Self-reported outcomes are associated with knee strength and functional symmetry in individuals who have undergone ACL reconstruction with hamstring tendon autograft

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ABSTRACT

Background: The aim of this study was to investigate the relationship between self-reported knee outcomes and limb symmetry indices (LSIs) for hip and knee strength, postural control and single leg hop distance in individuals who had undergone an ACL reconstruction with hamstring tendon autograft (HTG).

Methods: A total of 72 participants with a history of unilateral ACL reconstruction with HTG (Mean ± SD age, 28.0 ± 7.6 years; height, 178.4 ± 6.7 cm; mass, 76.9 ± 14.9 kg) were included. IKDC, Lysholm, KOOS and TAMPA scores were used to evaluate self-reported outcomes. Concentric and eccentric knee extensor and flexor strength, and hip abductor strength were measured with an isokinetic dynamometer. Postural control was assessed using the modified star excursion balance test and hop performance using the single leg hop test. The relationships between the LSI scores and the performance measures were explored using the Pearson correlation coefficient.

Results: The IKDC, Lysholm and KOOS scores were positively correlated with knee extensor and flexor strength LSIs ($p<0.05$, $r=0.34$ to $r=0.50$), and the TAMPA score was negatively correlated with eccentric extensor LSI ($p=0.02$, $r=-0.34$). Single leg hop distance LSI was correlated with IKDC and Lysholm scores ($p=0.003$, $r=0.50$; $p=0.04$, $r=0.29$) respectively, while postural control was only correlated with the KOOS scores ($p<0.001$, $r=0.51$ to $r=0.52$). No correlation was observed between self-reported outcomes and hip abductor strength ($p>0.05$).

Conclusions: Self-reported scores were correlated with knee extensor and flexor strength, postural control and hop performance in individuals who have undergone ACLR with HTG. Compared to Lysholm and TAMPA scores, KOOS and IKDC scores were more likely to be correlated with performance-based outcomes. Therefore, KOOS

and IKDC scores may help clinicians in RTS decision making when there is a limited time to perform extensive evaluations or access equipment.

Key words: anterior cruciate ligament; patient-reported outcomes; muscle strength; star excursion balance test; hop performance; return to sport

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1. Introduction

Anterior cruciate ligament (ACL) injuries mainly occur during sports which include cutting and pivoting maneuvers [1]. Individuals who suffer ACL injuries usually require ACL reconstruction (ACLR) if they wish to return to sport participation [1, 2]. Allografts, bone–patellar tendon–bone and hamstring tendon autografts (HTG) are commonly used in ACLR [1, 3-5]. However, the choice of HTG offers several advantages such as decreased postoperative pain, graft donor site morbidity, extension loss and postoperative quadriceps weakness [1, 3-5].

The most common criterion in return to sport (RTS) decision making after ACLR consists of strength and lower extremity functional performance testing with use of the limb symmetry index (LSI) and self-reported knee functions [6, 7]. Recently, patients have been allowed to return to a competitive level of sports when they achieve 90% on the LSI in quadriceps strength and hop performance tests [8, 9]. However the use of self-reported scores such as; the International Knee Documentation Committee 2000 Subjective Knee Form (IKDC), Knee Osteoarthritis Outcomes Scores (KOOS), Lysholm and TAMPA scores offer an important evaluation of the patients' quality of life, satisfaction, function, and kinesiophobia and may be related to objective measures of RTS [10-13]. Therefore, it is suggested that RTS decision should be made according to combination of subjective and objective measurements scores [10, 14].

The use of self-reported scores may help identify patients with neuromuscular impairments and activity limitations which may also be evaluated using isokinetic dynamometers and other performance-based test batteries when considering the return to sport phase of ACLR rehabilitation [10, 11, 15, 16]. Therefore, the use of simple questionnaires could help clinicians in the decision making of the patients ability

to RTS when there is limited time to perform extensive evaluations or access to equipment such as isokinetic dynamometers [11]. However, there are conflicting findings in the literature documenting the relationship between subjective and objective measurement outcomes after ACLR. Extensor strength, postural control and hop performance have been shown to be related with subjective scores [13, 15, 17], however some authors have failed to identify any relationship between objective outcomes and self-reported outcomes in individuals who had undergone ACLR [18, 19].

