isometric and isokinetic knee strength assessments, normalized to body mass, provide valuable data for strength and conditioning, physical therapy, and rehabilitation, aiding in understanding knee strength variations across different knee angles and populations [5].

Following a study four-week period, knee flexor optimum lengths increased by 2.3° in the control group and 4.0° in the exercise group, the latter showing a significantly greater change. Knee extensor optimum lengths rose by 6.5° solely in the exercise group, while peak torque levels and quadriceps to hamstring ratios

remained unchanged for both groups [6].

Examining professional female soccer players in preseason training, an 8-week NHE program, conducted twice weekly, boosts eccentric knee flexor strength and BFLH fascicle length. Monitoring individual responses is crucial due to varied benefits [7].

Reviewing rehabilitation techniques for knee articular cartilage repair in football players, this study notes a successful return to play during extended recovery periods [8].

Pro football players' knee joint stability was investigated in a prospective study about the effects of squat exercises. 32 participants in a 21-week off-season training programme showed normal knees. A comparison of anterior-posterior tibiofemoral translation shows no statistically significant differences [9].

In a study involving 37 football players who underwent anterior cruciate ligament (ACL) reconstruction following ACL rupture without additional injuries, the effectiveness of a range of therapeutic exercises in restoring knee joint function was investigated. The exercise therapy, graded progressively postoperatively based on the elapsed time since surgery, aimed to safeguard the graft and facilitate the return of athletes to their pre-injury performance levels [10].

In the rehabilitation of ACL knee injuries among football players, isometric strength exercises play a vital role in restoring muscle function, stability, and overall knee joint health. This introduction aims to explore the significance of isometric exercises as a cornerstone in the rehabilitation protocol for these athletes.

Drawing from prior research, we hypothesized that engagement in a 12-week isometric strength exercise would lead to a greater improvement in the chosen variables (i.e., active and passive flexion range of motion (ROM)). Significantly, football players' knee motion is improved by 12 weekly isometric strength rehabilitation exercise.

Material and methods

Electronic searches were carried out by the investiga-

tors (MR, EB and SS). Search engines used to locate published articles included MEDLINE, EMBASE, Scopus, Science Direct Databases Directory of Open Access Journals (DOAJ), PubMed, and Google Scholar. The terms "Isometric Strength", "Rehabilitation", "Range of motion", and the conjunctions "OR/AND" were used as essential terms. Searches could only be conducted in English. The studies detailing how Range of Motion is affected by isometric strength exercises are considered for literature review.

Study Participants

Thirty male ACL Knee injured football players were randomly assigned to 2 groups (i.e., ISEG and GG) (Table 1). using the method of randomly permuted blocks using Research Randomizer, a program published on a publicly accessible official website (www.randomizer.org) their ranged from 18 to 23 years. All subjects were advised not to decrease or increase their daily sports and regular activities over the course of the study.

Experimental Design

To minimize any learning effects, two familiarization sessions for the testing procedures and three familiarization sessions for the isometric strength exercises were held prior to the start of the intervention, right before the baseline assessments. In addition, participants were instructed to eat a regular food and abstain from caffeine for three hours prior to testing, as well as to refrain from any strenuous activity for a full day. To reduce the impact of circadian fluctuations, pre-post measurements were carried out for all participants at similar times of day.

Group I underwent isometric strength exercise group (ISEG), and Group II served as the control group (CG). They are doing regular activity following a cryotreatment. The isometric strength exercise protocol has been performed on five days in a week during the period of 12 weeks. All the selected variables of active and passive flexion range of motion (ROM) were measured by kinovea-0.9.5 software [11]. The methods

Table 1. Characteristics of participation (mean \pm SD)

Group of Subjects	No. of subjects	Age (In years)	Height (In Centimeter)	Weight (In kilograms)
Isometric Strength Exercise Group (ISEG)	15	20 \pm 1.9	171 \pm 4.5	60 \pm 6.0
Control Group (CG)	15	21 \pm 1.3	173 \pm 4.4	63 \pm 8.2

