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EFFECT OF FATIGUE ON THE RATE OF CONTRACTION AROUND THE KNEE AND FUNCTION IN FOOTBALLERS WITH A HISTORY OF ANTERIOR CRUCIATE LIGAMENT RUPTURE

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Abstract
Given that athletes endure fatigue after an anterior cruciate ligament rupture, it is crucial to comprehend the implications of fatigue on irreparable nerve regulation and functionality. This research aimed to examine the impact of fatigue on the contraction of knee circumferential muscles and functionality in athletes with a history of anterior cruciate ligament rupture. Materials and Methods: The sample included 24 athletes, categorised into three groups: 8 with ACLR repair, 8 with ACLD rupture without reconstruction, and 8 serving as a control group. The joint contraction of the quadriceps, hamstrings, and gastrocnemius was evaluated before and after exhaustion. Results: The quadriceps joint contraction rate in the afflicted groups (ACLR and ACLD) was considerably lower than that of the control group. The functionality in the single-leg Li test diminished markedly in the afflicted groups post-fatigue. Conclusion: The simultaneous contraction of the twin quadriceps is crucial for knee joint stability; hence, it is advisable to emphasise these muscles in rehabilitation activities. Due to the diminished functioning of injured athletes, it is advisable to assess functional tests under circumstances of exhaustion.

Keywords: Fatigue, Rate of Contraction, Knee, Function, Anterior Cruciate, Ligament Rupture.

Introduction

The rupture of the anterior cruciate ligament (ACL) is a prevalent cause of injuries in sporting activities (Gans et al., 2018; Filbay & Grindem, 2019). Two of the most significant sequelae of anterior cruciate ligament rupture, apart from surgical interventions, are often the resumption of athletic activities and the development of post-traumatic osteoarthritis (Ptasinski et al., 2022; Pérez-Prieto et al., 2023). Sports lead to injuries by impairing the function of irreparable nerves. Contraction is characterised by the concurrent activation of the periarticular counterparty (Farag, McDougall & Catapano, 2025). The objective of joint contraction is to enhance ligament functionality in preserving joint stability, provide resistance to joint rotation, and equilibrate pressure in articular tuberculosis (Singh et al., 2023). The inhibitory neural technique used during activity is deemed dynamic, aimed at stabilising the joint and mitigating shear and rotational pressures, both of which are detrimental to joint integrity (Lepley & Lepley, 2021). There are two perspectives regarding the relationship between athletes effort and the contraction of the muscles surrounding the knee following an injury to the anterior cruciate ligament; on one hand, irreversible contraction may serve as a beneficial adaptation to the inherent effects of the asymptomatic condition (Inostroza Millas, 2018). Joint contraction may function as a comprehensive preventive mechanism (Bulat et al., 2019). The concurrent stimulation of antagonistic vertebral cavities may influence the equilibrium of articular tuberculosis forces and enhance joint stability via synergy. Standardising Joints is seen as a detrimental method (Zorzi, 2024) .The impact of joint contraction on the uniform distribution of joint stress might lead to a rise in net flexural forces annually,