Such individuals may demonstrate different post-operative neuromuscular adaptations due to the graft used in the repair [3, 20], and may also provide information on the evaluation tools especially in self-reported functions. Therefore, the aim of this study was to investigate the relationship between self-reported knee outcomes including the IKDC, KOOS, Lysholm and TAMPA scores and limb symmetry indices for hip and knee strength, postural control and single leg hop distance in individuals who had undergone ACL reconstruction using a HTG. Hip abductor strength was also included as this may have a role in lower extremity alignment during functional activities [21] and has been previously identified as a possible risk factor for ACL injuries [22]. It was hypothesized that individuals with better self-reported knee scores would also have better limb symmetry indices and performance scores.

2. Materials and Methods

2.1. Participants

Seventy-two male participants with a history of unilateral ACLR (age: 28.0 ± 7.6 years, height: 178.4 ± 6.7 cm, mass: 76.9 ± 14.9 kg, BMI: 24.2 ± 4.2 kg/m^2, and pre-injury Tegner activity score: 7.3±1.4) were included in this study. Inclusion criteria were; age between 18 and 45 years, unilateral ACL reconstruction with hamstring tendon autograft, uninjured contralateral extremity, no history of neurological disease or vestibular or visual disturbance, and a pre-injury Tegner activity score of at least 5. Participants were excluded if they had an ACL revision, ACLR with patellar tendon autograft or allograft, posterior cruciate ligament injury and/or reconstruction, or had a previous injury or surgery to the contralateral limb. All patients were operated by the same surgeon (HO) with single-bundle anatomic ACLR using 4-strand semitendinosus and gracilis tendon autograft, and went through the same rehabilitation program after the ACLR. All patients were requested not to return to sport specific training program before the end of 6 months after surgery. Written informed consent was obtained from all participants, and the study was approved by the University Institutional Review Board.

2.2. ACLR rehabilitation

ACLR rehabilitation program started within the first week of surgery and the patients were instructed to visit physical therapy 3 days a week till week 12 after ACLR. The early rehabilitation program (0-4 weeks) emphasized limiting hemarthrosis and edema, obtaining full knee range of motion, achieving good quadriceps muscle control and normalization of the walking. Then, the rehabilitation program (4-12 weeks) included progressive neuromuscular training including core, balance and

strengthening exercises mostly performed on weight-bearing positions. The rehabilitation program until 12 weeks after surgery did not include any open kinetic chain quadriceps exercises for the reconstructed and the healthy limbs.

From 12th week to 24th week, all participants were instructed to perform the same training program. This program includes resistive hip and knee strengthening, plyometric, running and balance exercises for both limbs 3 days in a week during this period.

2.3. Data collection

Data collection was performed six months post-surgery in a single testing session, as the RTS tests are frequently perform at this time point.

2.3.1. Postural control

Modified Star Excursion Balance Test (SEBT) with anterior (ANT), posteromedial (PM) and posterolateral (PL) reach directions was used to evaluate the postural control of the participants [23]. This test has been shown to be a reliable tool to determine the balance deficits between limbs in individuals who had lower extremity injuries [23, 24]. Participants were instructed to stand in the middle of a grid with tapelines extending out 100 centimeters in the three directions. The angle between ANT and PM or PL lines was set at 135˚ and the angle between PM and PL lines was set at 90˚. Participants were instructed to reach as far as possible along each of the 3 lines, make a light toe-touch on the line without shifting weight, and return to the center of the grid whilst maintaining single-leg balance. Three practice trials were given for each limb for each direction. Participants then performed 3 trials in the 3 directions. Measurements were taken from the most distal aspect of the toes, and the average of the 3 reach distances in each direction was calculated for each limb. The reach

distance of the involved limb was divided by the reach distance of the uninvolved limb and expressed as a percentage.

2.3.2.Hop distance

Single leg hop test (SLHT) was used to assess the hop performance of the participants. The participants stood on single leg with toes behind a mark on the floor. They were instructed to jump as far as possible with a controlled landing. The test was performed until three successful jumps were performed for each leg. The distance was measured in centimeters and the average of the three trials was recorded. The tests were performed with the uninvolved limb first followed by the involved limb. The hop distance of the involved limb was divided by the hop distance of the uninvolved limb and expressed as a percentage.

2.3.3. Knee and hip strength

An isokinetic dynamometer (IsoMed®2000 D&R GmbH, Germany) was used to measure the concentric and eccentric knee extensor and flexor, and hip abductor strength at an angular velocity of 90°/s.

