



Research Paper

Intralimb Coordination Pattern of the Lower Limbs in Male Athletes With Allograft and Autograft Anterior Cruciate Ligament Reconstruction During Landing



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ABSTRACT

Background and Objectives: Two common choices exist for anterior cruciate ligament (ACL) reconstruction, autograft and allograft. Hamstring tendon autografts and soft-tissue allografts are commonly used for ACL reconstruction. The outcomes between these two grafts are controversial. This research aims to quantify and compare lower limb joint coordination between two ACL reconstruction graft options and healthy individuals.

Methods: Sixty-one athletes were enrolled after ACL reconstruction surgery (allograft, n=22; autograft, n=18). Furthermore, twenty-one healthy athletes were considered in the control group. The inclusion criteria included unilateral anterior cruciate ligament reconstruction surgery with allograft and autograft methods, male athletes with a minimum of 9 months and a maximum of two years since their surgery, successfully passing a series of quadriceps and hamstring strength tests and distance jumping before entering sports-specific activities under the supervision of a sports physiotherapist, and returning to pre-injury sports activities.

Results: Autograft was not statistically different from matched healthy limbs in terms of joint coordination variability and magnitude ($P>0.05$). However, the magnitude of joint coordination was superior to the allograft group compared to the autograft reconstructed ACL ($P<0.05$).

Conclusion: Although our result reported no significant difference between groups in joint coordination variability, having an insight into coordinative function after ACL reconstruction will help develop postoperative rehabilitation programs as well as minimize the re-injury risk among patients. We also suggest that scholars should conduct more robust trials with valid research designs to control the results of ACL reconstruction comparison with autograft and allograft.

Keywords: Allograft, Autograft, Anterior cruciate ligament, Athlete, Joint coordination variability

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↑ *What is “already known” in this topic:*

There are no significant differences after anterior cruciate ligament (ACL) between allograft and autograft in kinematics variables.

→ *What this article adds:*

The comparison of two types of grafts reveals our rehabilitation programs detail for each group and may decrease the re-injury rates.

Introduction

An anterior cruciate ligament (ACL) tear is one of the most common knee injuries among athletes [1, 2]. This ligament plays a crucial role in knee function and thus its damage leads to immobility, damage to cartilage, and joint destruction diseases [3, 4]. In addition to the mechanical role of ACL, the stimulation of mechanical receptors within the ligament results in muscle function about the joint as a motor control toward sudden movements [5]. Damage to the anterior cruciate ligament causes a partial interruption of the afferent pathway and changes the spinal and supraspinal control of motor function, which is followed by a change in joint proprioceptive accuracy and movement strategy and patterns [6]. Therefore, this injury is considered a neurophysiological dysfunction and not just a knee skeletal-muscular injury [7, 8]. ACL injuries are more common among athletes aged 15-40 who perform activities involving knee rotation, such as soccer, handball, volleyball, and alpine skiing [9, 10].

Annually, 15% of elite athletes suffer from such injuries [10]. In the United States, about 250000 cases of ACL injuries have been reported, mostly caused by sudden, non-collision, and non-directional deceleration [9, 11].

On the other hand, non-invasive treatments in injured people usually cause common instabilities and decreased activity levels, subsequently leading to long-term injury complications [12]. Various factors, including injury pattern, injury severity, possible damages following surgery, and the probability of simultaneous tissue reparability affect the decision-making to perform surgical or non-surgical treatment procedures [13, 14]. Reconstruction of the anterior cruciate ligament is usually performed for people with a high activity level or those suffering from lateral joint laxity [14, 15]. This procedure is performed as a standard treatment to reduce instability and prevent car-

tilage and meniscal injuries among athletes [16]. Despite displaying an acceptable level of knee function and stability after the surgery, literature affirmed that most athletes still have some degrees of difficulty in performing coordinated movements in the operated limb [17, 18].