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potentially predisposing individuals to the onset and progression of arthritis (Herasymenko et al., 2024). To enhance joint stability, a greater degree of joint contraction should be used. In instances of adverse consequences during training or competition, the inhibitory nerve control is compromised to a degree that results in irreversible abduction responses from mathematics (Al Behadili & Kasim, 2022; Zatsiorsky, Kraemer & Fry, 2020). Previous investigations have identified the impact of the anterior cruciate ligament and fatigue on the pace of joint contraction in the causative cavities next to the knee joint (Carlson, 2024). The findings of the Dewan (2022) investigation indicated that extensor knee flexor strain resulted in an elevation of the joint contraction %. The weakening of the four gowns and hamstrings during the movements of Farved Shadeh and Khalar exacerbates discomfort (Boling, M Padua & Prentice, 2024). In the research conducted by Inostroza Millas (2018), the use of the YAC protocol during the closed kinetic chain exercise (squat repetition) resulted in a favourable rise in the ratio of thigh muscle activity to hamstring (H:Q). De Melo et al. (2022) emphasise the need to examine itch exercises by Ach Nashan and Dhandanda Straw in May, which may substantially diminish contraction in the quadriceps, hamstrings, and gastrocnemius in patients with ACLD. The research by Buckthorpe et al. (2021) found no significant change in the external hamstring thigh muscle joint requirements after deterioration in individuals who had anterior cruciate ligament repair (ACLR) compared to those with good restoration. The report did not analyse the decision in conjunction with ACLR athletes; it examined solely the impact of joint muscle contraction on the foramen and canal, while the response of other knee limbs to fatigue remains unidentified (Balasingam, 2024). The capacity to engage in athletic activity while experiencing weariness (Pageaux & Lepers, 2018). Dynamic performance tests are conducted for athletic and rehabilitative objectives under situations distinct from exhaustion. To enhance the assessment of training and rehabilitation therapies, it is suggested to measure dynamic functioning under circumstances of exhaustion (Gruet, 2018). The Lee single leg test serves as an indication of the dynamic functionality of the knee joint, particularly in individuals with cruciate ligament injuries (Al Behadili & Kasim, 2022; Lee et al., 2018). Research indicates that the Lee test is the most dependable assessment for assessing individuals with an anterior cruciate ligament injury (Lange et al., 2015; Sokal et al., 2022). The Anda consistency index was evaluated in the single-leg Li test. Prior to the execution of the exhaustion treatment, Anda's consistency index was 12% across all patients; however, subsequent to tiredness, 38% of patients exhibited a lack of India symmetry (below 12%) (Yu et al., 2025). According to the researcher's expertise, few studies have examined the impact of tiredness on neurological peripheral indicators and functionality in athletes who have had anterior cruciate ligament repair. This study offers significant insights into the impact of fatigue on this cohort of athletes; however, it does not address the implications of tiredness on the joint contractility of the associated knee inhibitory groups and functional performance. A research was done to examine the effects of tiredness in athletes with a history of anterior cruciate ligament rupture who used non-surgical methods and were not treated. The objective of this study was to examine the impact of fatigue on the joint contraction of the knee-adjacent limbs (quadriceps, hamstrings, gastrocnemius) and functional performance in athletes with a history of anterior cruciate ligament rupture (both with and without reconstructive surgery) and in healthy individuals .

Search problem

Sports injuries have lately been a primary worry for professionals in the athletic domain, with the incidence of injuries steadily increasing due to intense exertion, training, and contests (Chen, Buggy & Kelly, 2019). Additionally, the endeavour involves the repetition of precise motions in some sporting activities that need high intensity and high frequency (Falk Neto & Kennedy, 2019). Incorrect technical execution of a specific movement results in a deviation of the strength axis from its proper trajectory, leading to ligament damage and exerting forces that exceed their capacity to withstand normal kinetic limits of the joint (McBurnie, Dos'

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Santos & Jones, 2021). The inadequacy of the playing surface resulted in an injury due to its failure to absorb and mitigate pressure on the joints, compounded by substandard sports equipment, all contributing factors to the incidence of injury, including damage to the anterior cruciate ligament (Aicale, Tarantino & Maffulli, 2018). Upon examining the comprehensive rehabilitation exercises prescribed for individuals with various knee joint injuries, it was determined that modified fatigue influences muscle contraction surrounding the knee and the functional performance of football players with a history of anterior cruciate ligament rupture in Misan Governorate. This was attributed to a precise scientific program administered to those who underwent endoscopic joint surgery, resulting in a significant number of athletes distancing themselves from football. This prompted academics to address the observed weaknesses and deficiencies in the creation of rehabilitation courses tailored to specific injuries. They observed a lack of diligence in the application of tests and measurements, which are crucial in rehabilitation as they indicate the degree of the injured individual's response to rehabilitation exercises. This response is essential for progressing to the next stage of rehabilitation. Additionally, there is a deficiency in understanding weights, frequencies, and loads, highlighting a research gap and the necessity for developing solutions for professionals in the rehabilitation field. In summary, the duration of rehabilitation for individuals with anterior cruciate ligament injuries prompted researchers to choose this issue due to its significant relevance in health and sports rehabilitation.