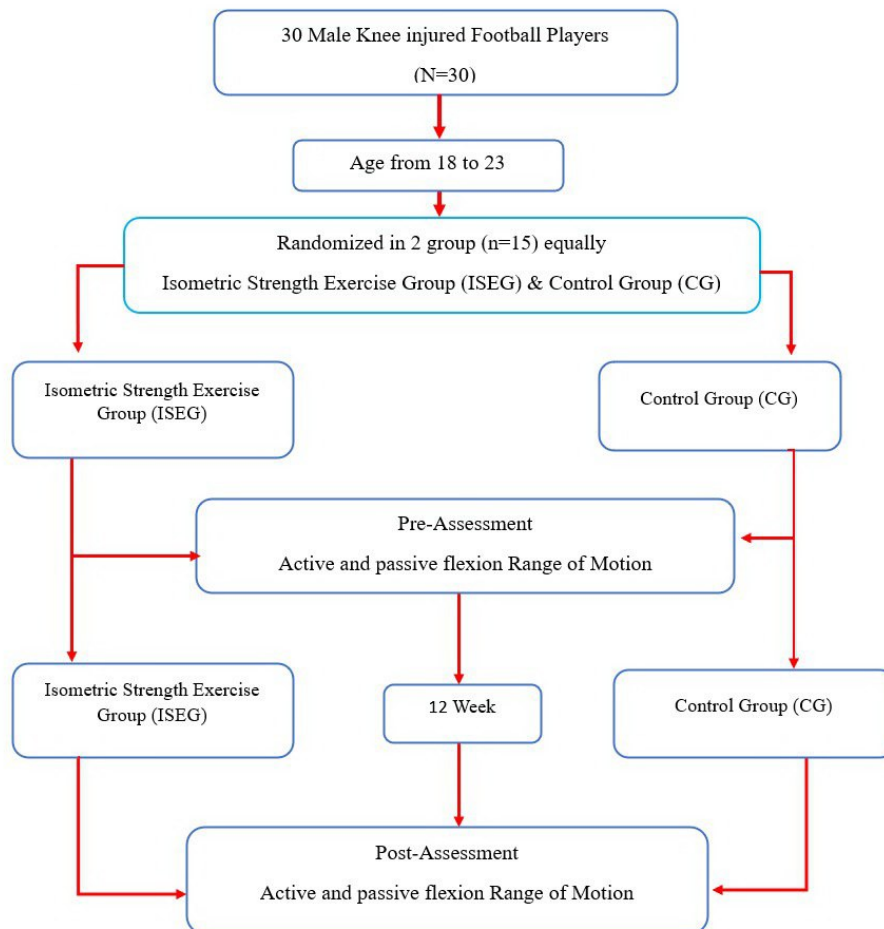


Figure 1. Schematic of the study design

used complied with the 1964 Helsinki Declaration and its subsequent amendments' ethical guidelines regarding human experimentation.

Procedure

All participants were informed in detail about the research protocol and the basic characteristics of the study. We measure the subject Characteristics profile namely age, height and weight. After that we arranged the tripod and fixed the Sony A73 camera for video recording of subjects' knee movements. We applied kinovea software application in recording knee movement video through the personal computer. We edited the video and placed tracking the markers on the player's knee to measure the angular movements of active and passive flexion range of motion.

Training protocol

The training was delivered over forty five to sixty minutes in both morning and evening sessions. This protocol is time-based (dependent on tissue healing) as well as criterion-based. Specific interventions should be based on the needs of the individual and should consider exam findings and clinical decision-making. The

time frame for isometric strength exercises was five minutes of preparation and five minutes of relaxation. The participants were given the protocol for a total of twelve weeks, five days per week. Expected outcomes contained within the guideline may vary based on the physiotherapist and researcher's preferences and the additional procedures performed. Even though referred to frame training protocol on this study Rehabilitation Protocol for Anterior Cruciate Ligament (ACL) Reconstruction [14].