The concentric and eccentric knee extension/flexion strength measurements were performed with the participants seated on the dynamometer with the hip and knee joints flexed to 90°. Stabilization straps were placed across the trunk, waist and the distal femur of the limb to minimize compensatory movement. The axis of the dynamometer was aligned to the lateral femoral epicondyle while the knee was flexed at 90° and the dynamometer force arm was secured 2 cm above the lateral malleolus. Prior to strength recordings, the participants were allowed three maximal concentric and eccentric quadriceps and hamstring tests to familiarize themselves with the testing procedures and to warm-up. The participants then performed five reciprocal maximal

concentric and eccentric extension/flexion contractions through a ROM of 90° with a two minute rest interval between each set.

For hip abductor strength measurement, participants were positioned in side lying with the knee of the side to be tested fully extended and the contralateral knee flexed to 90°. Two stabilization straps were placed over the anterior superior iliac spine and contralateral knee to prevent compensatory movements. The axis of the dynamometer was aligned to the greater trochanter of tested limb. The dynamometer lever arm was secured superior to the lateral knee joint line and the ROM was set to 45° of hip abduction. The participants then performed 5 reciprocal concentric and eccentric hip abduction contractions.

The knee strength measurements were performed prior to the hip strength test and the order of the muscles tested was randomized to minimize the effect of fatigue on individual muscular performance. Standardized verbal instructions were given for each test procedure. Normalized peak torque (Nm/kg) values for involved and uninvolved limbs were recorded. The muscle strength indices were calculated by the torque produced by the involved limb divided by the torque produced by the uninvolved limb, which were then expressed as percentages.

2.3.4.Self-reported outcomes

The knee injury and osteoarthritis outcomes (KOOS) score was used to evaluate subjective knee function. This has five subscales evaluating symptoms, pain, function in daily life (DL), and function during sport and recreational activity (Sport/Rec) and knee-related quality of life (QoL). Each subscale was scored from 0 to 100, where a score of 100 indicates good knee function [25, 26].

The Lysholm score was used to evaluate patients' knee function following knee ligament injury. This comprises of an eight-item questionnaire with a maximum score of 100 points, indicating no symptoms [27, 28].

The International knee documentation committee (IKDC) subjective knee form was used to measure symptoms, function and sports activity. This has previously been used to assess people with knee disorders, including ligamentous and meniscal injuries, osteoarthritis and patellofemoral dysfunction. This form contains 18 selected items designed to measure symptoms which allows clinicians to assess pain, stiffness, swelling, joint locking and joint instability, while other items designed to measure knee function evaluate the ability to perform activities associated with daily living. The total IKDC is scored from 0 to 100, with 100 indicating the absence of symptoms and higher levels of knee function [29, 30].

The Tampa scale of kinesiophobia (TSK) was used to assess the fear of re-injury, movement and physical activity. The TSK has previously been associated with not returning to sports after ACL injury [31]. Results for the total score range from 17–68, the higher the score indicating an increasing degree of kinesiophobia [32].

2.3.5. Statistical analysis

SPSS 22.0 (SPSS Inc, Chicago, IL) was used for statistical analysis. Data were expressed as means and standard deviations (SD) for descriptive data. A Kolmogorov Smirnov test was performed to test the normal distribution of the data, and all data were found suitable for parametric testing. Pearson product moment coefficient correlation tests were used to analyze the relationship between self-reported scores and performance-based outcomes. Each correlation coefficient (r) was interpreted based on a previously described classification using similar variables: 0 to 0.4 (weak),

0.4 to 0.7 (moderate), and 0.7 to 1.0 (strong) [33]. Student t test were also performed to determine the difference between involved and uninvolved limb for the performance-based outcomes. Statistical significance level was set at $p<0.05$.

3. Results

Descriptive statistics for self-reported and performance-based outcomes are reported in Table 1-3. The knee extensor and flexor strength, SLHT outcomes were significantly lower in involved limb compared to uninvolved limb ($p<0.001$). SEBT outcomes and hip abductor strength were found to be similar between limbs ($p>0.05$). (Table 2-3).

Significant moderate positive correlations were seen between IKDC score and LSIs for concentric ($p<0.001$, $r=0.45$), eccentric knee extensor ($p=0.009$, $r=0.39$), eccentric knee flexor ($p<0.001$, $r=0.47$), and SLHT ($p=0.003$, $r=0.50$). The Lysholm score showed significant but weak positive correlations with concentric ($p=0.03$, $r=0.30$), eccentric knee extensor strength ($p=0.02$, $r=0.34$) and SLHT LSIs ($p=0.04$, $r=0.29$).