Research Objectives

1. To recognize the effect of fatigue on the rate of muscle contraction around the knee and function in footballers with a history of anterior cruciate ligament tears.
2. To identify the effect of a history of anterior cruciate ligament rupture on the rate of contraction around the knee and the functional performance of football players.

Research hypotheses

1. Fatigue has an effect on the rate of contraction around the knee and function in footballers with a history of anterior cruciate ligament tears.

Research Areas

Human Area: Athletes with total rupture of the anterior cruciate ligament of the knee joint, who have (24) football athletes aged (19-30).

Time Area: For the period from 1/11/2023 to 1-1-2024

Spatial Area: Clubs in Misan Governorate, Physiology and Rehabilitation Laboratory at the College of Physical Education and Sports Sciences.

Materials and Methods

The design of this study is a case and a control. The statistical population of this study was male athletes in the age group of 19 to 36 years who had suffered an ACL tear during the past 6years and used surgical and non-surgical methods of treatment. From the statistical population, 24 athletes, 8 athletes with 1 ACLR, 8 athletes with 3 ACLD tears, and 8 healthy athletes were selected as the sample of this study. The sample size using SPSS software with statistical strength. Considering the mean and standard deviation of the population and sample in the key variables of the research (co-contraction of deficit) of the research design, repeated measurements were obtained . Inclusion criteria for the two groups of ACL injuries (with and without reconstructive surgery), 6 to 12 months after ACL reconstruction or conservative treatment, and the age group between 19 and 36 years, included completion of rehabilitation and return to moderate to high TB. The exclusion criteria for the two groups of ACL injuries (with and without reconstructive surgery) encompassed a history of Yande's Lower Leair surgery following ACL reconstruction, a Lower India injury subsequent to ACL reconstruction, bilateral injuries, damage to other knee ligaments including the medial and lateral cruciate ligaments, and the presence of additional lower extremity injuries (such as knee pain or ankle

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sprains). Did not possess Subjects in the control group had a history of knee joint injury and were comparable to those in the afflicted groups regarding age and levels of physical activity.

Table 1: Physical activity level rating after ACL injury (Paterno et al., 2018).

Levels	Physical activity
First Level	Sports involving jumping, cutting and twisting movements: football, handball, basketball.
Second Level	Sports involving side movements with lower rotation than level one, racquet sports, martial arts, wrestling, gymnastics.
Third Level	Activities that involve straight forward movements without jumping or turning: running, mountaineering.
Fourth Level	Inactivity