Active and Passive Range of Motion

The study utilized the Kinovea software application for body movement analysis. Participants lay on their backs with their legs straight on a flat, preferably hard surface. The first step involved setting up a tripod and fixing a Sony A73 camera, positioning the injured player on a bed. The camera was connected to a PC, allowing the Kinovea application to record the leg movements of football players. Once the video was recorded, it was edited, and tracking markers were placed on the player's knee to measure the angular movements of active and passive flexion range of motion. To measure knee flexion, participants bent their knees as far as

Table 2. Training Protocol

Weeks	Isometric Exercises	Repetitions	Rest
I-IV	Ankle pumps Chair squat Straight leg raises (Flexion, Abduction, Adduction) Standing Hamstring Curls Wall squat Double / Single Leg Bridge Standing Knee Flexion	8X3	30 secs
IV-VIII	Ankle pumps Chair squat Straight leg raises (3 directions) wall squat Standing Hamstring curls Quadriceps isometric setting Lateral lunges Multi-angle isometrics at 90 and 60 degrees (knee extension)	10X3	30 secs
VIII-XII	Ankle pumps Chair squat Straight leg raises (Flexion, Abduction, Adduction) Wall squat Double / Single Leg Bridge Standing Knee Flexion. Multi-angle isometrics at 90 and 60 degrees (knee extension)	8X3	30 secs

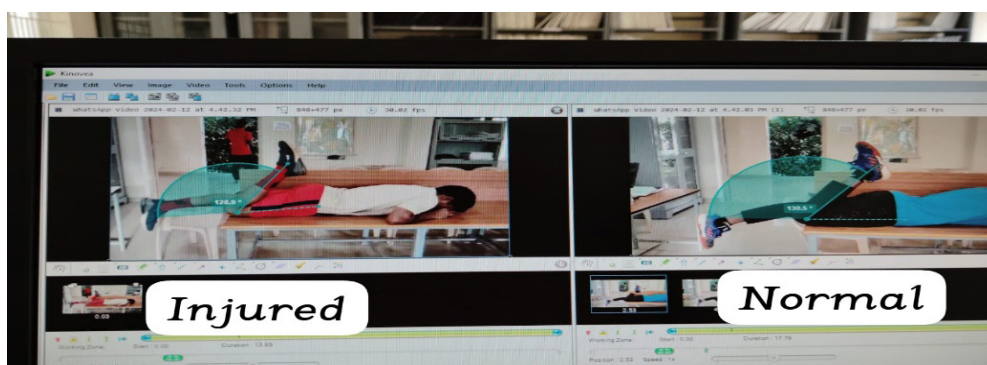


Figure 2. Shows the active angular motion by kinovea software.

possible by sliding their feet up towards their buttocks, while the arms and axis of the Kinovea software recorded the video and measured the angular movement. For those who preferred, knee flexion was measured while sitting, ensuring the leg could move freely. This worked best when sitting on a high chair or the edge of a table. The Kinovea software analyzed the movement as described, and participants bent their knees as much as they could.



Figure 3. Shows the passive movement.



Figure 4. Shows the passive movement.

Isometric strength exercises were given for 12 weeks, with pre- and post-testing sessions separated by five days in a week. Participants received instructions on ACL knee injury prevention and rehabilitation beforehand of study. Attendance varied; the isometric strength exercise group had higher rates without absent and any deviation and subject are healthy, while the control group received cryotreatment due to health

issues and lack of attendance. Data collection involved physiotherapist, orthopedicians from Coimbatore [12] and Researchers from Department of Physical Education, Bharathiar University. Active and passive flexion range of motion assessment were conducted though kinovea software application.

Statistics technique

The data analysis procedure in this study consisted of two steps: the Shapiro-Wilk test and the Paired Sample t-test. This study employs a paired sample t-test hypothesis test. This test's objective is to compare the pretest and posttest results. For the statistical analysis in this study, IBM SPSS Statistics 16.0 was used. (SPSS, Inc.; USA; Chicago, IL)

Results

There were no withdrawals from the study, injuries or missed training sessions among the participants.

The data displayed as mean \pm SD sig. value; if the sig. \geq 0.025. the data are considered normally distributed.