Moderate positive correlations were observed between concentric flexor strength and KOOS “symptoms” ($p<0.001$, $r=0.53$) and “pain” subscores ($p=0.02$, $r=0.32$). In addition, eccentric knee flexor strength showed moderate positive correlations with KOOS “symptoms” ($p=0.01$, $r=0.35$) and “pain” subscores ($p=0.001$, $r=0.47$). KOOS “Sport/Rec” was positively correlated with SLHT ($p=0.04$, $r=0.30$), SEBT_ANT ($p<0.001$, $r=0.52$) and SEBT_PL LSIs ($p<0.001$, $r=0.51$). In addition, KOOS “Sport/Rec” was positively correlated with concentric ($p=0.02$, $r=0.53$), eccentric knee flexor strength LSIs ($p=0.001$, $r=0.47$) and concentric knee extensor strength LSI ($p=0.03$, $r=0.31$). KOOS “QoL” was correlated with SLHT ($p=0.002$, $r=0.45$), concentric

and eccentric knee flexor strength LSIs (p=0.002, r=0.45; p=0.004, r=0.43) respectively, and concentric and eccentric knee extensor strength LSIs (p=0.001, r=0.47; p=0.004, r=0.44) respectively.

The Tampa score showed a weak negative correlation with eccentric quadriceps LSIs (p=0.02, r=-0.34). No correlation was seen between self-reported knee scores and hip abductor strength LSIs (p>0.05).

Table 1. Descriptive statistics of the self-reported outcomes.

Self-reported outcomes	**Mean±SD**
IKDC	81.2±11.5
LYSHOLM	96.6±3.9
KOOS	
Symptoms	84.8±10.7
Pain	89.0±8.1
Function in daily life	97.1±2.9
Function during Sport/Rec	81.6±15.9
Knee related quality of life	74.7±14.5
TAMPA	37.8±5.9

Abbreviations: IKDC, International knee documentation committee; KOOS, knee injury and osteoarthritis outcomes score

Table 2. Descriptive statistics of the knee extensor and flexor, and hip abduction isokinetic strength for involved and uninvolved limbs.

Strength	**Involved limb (Nm/kg)**	**Uninvolved Limb (Nm/kg)**	**95% CI of the difference**	**P value**	**Limb symmetry index (%)**
Knee extensor					
Concentric	2.71±0.99	3.04±0.74	-0.49,-0.15	<0.001	89.8±22.2
Eccentric	2.95±1.05	3.56±0.79	-0.76,-0.46	<0.001	82.1±19.8
Knee flexor					
Concentric	1.91±0.36	2.03±0.39	-0.19, -0.04	<0.001	95.3±14.6
Eccentric	2.14±0.39	2.45±0.44	-0.37, -0.25	<0.001	87.8±9.5
Hip abductor					
Concentric	1.56±0.36	1.52±0.38	-0.02,0.11	0.47	104.9±19.7
Eccentric	1.83±0.49	1.80±0.43	-0.05,0.10	0.22	102.2±16.9

Abbreviations: CI, confidence interval

Table 3. Descriptive statistics of the hop performance and postural control outcomes for involved and uninvolved limbs.

Functional tests	Involved limb (cm)	Uninvolved Limb (cm)	95% CI of the difference	P value	Limb symmetry index (%)
SLHT	149.53±29.60	163.32±26.25	-20.58,-7.01	<0.001	90.0±12.6
SEBT					
Anterior	69.86±6.41	70.67±5.72	-1.70, 0.06	0.07	98.9±4.9
Posteromedial	88.72±10.38	89.74±10.78	-2.30,0.28	0.12	99.1±5.6
Posterolateral	87.84±13.96	89.12±13.34	-2.84, 0.27	0.10	98.7±6.4

Abbreviations: SLHT, single leg hop test; SEBT, star excursion balance test; CI, confidence interval

Table 4. Correlation between self-reported and performance based outcomes. SAMPLE (needs p values, too hard to write down all the numbers.)