Study Procedures

Athletes having a prior ACL injury were chosen based on inclusion and exclusion criteria, with the approval of an orthopaedic specialist. Upon the completion of the meta-approval, the subject's demographic information, including age, athletic history, sports participation, and duration since injury or ACL surgery, was documented in the data collection. This research used a functional fatigue regimen to generate exhaustion in individuals. Athletes having a history of ACL tears were chosen based on inclusion and exclusion criteria, with the approval of an orthopaedic specialist. Upon completion of the permission form, the subject's demographic details (age, athletic history, sport discipline, duration since injury or surgery (ACL)) were documented in the data collecting form. This investigation used a functional fatigue protocol to produce exhaustion in the volunteers, as utilised in other research (Hughes et al., 2019; Kim et al., 2024; Wilke et al., 2016). The researcher first elucidated the task execution technique to the individual, followed by the acquisition of baseline measurements prior to the onset of weariness. Subsequent to baseline measurements, the subject engaged in a warm-up regimen lasting 10 to 15 minutes, followed by the fatigue protocol, which involved executing repeated sets of 8 squats at a 90-degree knee flexion angle, performing two maximal power vertical jumps, and concluding with three single-leg landings from a height of 30 cm onto the force plate apparatus (AMTI). The repeated sets continued until the participant was unable to execute five consecutive squats at a 90-degree knee angle. The individual faced no restrictions on the quantity of squats they could execute. It was impossible to do. The Borg scale, ranging from 6 (no perceived strain) to 20 (highest felt strain), was used to assess the tiredness levels in the individuals (Haddad et al., 2013). The participants' exhaustion level, as measured by the Borg scale, was required to attain a score of 17 or above. The three descents before the fatigue protocol and the last three descents of the patient prior to attaining maximal tiredness were examined.

Recording EMG data and calculating the co-contraction rate

The electrical activity of the quadriceps, hamstrings, and gastrocnemius was recorded using the Megawin electromyography (EMG) device manufactured in Finland. The EMG data was retrieved using the motion analysis system (Cortex software), and the neural Excel program (version 2013) was used for data analysis. The EMG signals were first amplified by a factor of 10 and then filtered within the frequency range of 10 to 500 Hz. Prior to estimating the aggregate contraction rate, the peak isometric contraction of all three muscles was recorded. To determine the maximal isometric contraction, the quadriceps and knee were positioned at a 90-degree flexion. The examiner exerted maximal resistance on the subject's upper ankle and instructed him to execute an isometric maximum contraction of the sacrum. To determine the maximum isometric

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contraction of the hamstrings, the subject was positioned in a saddle stance with the knee flexed at 20 to 30 degrees. The examiner then instructed the subject to execute a maximum isometric contraction of the hamstrings while applying maximal resistance to the upper ankle. The individual executed a plantar flexion movement at the ankle, while the examiner applied resistance to measure the maximal voluntary contraction of the gluteal muscle. The isometric maximum pastoral contracture test was conducted six times for each patient, with each session lasting one minute and a two-minute rest period between repetitions. This study calculated the simultaneous contraction of the medial hamstrings, external lateral hamstrings, medial gastrocnemius, and external lateral gastrocnemius during the vertical descent of one leg, within a 250 ms interval following foot contact with the ground (Jankaew et al., 2025). EMGL/EMGS × (EMGL + EMGS) was used, where TB EMGL denotes the activity in the least active muscles and TB EMGS represents the activity in the most active muscles. This equation indicates that the interventional activity during the first 50 milliseconds post-landing is segmented into a single 50-millisecond interval. This figure diminishes the total activity of the two muscles. The total of 50 milliseconds is divided by 5. To achieve the relative co-contraction in a kinetic exertion. The total constriction was calculated by dividing the sum of 6 tries by 3 (3 efforts before to exhaustion and 3 attempts subsequent to weariness).

Single-leg test to assess job performance

To conduct a one-leg test, a 2-meter tape measure was positioned on the floor, with the individual putting their big toe below the zero mark while keeping their hands on their back. Subsequently, Lee executed the procedure with the utmost vigour to get the greatest feasible distance. The whole heel movement was assessed on the ground, and the distance from the kick-off was quantified. Each individual completed the test three times before to tiredness and three times subsequent to weariness, with an average of three repetitions recorded. This study used the Anda Consistency Index for assessment, a widely utilised criterion. Prior to resuming sporting activities, the athlete sustained an anterior cruciate ligament injury.

The symmetry index is calculated by dividing the test result of the afflicted limb by that of the unaffected limb and multiplying the quotient by one hundred.

$$\frac{\text{Jump rate with the affected limb}}{\text{Jump rate with the unaffected liml}} \times$$

The limb symmetry index's reliability for the single-leg Lee test in healthy and ACL-injured persons is reported as 0.92 and 0.96, respectively (Salmela, 2025).

