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Relação Entre a Performance Muscular e o Desempenho Funcional em Atletas Recreacionais Submetidos à Reconstrução do Ligamento Cruzado Anterior

Porto Alegre

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RESUMO

Introdução: A ruptura do ligamento cruzado anterior (LCA) é uma das lesões de joelho, que acomete indivíduos fisicamente ativos. A reconstrução ligamentar é indicada para restaurar a estabilidade do joelho e possibilitar o retorno às atividades desportivas pré-lesão. No período pós-operatório podem ser encontrados déficits na força muscular, alterações do controle neuromuscular e grande instabilidade articular, que acarretam em restrição da funcionalidade e limitação das atividades desportivas. Essas complicações podem persistir por longo período e estando presentes no momento de retorno ao esporte. Assim, diversas avaliações, incluindo testes de força muscular e testes funcionais podem ser utilizados para avaliar as condições físicas destes indivíduos. **Objetivos:** Correlacionar a performance muscular dos extensores e flexores dos joelhos com o desempenho nos testes funcionais em atletas recreacionais submetidos à reconstrução de LCA. **Metodologia:** Estudo transversal de caráter correlacional, comparativo e descritivo. Trinta e cinco indivíduos homens (29.5±6.0 anos de idade) entre 6 a 8 meses de pós-operatório (7.2±0.6 meses) foram avaliados. Aplicaram-se dois questionários: *The International Knee Documentation Committee* (IKDC) e *The Anterior Cruciate Ligament Return to Sport after Injury* (ACL-RSI). Os testes funcionais utilizados foram o salto vertical, analisado pela escala *Landing Error Score System* (LESS), *Single-leg Hop Test* (SLHT) *e* o *Y Balance Test* (YBT). A força concêntrica do quadríceps e isquiotibiais a 60º e 300º / s foi avaliada pelo dinamômetro isocinético. As diferenças entre o membro lesionado e não lesionado nos testes funcionais e no teste de força foi calculada pelo índice de simetria de membros (ISM). Para tratamento estatístico dos dados, foi utilizado o programa estatístico SPSS *for Windows* (versão 23.0), realizou-se o teste *t* de amostras pareadas para comparação entre o membro operado e o não operado e o teste de Spearman para correlação entre ISM da força muscular dos extensores e flexores do joelho e o ISM do SLHT, do YBT e a média LESS. Adotou-se um nível de significância de $p \leq 0.05$. **Resultados:** Valores significativamente maiores ($p<0.001$) foram observados no membro não afetado para pico de torque de quadríceps e isquiotibiais, em ambas as velocidades, bem como para os resultados do SLHT e do YBT, quando comparado ao membro operado. A média encontrada no LESS foi de 6.7±1.5 erros. Os pacientes apresentaram média 79.8±11.5 no IKDC e 52.9±5.3 no ACL-RSI. Foram encontradas correlações do ISM entre o SLHT e o pico de torque de quadriceps a 60º/s ($p<0.003$, $r= 0.48$) e a 300º/s ($p<0.001$, $r= 0.55$). Também foi encontrada correlação significativas entre o escore composto do YBT e pico de torque de isquiotibiais a 300º/s ($p<0.02$, $r = 0.3$). Não foram encontradas correlações estatisticamente significativas entre a força da musculatura do joelho e o escore de LESS. **Conclusão:** Os achados concluem que foram encontradas correlações entre o a força dos músculos extensores e flexores e os testes funcionais. Os pacientes após a reconstrução de LCA apresentam déficits musculares e de controle neuromuscular, assim como comprometimentos de fatores psicológicos no momento de retorno ao esporte, esses fatores devem ser levados em conta nos programas de reabilitação.

Palavras-chave: Joelho; Ligamento cruzado anterior; Reconstrução do ligamento cruzado anterior; Retorno ao esporte; Força muscular; Performance funcional.