Landing on a limb is one of the activities causing ACL injury and this damage seems to occur during the maximum vertical force of the ground reaction [19]. An increase in vertical ground reaction force (VGRF) applied to the knee may increase anterior tibial shear force, which is one of the destructive factors for the reconstructed knee. According to Newton's third law (action and reaction), when feet hit the ground, they apply an action force and in return, they receive the same force and reaction in the opposite direction from the ground [20]. The functional role of the lower extremity is landing, weight-bearing, and transmitting of VGRF [21]. The functional movement analysis of handball players revealed two distinct mechanisms in the case of ACL injury. One of the most common was the combination of landing with shear movement and the other was landing on a single leg causing valgus moments on the knee joint and tibia rotation position close to full extension [22]. Literature affirms that most people after ACL reconstruction will suffer from advanced osteoarthritis, re-injury, or inability to resume strength and sport-specific activities [23]. However, the risk factors for these conditions are not clear. In a natural state, the interaction of kinetic and kinematic factors causes proper coordination of segments and joints and minimizes energy consumption. In case of injuries caused by defective movements, the coordination pattern changes and this change also occurs in people with ACL reconstruction. In the dynamic system approach and kinematic analysis, the mutual effect of joints is evaluated, which provides a more comprehensive evaluation of the activity. In particular, the variability of joint coordination may determine the use or non-use of different movement strategies, revealing the system's limitations. Variability in coordination pattern

has a functional importance in movement control and makes the neuromuscular system capable of adapting to different constraints of the movement task (such as landing) in dynamic environments and maintaining stability in its consequences (speed, acceleration, and force distribution). Assessing coordination and variability phases can reveal compensatory mechanisms and describe joint excursions [23]. Furthermore, assessing coordination patterns provides comprehensive information on how the neuromuscular system organizes different degrees of freedom in movements. The variability of joint coordination is measured using the angular displacements of adjacent joints and vector coding to analyze the kinematics of the lower limb.

The results from quantifying and comparing the coordination variability between the operated and control groups can contribute to our knowledge regarding activity-related ACL injury. It is expected that by increasing our knowledge about different side effects of functional activities and returning to sports that may be related to the lack of proper coordination of joint pain, the rehabilitation program can properly organize the degrees of freedom in people with different injuries to reduce surgery-associated side effects and the rate of re-injury as well as increasing the quality level of appropriate sports activities leading to the desired direction. Therefore, this study was conducted to compare the joint coordination patterns and joint forces in people with autograft and allograft reconstruction surgery of ACL during the landing activity.

Materials and Methods

Study type and participants

This case-control study was conducted among male athletes in an age range of 18 to 35 years old who were undergoing surgery in two different groups, a minimum of 9 months and a maximum of two years have passed since their surgery. One group included athletes who underwent ACL reconstruction surgery with autograft, and the other included those who underwent reconstruction surgery with allograft. Finally, the control group was considered as healthy male athletes in the same age category.

Study sample size

Based on the pilot study that was conducted on 8 people with eligible criteria to take part in the research, G-Power software was used to calculate the study sample size based on the comparison of case and control groups. A total of 61 people were recruited for the study; among which 40 patients were considered as a case group, in-

cluding 18 athletes who underwent ACL reconstruction surgery with autograft and 22 patients who underwent reconstruction surgery with allograft. Gender and sports activity levels were used to match the groups. All the athletes in different fields, including football, volleyball, basketball, and handball were engaged in sports activities that included movement and rotation challenges and landing activities. Number of participants from each activity group was matched accordingly. All people who underwent arthroscopic surgery were operated on by knee orthopaedic surgeons and were under the supervision of a sports physiotherapist to receive a full rehabilitation period. They also underwent balance training and started running about three months after the surgery. Likewise, they passed the courses of weight training, agility training, plyometrics, starts, and specialized sports activities. Then, a minimum of 9 months and a maximum of 24 months after the surgery, if they successfully could pass the muscle strength and distance jumping tests in the absence of pain and swelling, they were allowed to participate in intense sports activities and competitions without movement restrictions.

Inclusion and exclusion criteria

The inclusion criteria included all patients with unilateral anterior cruciate ligament reconstruction surgery with allograft and autograft methods, male athletes who have been a minimum of 9 months and at most 24 months since their surgery, successfully passing a series of quadriceps and hamstring strength tests and distance jumping before entering sports-specific activities under the supervision of a sports physiotherapist, and returning to pre-injury sports activities. The exclusion criteria included patients with a history of bilateral damage or surgery in the knee or meniscectomy, repair of the meniscus and lateral ligaments, pain and swelling of the soft tissue of the knee joint, and limited range of joint motion as well as patients with a history of surgery in lower limbs and spine joints in ACL reconstruction group, having metabolic-rheumatoid and neurological diseases, suffering from cardiovascular and pulmonary problems, and having obvious misalignments, such as crossed knees, bent knees and flat feet.