Statistical analysis

Descriptive and inferential statistical techniques were used to analyse the gathered data. The Shapiro-Wilk test was used to assess the normality of the data. This research assessed the primary impacts of tiredness before and after in the ACLR (ACLD) group and the control group, as well as the interaction effect of fatigue within the group, using repeated measures multivariate analysis of variance. Subsequently, the univariate dependent t-test, one-way analysis of variance, and Tukey's post hoc test were used to ascertain the intragroup and intergroup differences, respectively. The effect size index (ES) was computed for each

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significant intragroup and intergroup difference (Else-Quest, Hyde & Linn, 2010). The data analysis was conducted at a significance level of 95% with an alpha value of ≤ 0.05. All statistical analyses were conducted with SPSS version 24.

Results

The mean and standard deviation of the demographics of the subjects are shown in Table 2.

Table 2: Mean and standard deviation of the demographic characteristics of the sample under study

Variable	Unit of Measurement	ACLD Group		ACLR Group		Control Groug	
		M	SD	M	SD	M	SD
Age	**Year**	24.6	2.48	25.05	2.39	26.01	2.66
Weight	**Kg**	75.30	8.24	76.48	7.90	77.49	7.67
Height	**CM**	176.20	4.73	175.60	3.99	177.03	3.82
Time since surgery or initial injury	**Month**	24.19	6.87	22.17	5.69	23.90	5.73

Table 3: Repeated measures multivariate analysis of variance test for muscle cocontraction rate

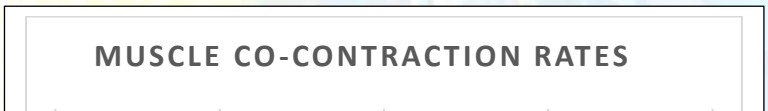
Effects	F	Effect size	Sig
Group	3.78	0.33	0.001
Fatigue	2.82	0.27	0.018
Interactive effect of fatigue in group	1.40	0.16	0.013

Table 3 illustrates a substantial group effect, indicating a notable variation in the rate of muscle co-contraction across the examined groups. The influence of tiredness and its interaction within the group is not significant, indicating no substantial change in the rate of muscular co-contraction among the study groups before and after exhaustion. Univariate tests were used to ascertain the intra-group and inter-group variations in muscle activity rates.

Table 4: Intra-group comparison of muscle co-contraction rate from before to after fatigue (%MVC)

Muscle co-contraction	Time periods	ACLD Group			ACLR Group			Control Groug		
		M	SD	Sig	M	SD	Sig	M	SD	Sig
Internal latissimus dorsi - internal hamstring	Before fatigue	19.20	6.41	0.25	23.50	11.04	0.94	18.83	18.83	0.81
	After fatigue	18.26	5.68		23.08	11.10		19.13	19.13	
External latissimus dorsi - external hamstring	Before fatigue	19.01	9.36	0.57	15.99	6.04	0.29	21.52	21.52	0.70
	After fatigue	20.94	9.47		20.69	6.16		20.98	20.98	
Internal latissimus dorsi - internal gastrocnemius	Before fatigue	33.97	12.82	0.84	36.55	11.71	0.84	36.14	4.88	0.08
	After fatigue	34.97	12.36		35.81	12.02		29.51	8.07	
Internal latissimus dorsi - external gastrocnemius	Before fatigue	27.68	9.00	0.91	25.25	8.67	0.05	50.56	12.62	0.01
	After fatigue	27.95	11.64		21.95	8.54		34.66	10.80	

Table 4 illustrates the intra-group comparison of muscle co-contraction across the examined groups. Table 4 illustrates a significant variation only in the co-contraction of the quadriceps-external gastrocnemius within the control group from pre-fatigue to post-fatigue. An analysis of the methods indicates that the co-



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contraction of the quadriceps and external gastrocnemius in the control group diminished considerably after exhaustion. In the ACLR and ACLD cohorts, no significant change was seen in any of the co-contractions from pre-fatigue to post-fatigue.