ABSTRACT

Introduction: The anterior cruciate ligament (ACL) rupture is knee injuries that affecting mostly physically active individuals. The ACL reconstruction is the treatment aiming at restoring the knee stability and enabling return to sport. The surgical intervention can lead to significant impairments, such as muscle strength deficits, neuromuscular control disability, and increased joint instability. Such changes may results in functional restriction and decreased sports engagement. These complications may persist for long periods postoperatively and remain at the time of return to sport. Thus, stablishing and using clinical criteria through muscle strength and functional tests is decisive when releasing patients for safe return to sports practice. **Objectives:** To correlate the function of knee extensor and flexor muscles with performance of functional tests in recreational athletes submitted to ACL reconstruction. **Methods:** A cross-sectional, correlative, comparative, descriptive study was conducted. Thirty-five male subjects (29.5±6.0 years) at 6 to 8 months post-operation (7.2±0.6 months) were included. Two questionnaires were applied: The International Knee Documentation Committee (IKDC) and The Anterior Cruciate Ligament Return to Sport after Injury (ACL-RSI). Function was assessed though the following functional tests: vertical jump test analyzed by the Landing Error Score System (LESS) scale, the Single-leg Hop Test (SLH) and the Y Balance Test (YBT). Quadriceps and hamstring muscle concentric strength, at both angular velocities of 60º/s and 300º/s, were evaluated through isokinetic dynamometry. Differences between the injured and non-injured limbs were measured using the limb symmetry index (LSI). Statistical analysis was performed using SPSS for Windows (version 23.0), the paired Student's t test was employed to determine differences between non-injured and injured leg. Spearman's correlation tests were used to examine the association between the LSI of knee extension and flexion strength and the LSI of SLH, YBT composite score, and LESS score. Significance level of $p < 0.05$ was adopted. **Results:** Significantly higher values ($p < 0.001$) were observed in the unaffected limb for quadriceps and hamstring isokinetic peak torques, at both velocities, as well as for SLH and YBT, when compared to the operated limb. Participants demonstrated average LESS score of 6.7±1.5, mean of 79.8 ± 11.5 in the IKDC and 52.9 ± 15.3 in the ACL-RSI. Correlations were found between LSI for SLH and quadriceps peak torque at both 60º/s ($p<0.003$, $r=0.48$) and at 300º/s ($p <0.001$, $r=0.55$). In addition, correlation was observed between the YBT composite score and the hamstring peak torque at 300º/s ($p<02$, $r=0.30$). No statistically significant correlations between knee extension and flexion strength and the LESS score were observed. **Conclusion:** Correlations were found between extensor and flexore muscles and the functional tests. Patients following ACL reconstruction showed deficits in muscle strength and neuromuscular control, as well as lower psychological readiness at the moment of return to sport, these factors must be taken into account in rehabilitation programs.

Keywords: Knee; Anterior Cruciate Ligament: Anterior Cruciate Ligament Reconstruction; Return to Sport; Muscle Strength; Functional performance.

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LISTA DE ABREVIATURAS E SIGLAS

Revisão da Literatura

LCA	Ligamento Cruzado Anterior

Artigo

ACL	Anterior Cruciate Ligament
ACLR	Anterior Cruciate Ligament Reconstruction
ACL-RSI	Anterior Cruciate Ligament Return to Sport After Injury
IKDC	The International Knee Documentation Committee
LSI	Limb Symmetry Index
LESS	Landing Error Score System
RTS	Return to Sport
SLHT	Single-Leg Hop Test
YBT	Y Balance Test

SUMÁRIO

1 INTRODUÇÃO

O ligamento cruzado anterior (LCA) possui a função de conter a translação anterior da tibia em relação ao fêmur. A ruptura deste ligamento é uma das lesões mais frequentes da articulação do joelho, que acomete jovens adultos fisicamente ativos (KIAPOUR & MURRAY,2014), sendo considerada uma ocorrência grave, que acarreta em complicações físicas, psicológicas e econômicas para o indivíduo. As lesões do LCA são responsáveis por gerar grande instabilidade articular, perda de força muscular e alterações no controle neurosmuscular. Consequentemente, levando à perda funcional, diminuição da qualidade de vida, promovendo o afastamento do atleta de sua prática desportiva por longos períodos, e também levando ao aumento das chances de desenvolver osteoartrite precoce no joelho (HEWETT et al., 2006).