The data displayed as mean \pm SD sig. value; if the sig. \geq 0.05. The data are considered normally distributed. The result of the pre and posttest for Isometric Strength exercise group as well as the control group were obtained using the Shapiro-Wilk test instrument, based on the results of table 3 above. Each and every value is sig. \geq 0.05. The paired sample t-test in parametric statistics was used to the hypothesis because all the re4search results data were normally distributed.

Based on the results of Table 4 above and from the results of the hypothesis test with the Paired Sample t-Test, the active and passive ROM of experimental group results obtained sig (2-tailed) value of 0.000 $<$ 0.05, it can be concluded that there is a significant improvement in the selected variables due to twelve-week isometric strength exercises.

Discussion

The Purpose of the study was to find out the advantages of isometric strength exercises in knee rehabilitation. The main objective of the study is to improve the active and passive knee flexion range of motion (ROM)

Table 3. Shows Normality Calculation

Variables	Group	Test	Shapiro-Wilk		
			Statistic	df	Sig.
ISEG	Active	Pre-test	0.88	15	0.06
		Post-test	0.92	15	0.24
	Passive	Pre-test	0.90	15	0.10
		Post-test	0.88	15	0.06
CG	Active	Pre-test	0.93	15	0.30
		Post-test	0.92	15	0.19
	Passive	Pre-test	0.90	15	0.09
		Post-test	0.91	15	0.13

Note: ISEG-Isometric Strength Exercise and CG- Control Group.

Table 4. The mean and t-ratio for pre and post-test on Active and passive range of motion of Isometric Strength Exercise Group (ISEG) and Control Group (CG)

Variables	Group	Test	Mean \pm SD	't' ratio	p-value
Active ROM	CG	Pre	129.90 \pm 2.34	1.65	0.12
		Post	130.44 \pm 2.10		
	ISEG	Pre	130.30 \pm 2.37	13.71*	0.00
		Post	133.11 \pm 2.32		
Passive ROM	CG	Pre	136.68 \pm 1.12	2.11	0.53
		Post	136.86 \pm 1.05		
	ISEG	Pre	136.74 \pm 1.06	8.28*	0.00
		Post	138.96 \pm 1.50		

Note: Statistically significant difference, mean score at point comparisons from baseline: sig (2-tailed) value of ≤ 0.05 ; data are presented as means \pm SD.

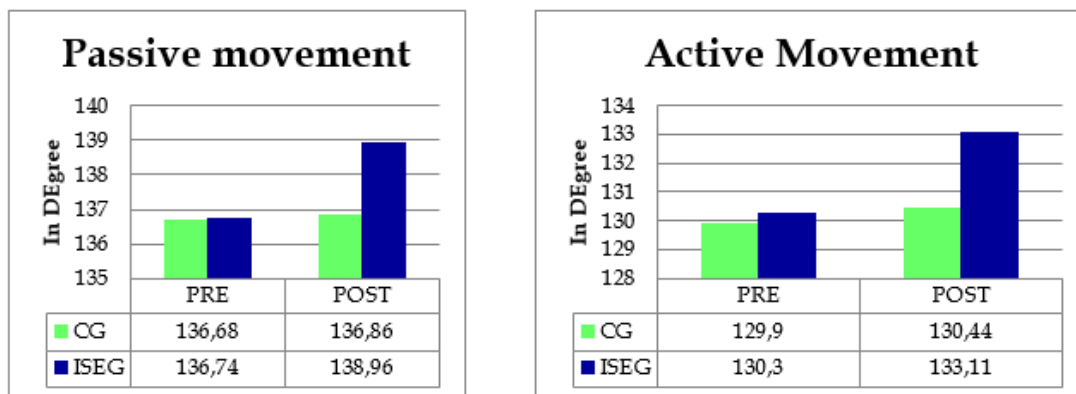


Figure 5 and 6. Graphical representation of individual comparison between pre and post test on Active and passive ROM of isometric strength exercise group and control group.

of ACL knee injured male football players' through the systematic isometric strength exercise.