* Significant difference between ACLR and ACLD groups with control before fatigue and significant difference between ACLR and control groups after fatigue

- Med Q:H: Quadriceps medial hamstrings.
- Lat Q:H: Quadriceps - hamstring, lateral.
- Med Q:G: Foreign twin quads.
- Lat Q:G: Internal twin quad.

Figure 1: Comparison of muscle co-contraction rates before and after fatigue between the study groups Med QH Quadriceps-Hamstrings.

Analysis of Figure 1 reveals a notable disparity in the co-contraction rates of the quadriceps and external gastrocnemius muscles, irrespective of fatigue levels, between the ACLR and control groups, as well as between the ACLD and control groups. Following weariness, a notable distinction exists. The impact size index for all significant differences exceeded 1, indicating a considerable effect size.

Table 5: Repeated measures analysis of variance test for one-tailed test

Effects	F	Effect size	Sig
Group	6.78	0.35	0.006
Fatigue	13.25	0.38	0.001
Interactive effect of group on fatigue	4.59	0.17	0.031

Table 5 illustrates a strong group impact. Consequently, a notable disparity exists in the performance of the single-leg Ly test across the examined groups. The primary impact of tiredness is substantial, indicating a notable change from before to subsequent exhaustion. The interaction effect of tiredness within the group is substantial, indicating a varied reaction to exhaustion within each group. Consequently, univariate tests are used to ascertain the intra-group and inter-group disparities in the performance of the single-leg test.

Muscle co-contraction	Time periods	ACLD Group			ACLR Group			Control Groug		
		M	SD	Sig	M	SD	Sig	M	SD	Sig

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Limb symmetry index in the single-leg test	Before fatigue	92.47	5.51	0.004	95.66	3.65	0.003	96.38	1.25	0.073
	After fatigue	89.37	4.46		93.01	4.14		96.30	2.10	

Table 6 illustrates that the limb symmetry index in the single-leg Lee test for the ACLD and ACLR damaged groups considerably decreased post-fatigue in comparison to the control group.

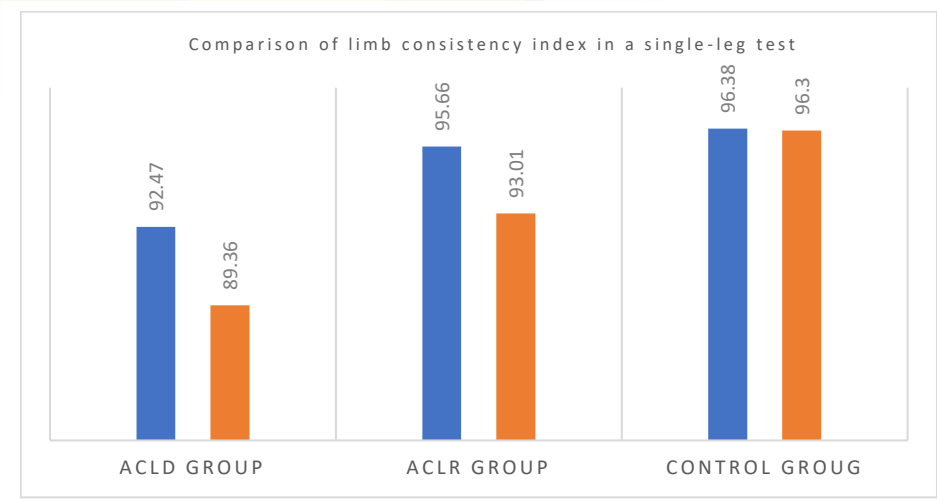

Figure:2 Comparison of limb consistency index in a single-leg test before and after fatigue between the studied groups.