		IKDC	Lysholm	KOOS					TAMPA
				Symp	Pain	DL	Sport	QoL	
Knee extensor	Con	r=0.45	r=0.30	NS	NS	NS	r=0.31	r=0.47	NS
	Ecc	r=0.39	r=0.34	NS	NS	NS	NS	r=0.44	r=-0.34
Knee flexor	Con	NS	NS	r=0.53	r=0.32	NS	r=0.53	r=0.45	NS
	Ecc	r=0.47	NS	r=0.35	r=0.47	NS	r=0.47	r=0.43	NS
Hip abductor	Con	NS	NS	NS	NS	NS	NS	NS	NS
	Ecc	NS	NS	NS	NS	NS	NS	NS	NS
SEBT	Ant	NS	NS	NS	NS	NS	r=0.52	NS	NS
	Pm	NS	NS	NS	NS	NS	NS	NS	NS
	Pl	NS	NS	NS	NS	NS	r=0.51	NS	NS
SLHT		r=0.50	r=0.29	NS	NS	NS	r=0.30	r=0.45	NS

Abbreviations, International Knee Documentation Committee (IKDC), Knee Injury and Osteoarthritis Outcome Score (KOOS)

r=correlation coefficient (significant p<0.05), NS – not significant

4. Discussion

This study showed that self-reported outcomes assessed using IKDC, KOOS, Lysholm and TAMPA scores in individuals who had undergone ACLR with HTG at 6 months post-surgery were related to knee extensor and flexor strength, postural control and hop performance LSIs with a low to moderate correlation. Whereas, hip abductor strength LSI was not correlated with any of patient reported outcomes. Therefore, patient's perspective for their knee function and level of kinesiophobia might be associated with their knee strength and performance at the return to sport phase of ACL rehabilitation.

Knee specific self-reported outcomes reflect the patient's perspective on how the knee injury affects their daily life including symptoms, function, quality of life and activity level. IKDC score is the most widely used patient reported outcome to evaluate subjective knee functions in individuals who had ACL injuries and/or surgery. In this study, the mean IKDC score of the participants was 81 which shows a 19% deficit, which is lower than the normative values for healthy individuals for a similar age range [34]. IKDC score was found to be related to LSIs for concentric and eccentric knee extensor and flexor strength and related to single leg hop distance, but the correlations were only moderate. Our findings are consistent with previous findings, which have shown positive weak to strong associations between IKDC score and knee extensor strength in individuals who had undergone ACLR [14, 35, 36]. Zwolski et al.[14] suggested that score of >94.8 on the IKDC is likely to indicate that a patient's quadriceps strength is at an acceptable level for RTS. Individuals whose IKDC score was below the normal range were more than 4.5 times more likely to have failed RTS at 6 months post ACLR [11]. To our knowledge, this is the first study to investigate the association between IKDC score and hamstring strength in individuals who had undergone ACLR with HTG. We found that moderate correlations exist between IKDC score and LSIs for hamstring eccentric and concentric strength. This important finding indicates that IKDC score could reflect the hamstring strength impairments after ACLR with HTG at 6 months after surgery.

Although the sensitivity of the Lysholm score for detecting functional deficits in patients with ACL surgery is questionable when compared to other self-reported knee function scores, it is still frequently used for evaluating subjective knee outcomes. In this study, the mean Lysholm score was 96 which is accepted as a normal value, this was found to be only related with concentric and eccentric knee extensor strength LSIs,

and hop performance with weak correlations. Contrary to our findings, Dobija et al.[37] found positive correlation between Lysholm score and SEBT PM reach direction in individuals with ACL deficiency with moderate correlation.

In this present study, lower scores for KOOS were observed in “symptoms”, “Sport/Rec” and “QoL” subscores. Postural control evaluated with the modified SEBT was correlated only with KOOS “Sport/Rec”. Consistent with our findings, Trulsson et al.[38] also showed that altered postural orientation was related with worse KOOS “sport and recreation”. KOOS “symptoms and pain” subscores were only related to knee flexor strength LSI, whereas KOOS “Sport/Rec” and “quality of life” subscores were correlated with both knee extensor and flexor strength LSIs. Hence, it could be said that KOOS score is more related with knee flexor strength and postural control LSIs in individuals who had undergone ACLR with HTG. This is in agreement with Holsgaard-Larsen et al.[39] who found moderate to strong correlations between KOOS “sport” and “quality of life” subscales and knee extensor and flexors strength in patients with ACL surgery. They suggested that improving quadriceps and hamstring strength might improve the quality of life and function in sport.