Study data collection

The Tegner questionnaire, developed in 1985, was initially designed for physician administration after ACL and meniscal injuries. This activity rating system, often used by patients, consists of a one-item score that ranks work and sports activities on a scale of 0 to 10. Zero signifies disability due to knee problems and 10

represents national or international level soccer [24]. Negahban et al. published the Persian translation of this questionnaire, with proven validity and reliability [25]. The second questionnaire was introduced by the International Knee Document Committee (IKDC) to examine patients' subjective perception of performance and measure functional disability of patients in performing daily and sports activities [26]. The validity and reliability of the questionnaire have been proven, particularly in the case of ACL [26]. Furthermore, Rahimi et al. [27] prepared and published its Persian translation for Iranian patients after ligament and meniscus surgery.

Before landing, all study participants warmed up by cycling on a stationary bike and gentle stretching of the muscles of the lower limbs with very short stretches and three repetitions for each muscle group. Then to learn how to perform the test, the participants were asked to land on a 30 cm obstacle five times, with a 30-s rest between each landing [28]. Afterward, three single-limb landing attempts were performed in a random order for each limb separately. Furthermore, Qualisys 3D motion analysis system with 120 Hz frequency with six cameras and tracking markers placed on the pelvis and lower limbs were used to record kinematic information. To track, joints' position markers were placed on the sacrum, bilateral superior posterior iliac spine, bilateral superior anterior iliac spine, greater trochanter of the femur, the lateral and medial condyles of the femur, lateral and medial malleolus of the ankle, and the first and the fifth metatarsals [17, 29]. In three landings, the joint angles of the hip, knee, and ankle were recorded for each limb and then, the range of motion of the body joints was measured by calculating the difference between the minimum and maximum range of motion of a joint. VGRF data was calculated by the Kistler force plate device with a frequency of 100 Hz and normalized based on each athlete's weight. Kinetic information was also obtained by measuring VGRF and joint torques normalized for height and body weight.

Study data analysis

Based on the literature, 6 pairs of joint movements were selected to analyze kinematic differences [17, 18, 30]. Accordingly, hip abduction-adduction/knee abduction-adduction (HA/KA), hip abduction-adduction/knee rotation (HA/KR), hip flexion-extension/knee flexion-extension (HF/KF), hip rotation/knee abduction-adduction (HR/KA), hip rotation/knee rotation (HR/KR) and knee flexion-extension/ ankle dorsiflexion-plantar flexion (KF/ADF) were measured. Before performing the test, the method of single-leg vertical landing was explained

to the participants. Then, they were asked to stand on a 30 cm obstacle 11 cm from the edge of the force plate with the ankle in a neutral position [28]. To avoid lateral movement and vertical landing on the centre of the force plane, they were also told to place their hands on the hip on both sides and the knee of their opposite limb to be in 90 degrees of flexion. With the examiner's verbal command, participants landed on the force plate. This activity was repeated three times and was valid when the foot landed in the right place of a force plane and the balance was kept on the lower limb [28].

Information about joint angles was entered into MATLAB software, and biomechanical analysis was performed for all participants. Sparrow et al. first used this method in 1987 to measure movement coordination and included drawing axes in the angle map for adjacent points [31]. The vector coding method was used to analyze the kinematics of the lower limb and quantitatively measure the variability of the joint coordination. Likewise, the joint angles of lower limbs were calculated in landing phases.

Study statistical analysis

First, the normality of variables was checked via the Kolmogorov-Smirnov test. Descriptive data analysis was performed to capture data in terms of Mean±SD. Then, to examine the effect size in variables, partial η^2 was used. A $P < 0.05$ was considered statistically significant.

Results

Table 1 presents the study participants' characteristics. As the results reveal, the variables' values in three different study groups are close to each other.

Tables 2 and 3 present the results of comparing joint coordination variability and magnitude between reconstructed autograft and allograft groups.

The results showed no statistically significant difference in joint coordination variability based on groups ($P=0.153$). However, regarding joint coordination magnitude, a statistically significant difference was observed between groups ($F_{(6, 32)}=2.51$, $P=0.042$; Wilk's $\Lambda=0.680$, partial $\eta^2=0.32$).

Tables 4 and 5 present the results related to the comparison of joint coordination variability and magnitude between reconstructed autograft and matched limb health groups.