Discussion of the results

This research aimed to examine the impact of fatigue on joint contraction in the peripheral knee and surgical performance in athletes with a history of ACL injury. The current investigation revealed a significant difference in the joint contraction of the quadriceps and exotwins between the afflicted groups (ACLR and ACLD) and the control group. No notable variation was seen between the groups regarding the rate of joint contraction of the surrounding muscles of the knee. Furthermore, there was a notable decrease in superlunges during the single-leg test in the afflicted mouths post-fatigue, with a substantial disparity seen between the ACLD and control groups in the intergroup comparison. The rate of joint contraction of the external quadriceps muscles was substantially greater in the pre-fatigue control group compared to the ACLD group. Patients with ACLD seem to use a strategy of minimising joint contraction around the knee to alleviate compressive stresses on the joints. This section of the findings is derived from the study conducted on 33 subjects. Alarifi (2017), Zeng et al. (2024), and Zhang et al. (2018) concur. Previous study has examined the rate of joint contraction in the limbs of individuals with ACLD when walking. Rudolph et al.'s study indicated that the joint contraction rate of the outer quadriceps and twin limbs in ACLD patients was much lower than that of the control group. The simultaneous contraction of the knee flexors and extensors (hamstrings and quadriceps) serves as a mechanism to mitigate shear stresses in the knee joint; nonetheless, it may elevate compressive and load forces on the joint (Adouni et al., 2023). In the study conducted by Coskun, Talu, and Cools (2018), individuals with ACL injuries exhibited joint contraction rates before and after external strain in comparison to healthy patients. They exert inhibitory effects on joint leads, enhancing the joint's capacity to endure external stresses. Joint fixation in individuals with ACLD seems to need a more intricate mechanism

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than just reversal and passive motions executed by ligaments. Santuz and Akay (2023) assert that the inhibitory spindle system contributes to the regulation of joint stiffness. Saqee and Hussein (2021) shown in their study that stretching exercises may significantly decrease the rate of joint contraction in the quadriceps and gluteal muscles of individuals with ACLD. The ACLD group had a higher likelihood of joint contraction than healthy individuals before to activity; however, post-exercise, the incidence of joint contraction decreased. Discontinuing the joint tightening approach is crucial for ACLD patients. Intense joint contraction may enhance joint stability; nevertheless, this approach might be deleterious in the long term. Shear forces (occurring when the knee is devoid of load), compression (coupled with excessive inhibitory joint contraction), and diminished shock absorption may correlate with biomechanical alterations, ultimately resulting in the degradation of articular cartilage over time (Zhang et al., 2020). In the research by He (2021), the joint contraction of the intestines at normal fatigue demonstrated that the joint contraction balance of the external quadriceps muscles in the control group was substantially greater than that in the ACLR group. No studies have been identified in the scientific literature that compare the joint contraction of the quadriceps and twin limbs between ACLR participants and healthy individuals. Nonetheless, the findings of the research by Cannon, Cambridge, and McGill (2019) indicated that the concurrent activation of the quadriceps and twin limbs was much greater, demonstrating a stronger association with the anterior cruciate ligament than the isolated activity of both sacra. Consequently, the reduced rate of quadriceps joint contraction in the afflicted groups (ACLR and ACLD) relative to healthy patients, as noted by Talshi, seems to represent a mechanism to alleviate pressure on the ACL (He, 2021). The primary effects of tiredness in the single-leg test were substantial within the group, as well as the reactive effects of fatigue in the group. The Anda symmetry index in the single-legged test was markedly reduced in the afflicted groups (ACLD and ACLR) after fatigue. The comparison of the groups revealed a considerable disparity in the Anda symmetry index between the ACLD group and the healthy group. The Anda symmetry index was markedly reduced in the ACLD group compared to the control group, irrespective of tiredness condition. The capacity to execute athletic endeavours amidst tiredness (the ability to sustain strength and functionality) is of significant relevance. Injuries occur at the conclusion of an athletic event when an individual is fatigued. Nonetheless, ELB tests are conducted for athletic and rehabilitative objectives in circumstances distinct from exhaustion. To enhance the evaluation of training and rehabilitation therapies, dynamic performance testing under circumstances of exhaustion is recommended (Gruet, 2018). The prediction of the dynamic function of the knee joint has been particularly used in individuals with ACL injuries (Ueno et al., 2020). Research indicates that among Lee's assessments, the single-legged test is the most dependable and consistent evaluation for individuals post-ACL damage (Schweizer, 2023). The findings of this research align with those of Arikan et al. (2022), Bakhsh et al. (2022), Davies, Myer, and Read (2020), He et al. (2021), Samaan et al. (2018), and Schweizer et al. (2022). This research assessed 24 male patients 22 months post-ACL repair under fatigue-free settings. This research analysed the Anda symmetry index in the single-legged test for the unilateral leg day. Prior to the implementation of the procedure, the Anda symmetry index was 11% across all patients; however, after exhaustion, 39% of patients exhibited an Anda symmetry index below 11% (Jesper et al., 1113). This research found a substantial reduction in the ADA symmetry index in the afflicted groups (ACLD and ACLR) after tiredness. Researchers assert that single-legged fatigue training is a dependable method for evaluating functional performance in fatigued states (Becker et al., 2023). In the research of Kirsch et al. (2019). The inductive symmetry index was reduced in ACLD patients compared to healthy individuals, as reported in the research by Winkelmann et al. (2019) and corroborated by Sovatzidis et al. (2020). Kotsifak et al. (2023) demonstrated no significant disparity in the symmetry index between female football players with a history of ACL reconstruction (12 months post-surgery) and healthy women. This research revealed a 5% difference in