Rehabilitating football player's post-cruciate ligament reconstruction involves gradually escalating exercise therapy, ensuring graft protection, and restoring performance levels comparable to pre-injury standards [14]. The effect of specific exercises on football players' acute cruciate ligament reconstruction rehabilitation. The study found that football players' muscle strength, motor range, and perception of pain were all improved by specific workouts performed during ACL rehabilitation. Players with injuries other than their knees might benefit from these exercises [15]. Participant of axial tibial force to the knee at a fixed flexion angle has been shown to generate ACL force. However, the study shows ACL forces generated during knee extension were significantly greater than those generated during knee flexion [16]. In this study, we consider motion analysis, the anterior cruciate ligament, and the classification of injury risk. Anterior cruciate ligament (ACL) injuries are common. There is strong evidence to indicate that athletes who consistently classify as high-risk loaders during landing suffer from combined joint stability deficits in both the active and passive knee restraints and show poor control of the active knee stabilisers, which reduces the incidence of ACL injuries [17]. Knee function among elite handball and football players 1-6 years after anterior cruciate ligament inju-

ry. ACL-injured players who have successfully returned to elite sports have comparable strength and balance measures as their non-injured teammates. Subjective perception of knee function is strongly affected by injury history, with clinically relevant lower scores for the KOOS subscores Pain, Function, Sport, and Quality of Life [18]. While the study referees to anterior cruciate ligament injuries, which are prevalent in athletes, few studies examine long-term outcomes. Elite collegiate athletes with ACL injuries showed comparable quality of life but varied knee function compared to their uninjured peers [19]. In former soccer players, twelve weeks of knee-specific training improved knee kinetics and kinematics, reducing knee stiffness during demanding hop activity. Further research is required to validate findings in diverse ACL-injured populations [20]. Based on our research, incorporating EMS into a rehabilitation program post-ACL reconstruction appears to effectively improve muscle circumference, muscular activity, and muscle function. However, no significant differences were observed in thigh circumference or subjective knee function evaluations. Further investigation is needed to confirm the mechanisms and effectiveness of EMS in rehabilitation programs for muscle hypertrophy and ligament strengthening, particularly in the context of isometric strength exercises in knee rehabilitation for football players [21]. Investigations into kinetic asymmetries during bilateral squats follow-



ing anterior cruciate ligament reconstruction (ACLR) have largely been confined to cross-sectional studies and discrete data points at specific knee angles. Our study assessed loading asymmetries during squats longitudinally throughout the rehabilitation process using curve analysis. Additionally, we compared patient-reported outcome measures (PROMs) between individuals exhibiting asymmetry and those without. This approach provides a more comprehensive understanding of the rehabilitation process, particularly focusing on the efficacy of isometric strength exercises in knee rehabilitation among football players [22]. Participants who received pre-surgery physical therapy, combined with post-surgery electrostimulation and an intensive physical therapy program, demonstrated higher levels of knee extensor and flexor muscle strength following anterior cruciate ligament reconstructive surgery compared to those who underwent a traditional physical therapy and strength exercise program solely after surgery. This suggests that a comprehensive rehabilitation approach may enhance muscle strength outcomes. This discussion highlights the potential benefits of incorporating isometric strength exercises in knee rehabilitation programs, particularly for football players, to optimize recovery and performance [23]. In conclusion, the ARP trainer's electrostimulation (ES) can activate muscle fibers at frequencies significantly higher than both the critical fusion frequency (the minimum firing rate required for a tetanic response) and the normal firing rate for quadriceps femoris (QF) fibers. In this study, patients who received post-operative rehabilitation augmented with the ARP trainer experienced a 3:1 increase in thigh girth compared to those who followed a standard isometric rehabilitation program alone. These results suggest that incorporating the ARP trainer protocol can effectively combat disuse atrophy and enhance thigh girth restoration after ACL reconstruction. This discussion underscores the potential benefits of advanced ES techniques in isometric strength exercises for knee rehabilitation, particularly among football players [24].

Conclusion

The findings of the study shows that the 12-week isometric strength exercise significantly improved the active and passive flexion range of motion (ROM) of male football players compared to control group. Football players may benefit from knee stability and function through isometric strength exercises after the ACL knee injury that may help both rehabilitation and performance.

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Supplementary Information

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Conflict of interest

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