Table 1. Assessment of study variables in case and control groups

Group	Minimum	Maximum	Mean±SD	
Auto n=18 (7 left, 11 right)	Age (y)	19	32	23.83±3.01
	BMI (kg/m ²)	21.97	26.80	24.06±1.41
	Tegnar	8	9	8.88±0.32
	IKDC	88	100	96.03±3.93
	Weight (kg)	65	93	78.33±7.054
Allo n=22 (3 left, 19 right)	Age (y)	19	26	22.63±2.08
	BMI (kg/m ²)	22.10	23.90	22.89±0.51
	Tegnar	8	9	8.90±0.29
	IKDC	10	100	92.80±18.89
	Weight (kg)	71	82	76.86±3.13
Health n=21 (1 left, 20 right)	Age (y)	18	27	21.52±2.46
	BMI (kg/m ²)	19.30	25.40	22.7±1.37
	Tegnar	8	9	8.90±0.3
	IKDC	88	100	97.38±4.09
	Weight (kg)	60	78	69.61±4.46

IKDC: International Knee Document Committee; BMI: Body mass index; Tegnar: Activity level questionnaire.

No significant difference was observed in joint coordination variability based on groups ($P=0.971$).

Likewise, no significant difference was found in terms of joint coordination magnitude in different study groups ($P=0.476$).

Tables 6 and 7 present the results related to the comparison of joint coordination variability and magnitude between reconstructed allograft and matched limb health groups.

Table 2. Joint coordination variability in the reconstructed limb for autograft versus allograft groups

Coupling Angles	Coordination Variability (Mean±SD)		P	Partial η^2
	Autograft	Allograft		
HA/KA	45.4±7.1	47.4±7.9	0.403	0.019
HA/KR	47.1±4.8	48.7±7.7	0.414	0.018
HF/KF	32.2±8.7	36.8±10.2	0.146	0.056
HR/KA	50.1±6.5	52.5±5.1	0.195	0.045
HR/KR	50.2±4.4	53.3±4.6	0.041	0.108
KF/AF	30.9±7.6	37.4±10.6	0.038	0.111

Abbreviations: HA/KA: Hip abduction-adduction/knee abduction-adduction; HA/KR: Hip abduction-adduction/knee rotation; HF/KF: Hip flexion-extension/knee flexion-extension; HR/KA: Hip rotation/knee abduction-adduction; HR/KR: Hip rotation/knee rotation; KF/AF: Knee flexion-extension/ankle dorsiflexion-plantar flexion.

Table 3. Joint coordination phase magnitude in the reconstructed autograft versus allograft groups

Coupling Angles	Magnitude Phase (Degree) (Mean±SD)		P	Partial η^2
	Autograft	Allograft		
HA/KA	148.2±104.1	197.1±106.6	0.158	0.053
HA/KR	152.9±108.3	234.1±97.8	0.019	0.140
HF/KF	162.6±177.1	248.5±98.4	0.064	0.090
HR/KA	157.1±100.8	155.1±88.6	0.949	0.001
HR/KR	178.3±100.1	216.6±81.6	0.197	0.045
KF/AF	184.8±8.9	213.5±42.9	0.008	0.174

Abbreviations: HA/KA: Hip abduction-adduction/knee abduction-adduction; HA/KR: Hip abduction-adduction/knee rotation; HF/KF: Hip flexion-extension/knee flexion-extension; HR/KA: Hip rotation/knee abduction-adduction; HR/KR: Hip rotation/knee rotation; KF/AF: Knee flexion-extension/ankle dorsiflexion-plantar flexion.

No significant difference was observed in joint coordination variability based on groups ($P=0.140$).

Table 7 presents a significant difference in joint coordination magnitude based on groups ($F_{(6,35)}=2.55$, $P=0.037$; Wilk's $\Lambda=0.695$, partial $\eta^2=0.31$).

Discussion

The goal of ACL reconstruction is to improve the function and firmness of the knee joint to return patients to pre-injury skills [32]. The clinical outcomes of this surgery have been proven successful in the literature [33]. However, despite the success rate and effective return to sport, significant considerations are observed in terms

of surgery cost and decreased quality of life. Ardem et al. reported that around 63% of ACLRs can successfully return to their pre-injury sport [22]. Furthermore, some studies showed that the re-injury rate increased among individuals who underwent ACL reconstruction surgery so that the risk of first-time ACL injury was estimated at 1 per 80 people, while the re-injury risk after the reconstruction was reported to be 1 in 17 individuals [34, 35].