The Tampa score has been widely used for assessing the fear of re-injury in individuals during the return to sport phase after ACL surgery [11, 40, 41]. Although TSK scores generally decrease after ACL surgery, higher TSK scores still exist in after rehabilitation post ACLR and has been associated with the lower knee function.[11, 40] The mean TSK score of the participants in this study was 35 and which showed a low to moderate correlation with eccentric quadriceps LSIs. This is contrary to the findings by Lentz et al.[41], who did not find a significant correlation between TSK score and quadriceps eccentric LSI. Although correlation between knee strength and TSK

score was weak in this current study, we suggest that eccentric quadriceps strength deficit may affect the kinesiophobia level in individuals who have undergone ACLR.

We are not aware of any study that investigated the associations between hip strength and self-reported outcomes in ACLR individuals, therefore we could not compare our results to previous findings. The reason for the consideration on hip abductor muscles' strength was to their role in stabilizing the pelvis during single leg activities. In addition, deficits in hip abductor strength have been shown related with second ACL injury risk following ACLR [21, 22]. Contrary to our expectation, no correlations were observed between hip abductor strength LSIs and the self-reported knee outcomes. Unlike knee extensor and flexor strength, hip abductor strength may not directly affect patients' perception of their knee function.

The literature suggests that 6 months after ACLR is a critical time point when RTS decisions are frequently made. Although the RTS criteria that clinicians use to make this determination are highly variable, RTS decision is usually made up several performance-based tests including; muscle strength, postural control and hop performance [1, 8, 9]. Limb symmetry indices for strength and performance are also a common method to evaluate the difference between involved and uninvolved limbs. Recent studies suggest 90% or 100% LSI for knee strength and performance is needed before a return to sports is advised, which includes pivoting and cutting activities [1, 8, 9, 42]. The strength deficits after ACLR have been shown to be graft-specific and knee extensor strength deficits are observed more in patients with BPTB and knee flexor strength deficit are present in patients with HTG [20]. In present study, knee flexor strength LSI was found 95% for concentric and 88% for eccentric strength while knee extensor strength LSI was 90% for concentric and 82% for eccentric contractions. Therefore, the participants of the study had not completely reached the desired level

for knee extensor and flexor strength criteria of RTS at 6 months post-surgery. It was documented that deficits in quadriceps strength may persist for up to 2 years following ACLR [43] and quadriceps strength deficit of more than 15%, causes asymmetries during squatting, landing and jumping activities [42, 44]. Gokeler et al. [45] also suggested that recovery of quadriceps strength might not be complete within the first year after ACLR. This is supported from our findings that eccentric strength deficits were greater than concentric strength deficits for both knee extensor and flexor muscles at 6 months after ACLR. Therefore, we recommended that eccentric strength measurements should be included in evaluation program after ACLR especially in RTS period. However, we did not observe strength deficit in concentric and eccentric contractions of hip abductor muscles.

The LSIs for modified SEBT and SLHT reached greater than 90%. Both SEBT and SLHT are the performance-based knee function tests that are commonly used to assess the neuromuscular control deficits of the individuals who had ACL injuries/surgery especially in RTS decision. SLHT is also frequently used for evaluating confidence in the injured limb and to ability to tolerate the loads in landing after jump [8, 9, 23, 42, 46].

4.3. Limitations

To include a homogenous sample, the present patient group was composed by male patients who had ACLR with HTG. Ageberg et al. [47] reported that sex difference could exist in self-reported knee function after ACLR. Hence, the results of this study do not address any potential gender or graft difference in these factors, which may reduce the generalizability of the present findings. Due to cross-sectional design of the study, the results only demonstrate the association between subjective and objective

outcomes at 6 months after ACLR so the findings of the study is not able to reflect the long term after surgery.

5. Conclusions

Self-reported outcomes assessed with IKDC, KOOS, Lysholm and TAMPA scores were related with knee extensor and flexor strength, postural control and hop performance symmetry in individuals who had undergone ACLR with HTG at the time when return to sport is frequently considered. Hip abductor strength was not correlated with any of patient reported outcomes. These associations suggest that improving knee strength and knee function during ACL rehabilitation could improve patient's perspective on their knee function. Compared to Lysholm and TAMPA scores, KOOS and IKDC scores had a greater correlation with performance-based outcomes, which may help clinicians in RTS decision making when there is a limited time to perform extensive evaluations or access equipment.

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