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the Anda consistency score between the ACLD and control groups before to fatigue, and a 25% difference post-fatigue, all of which were statistically significant irrespective of tiredness condition. Prior to tiredness, there was no distinction between the ACLR and control groups; however, post-fatigue, the Anda consistency index in the ACLR group was 5% lower than that of the control group, a difference that lacked statistical significance. Despite a substantial reduction in the Anda symmetry score in both fatigued groups, a considerable disparity was seen between the ACLD and control groups in their comparative analysis. The effect size index for significant differences within the group was around 1.1, which, according to the Cohen scale, indicates a large impact. The effect size index for the difference between the ACLD and control groups post-fatigue was 90.6, indicating a substantial impact according to Cohen's scale. This research also has several shortcomings. The use of various grafts (patellar tendon, hamstring tendon, and aloe vera graft) in the ACLR cohort may influence the outcomes. Future studies should examine potential changes in induction activity associated with the usage of various handles. The participants in the present research were from football, which might ascertain people' capacity to mitigate the impact of receding Farood. The research only included male individuals, rendering the findings inapplicable to women.

Conclusion

The findings indicate that in afflicted persons (ACLR and ACLD), the propensity to diminish anterior tibial pressure and shear forces by decreasing the joint contraction rate of the femoral twins is more pronounced than the increase in joint stiffness. The effect size index for the disparity in joint contraction rates between the damaged and healthy groups of the twin femurs exceeded, indicating a substantial impact as per the Cohen scale. The search results underscore the significant function of the quadriceps and gastrocnemius muscles in stabilising the knee joint; hence, it is advisable to emphasise these two muscles in the rehabilitation activities for this group of athletes. Fatigue seems to influence functioning in both afflicted cohorts (ACLD and ACLR). Nonetheless, a comparison between the groups indicates that tiredness had a greater impact on the ACLD group, whereas the ACLR group exhibited superior performance. Considering that the performance of athletes with a history of ACL damage diminishes after fatigue, it is advisable to conduct performance assessments of the lower extremities post-ACL injury under both fatigued and non-fatigued situations.

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