Two main common graft options exist for ACL reconstruction, including autograft and allograft. An autograft is a graft taken from the individual's muscle [36-39]. While allograft is a tissue graft that is transplanted from a donor's patellar tendon, hamstring, or intact ACL. Some advantages regarding the use of an autograft fo-

Table 4. The reconstructed for autograft versus matched limb for control in joint coordination variability

Coupling Angles	Mean±SD		P	Partial η^2
	Coordination Variability			
	Autograft	Control		
HA/KA	45.4±7.1	43.6±9.0	0.515	0.013
HA/KR	47.0±4.8	46.0±8.2	0.657	0.006
HF/KF	32.2±8.7	31.6±8.1	0.826	0.001
HR/KA	50.1±6.5	49.5±5.6	0.811	0.002
HR/KR	50.2±4.4	49.9±5.2	0.867	0.001
KF/AF	30.9±7.6	29.3±8.9	0.565	0.010

Abbreviations: HA/KA: Hip abduction-adduction/knee abduction-adduction; HA/KR: Hip abduction-adduction/knee rotation; HF/KF: Hip flexion-extension/knee flexion-extension; HR/KA: Hip rotation/knee abduction-adduction; HR/KR: Hip rotation/knee rotation; KF/AF: Knee flexion-extension/ankle dorsiflexion-plantar flexion.

Table 5. The reconstructed for autograft versus matched limb for control in joint coordination magnitude

Coupling Angles	Mean±SD		P	Partial η^2
	Magnitude Phase (Degree)			
	Autograft	Control		
HA/KA	148.2±104.1	181.7±110.6	0.357	0.025
HA/KR	152.9±108.3	153.4±109.8	0.990	0.001
HF/KF	162.6±177.1	148.7±159.5	0.807	0.002
HR/KA	157.1±100.8	154.3±97.6	0.934	0.001
HR/KR	178.3±100.1	175.5±97.5	0.931	0.001
KF/AF	184.8±8.9	197.9±26.5	0.060	0.104

Abbreviations: HA/KA: Hip abduction-adduction/knee abduction-adduction; HA/KR: Hip abduction-adduction/knee rotation; HF/KF: Hip flexion-extension/knee flexion-extension; HR/KA: Hip rotation/knee abduction-adduction; HR/KR: Hip rotation/knee rotation; KF/AF: Knee flexion-extension/ankle dorsiflexion-plantar flexion.

cus on no risk of body rejection or disease transmission, faster incorporation into the body, lower cost, and ready availability. On the other hand, it suffers from some drawbacks, such as procurement morbidity, donor site pain, and the need for a second surgical procedure. The benefits of using an allograft are avoiding donor site defects, fewer incisions, reduced surgical and rehabilitation time, accessibility to larger grafts in varying forms, and no weakening of the extensors or flexor digitorum apparatus. However, the allograft option has some disadvantages, including the possibility of body rejection and infection transmission from the allograft. It may also increase instability and failure to return to sport [40-42].

Evidence has shown no significant differences in clinical outcomes between autografts and allografts. Based on our study results, no significant differences were observed between the two types of graft regarding joint coordination variability. Furthermore, joint coordination magnitude between autograft and matched limbs was similar for the control group. Similarly, Hu et al. reported no significant difference between autograft and allograft in terms of clinical outcomes [43]. In most literature, failure rates were very similar in the two graft options [44]. A meta-analysis conducted in 2018 revealed similar IKDC, and Tegner scores, and failure rates between two groups [45]. Likewise, a systematic review in 2014 found no significant differences between the mentioned

Table 6. The reconstructed for allograft versus matched limb for control in the joint coordination variability

Coupling Angles	Mean±SD		P	Partial η^2
	Coordination Variability			
	Allograft	Control		
HA/KA	47.4±7.9	44.8±8.5	0.315	0.025
HA/KR	48.7±7.7	47.7±7.2	0.676	0.004
HF/KF	36.8±10.2	32.2±6.8	0.095	0.068
HR/KA	52.5±5.1	50.1±5.2	0.145	0.052
HR/KR	53.3±4.6	51.1±5.1	0.145	0.052
KF/AF	37.4±10.6	29.7±7.5	0.010	0.153

Abbreviations: HA/KA: Hip abduction-adduction/knee abduction-adduction; HA/KR: Hip abduction-adduction/knee rotation; HF/KF: Hip flexion-extension/knee flexion-extension; HR/KA: Hip rotation/knee abduction-adduction; HR/KR: Hip rotation/knee rotation; KF/AF: Knee flexion-extension/ankle dorsiflexion-plantar flexion.

Table 7. The reconstructed for allograft versus matched limb for control in the joint coordination magnitude

Coupling Angles	Mean±SD		P	Partial η^2
	Magnitude Phase (Degree)			
	Allograft	Control		
HA/KA	197.1±106.6	152.7±84.8	0.143	0.053
HA/KR	234.0±97.8	182.9±109.4	0.119	0.060
HF/KF	248.5±98.4	157.2±123.1	0.011	0.150
HR/KA	155.1±88.6	129.2±64.8	0.287	0.028
HR/KR	216.6±81.6	192.3±82.6	0.344	0.022
KF/AF	213.5±42.9	196.2±25.2	0.119	0.060

Abbreviations: HA/KA: Hip abduction-adduction/knee abduction-adduction; HA/KR: Hip abduction-adduction/knee rotation; HF/KF: Hip flexion-extension/knee flexion-extension; HR/KA: Hip rotation/knee abduction-adduction; HR/KR: Hip rotation/knee rotation; KF/AF: Knee flexion-extension/ankle dorsiflexion-plantar flexion.

groups regarding failure rate, knee laxity, or coordination variability [46]. On the other hand, a randomized clinical trial revealed a remarkable allograft failure rate of 27%. The probable reason for this case may be that surgeries were performed many years ago with underdeveloped surgery and processing methods [47]. Similarly, a meta-analysis found that autografts had better clinical outcomes compared to allografts [48-50]. These discrepancies may be due to various study populations, sampling methods, statistical analyses, and research designs applied in previous literature. If a satisfactory autograft is not accessible, or if a revision ACL reconstruction is the goal, allograft can be used as an optimal option. Factors, including previous reconstruction, surgery in another leg, tunnel size, or position are also among crucial determinants for preferring allografts to autografts. In most cases, studies concluded that allograft ACL reconstruction is a safe but more expensive option that can be considered in some conditions.

Regarding the rate of ligament rupture after ACL reconstruction, Jia and Sun found a higher rate of rupture and ACL reconstruction failure in the allograft group. They believed that a faster postoperative rehabilitation course in patients with allograft may lead them to return to sports and physical activity before complete healing, which increases the risk of reinjury among them [51]. A similar study compared the graft incorporation between two graft options in an animal model. Study results revealed that autografts incorporated faster compared to allografts [52]. This may be another reason for a risk of graft failure in allograft after ACL reconstruction, suggesting more need for conservative rehabilitation in al-

lograft reconstruction patients. Despite these variations, no statistically significant differences were approved.

One of the contributions of the present research is to compare the joint coordination variability and magnitude between reconstructed allograft and matched healthy limb, reconstructed autograft and matched healthy limb, reconstructed autograft and allograft, and finally non-reconstructed autograft and allograft. Consistent with a study conducted by Davis, our study results revealed an increased variability in the ACL reconstruction group for several joint couplings compared to the control group. These results indicated that patients with ACL reconstruction exhibit a different coordinative function in their reconstructed lower extremity compared to the control group [17]. Kiefer et al. discriminated between athletes with and without ACL reconstruction based on intralimb coordination. The ACL reconstruction group showed higher variability for the low-frequency target oscillation. The increased variability in the mentioned group was interpreted as instability in these athletes that suggested a lower proprioceptive function post-surgery [53]. Pollard et al. also found an increased lower extremity variability in an ACL reconstruction group [18]. Consistent with Kiefer et al., researchers suggested a different neuromuscular control as a reason for a higher variability in the ACL reconstruction group. They mentioned the higher variability as a risk factor for re-injury [53].

Conclusion

Study results affirmed that in clinical decision-making regarding a direct choice between allografts and auto-



grafts, clinicians should consider the efficacy of different graft options and patients' characteristics, and the variability of joint coordination as a vital element of movement. Movement variability is an integrated part of human motor behaviour. A decrease in joint coordination variability shows a limited movement capability in individuals, which subsequently leads to malmovement strategies in a dynamic system. Lower variability in study participants has also been associated with an increased likelihood of re-injury after the ACL reconstruction procedure. Although our result reported no significant difference between groups in joint coordination variability, having an insight into coordinative function after ACL reconstruction will help develop rehabilitation programs after the surgery as well as minimize the re-injury risk among patients. We also suggest that scholars should conduct more robust trials with valid research designs to control the results comparing ACL reconstruction with autograft and allograft.

Limitations

This study has some limitations. First, blinding patients were not used in this research, which may increase the risk of bias. Second, our study included athletes with ACL reconstruction on either the right or left side of the body, regardless of limb dominance. Third, this research procedure is accomplished in a laboratory condition and results may be different in a field.

Ethical Considerations

Compliance with ethical guidelines

This study was approved by the Ethics Committee of Iran University of Medical Sciences (Code: IR.IUMS.REC.1398.1406).

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Authors' contributions

Conceptualization, Supervision: Reza Salehi, Mohammad Ali Sanjari; Methodology: Kasr Kazemi; Investigation, Writing – review & editing: All authors; Writing – original draft: Kasra Kazemi, Reza Salehi; Funding acquisition, Resources: Kasra Kazemi, Reza Salehi.

Conflict of interest

The authors declared no conflict of interest.

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مقاله پژوهشی



الگوی هماهنگی درون اندامی اندام تحتانی در مردان ورزشکار بعد از بازسازی رباط متقاطع قدامی با آلوگرافت و اتوگرافت در هنگام فرود

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چکیده

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مقدمه: دو انتخاب رایج اتوگرافت و آلوگرافت برای بازسازی رباط متقاطع قدامی وجود دارد. اتوگرافت تاندون عضله همسترینگ و آلوگرافت بافت نرم معمولاً برای بازسازی رباط متقاطع قدامی استفاده می‌شوند. خروجی نتایج این دو پیوند متفاوت است. هدف این مطالعه، کمی کردن و مقایسه هماهنگی مفاصل اندام پایین بین دو نوع پیوند بازسازی رباط متقاطع قدامی و افراد سالم بود.

مواد و روش‌ها: ۶۱ ورزشکار پس از جراحی بازسازی رباط متقاطع قدامی وارد مطالعه شدند که شامل آلوگرافت (۲۲ نفر)، اتوگرافت (۱۸ نفر) و همچنین ورزشکاران سالم (۲۱ نفر) بودند. همه بیماران معیارهای ورود به مطالعه را داشتند که عبارت بودند از: ۱) جراحی بازسازی رباط صلیبی قدامی یک‌طرفه با روش‌های آلوگرافت و اتوگرافت، ۲) ورزشکاران مرد که حداقل ۹ ماه و حداکثر ۲ سال از زمان جراحی آن‌ها گذشته بود، ۳) موفقیت در گذراندن یک سری از تست‌های قدرت عضلات چهارسر ران و همسترینگ و پرش تک‌پا تحت نظارت فیزیوتراپیست ورزشی قبل از ورود به فعالیت‌های تخصصی ورزشی و ۴) بازگشت به فعالیت‌های ورزشی قبل از آسیب.

یافته‌ها: تغییرپذیری هماهنگی گروه اتوگرافت نسبت به اندام متناظر گروه سالم تفاوت معنی‌داری نداشت ($P > 0/05$). اما مقدار بزرگی فاز هماهنگی در گروه آلوگرافت نسبت به گروه اتوگرافت بیشتر بود ($P < 0/05$).

نتیجه‌گیری: اگرچه در یافته ما هیچ تفاوت آماری معنی‌داری بین گروه‌ها از نظر تغییرپذیری هماهنگی مفاصل دیده نشد، داشتن بینش در مورد عملکرد هماهنگ پس از بازسازی رباط متقاطع قدامی به توسعه پروتکل‌های توانبخشی پس از جراحی و همچنین به حداقل رساندن خطر آسیب مجدد در این بیماران کمک می‌کند. ما همچنین پیشنهاد می‌کنیم محققان آزمایش‌های قوی‌تری با طرح‌های تحقیقاتی معتبر انجام دهند تا نتایج مقایسه بازسازی رباط متقاطع قدامی اتوگرافت و آلوگرافت را ارزیابی کنند.

کلیدواژه‌ها:

آلوگرافت، اتوگرافت، رباط متقاطع قدامی، ورزشکار، تغییرپذیری هماهنگی مفاصل

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