Desta forma, após a lesão do LCA o procedimento cirúrgico de reconstrução do ligamento é o tratamento mais indicado para recuperar a estabilidade mecânica do joelho e possibilitar a prática desportiva (FARSHARD et al., 2011). Entretanto, no período pós-operatório os pacientes geralmente são afetados por inibição muscular, que ocorre devido às alterações provocadas nos receptores articulares no momento da lesão, o que acarreta na diminuição de ativação da musculatura do joelho. Essa inibição pode levar à perda de massa e de força muscular, principalmente, das musculaturas extensora e flexora do joelho (NOYES, 2010), podendo esses déficits musculares permanecerem até 2 anos após a realização do procedimento cirúrgico (NAGELLI & HEWETT, 2017). Além disso, a ruptura do LCA também compromete o sistema de controle neuromuscular, causando a diminuição da propriocepção e da estabilidade articular do membro acometido. Esses comprometimentos musculares e de controle neuromuscular podem acarretar em desequilíbrios entre o lado acometido e o não acometido, estando esses fatores relacionados à chance de re-lesão e ao processo de retorno dos atletas ao esporte (DINGENEN & GOKELER, 2017).

Ardern et al. (2014), relatam que apenas 65% dos atletas recreacionais retornam às suas atividades desportivas pré-ruptura, e a incidência de segunda lesão ou lesão contralateral aumenta quando comparado à pessoas saudáveis, de aproximadamente 1 a cada 3 indivíduos, sendo o período de 12 a 24 meses de pós-operatório apresentando o maior risco após o retorno ao esporte

(PATERNO et al., 2014). Devido à alta taxa de recidiva, revisões sistemáticas observaram que não há um consenso na literatura dos critérios para retorno ao esporte pós-reconstrução ligamentar (BARBER-WESTIN & NOYES, 2011; ANDERSON et al., 2016; DINGENEN & GOKELER, 2017). Barber-Westin & Noyes (2011), relatam que 60% dos estudos consideram somente o tempo de pós-operatório como decisão clínica, frente à isso, com o intuito de minimizar o risco de segunda lesão nestes pacientes, um consenso multidisciplinar recomendou o uso de critérios objetivos e baseados em evidências (VAN MELICK et al., 2016). A intenção desta nova recomendação é avaliar os déficits persistentes nestes pacientes durante o retorno ao esporte, de modo que, recentes estudos vêm desenvolvendo um conjunto de testes que consistem na avaliação da performance muscular por meio da avaliação do torque muscular, do controle neuromuscular, com o uso de testes funcionais e das perspectivas do paciente por meio de questionários auto relatados (GOKELER et al., 2017; WELLING et al., 2018; KYRITSIS et al., 2016).

Entretanto, até o momento, ainda não está claro na literatura quais as relações existentes entre os testes de força muscular e os testes de controle neuromuscular. Bem como, quais os déficits presentes no momento de retorno às práticas desportivas após a reconstrução ligamentar. Com isso, faz-se necessário este estudo para investigar a correlação entre esses critérios objetivos de retorno ao esporte, afim de contribuir nas tomadas de decisões em pacientes submetidos a reconstrução de LCA.

2 REVISÃO DE LITERATURA – CONTEXTUALIZAÇÃO

2.1 ARTICULAÇÃO DO JOELHO

O joelho é a articulação mais solicitada do corpo humano devido a sua função de descarga de peso no momento da locomoção, sendo considerada a maior articulação diartrodial e uma das mais complexas do nosso corpo. É composta pelos ossos do fêmur, da tíbia, da fíbula e da patela, acoplados por ligamentos, cápsula articular, meniscos e músculos que realizam a sua estabilização (FLOYD, 2016).

O joelho é formado por três articulações: a tibiofemoral, a patelofemoral e a tibiofibular proximal. Seus dois principais movimentos osteocinemáticos são a flexão e a extensão e, além destes, de forma acessória, os movimentos de rotações sobre o eixo longitudinal da perna, que estão presentes somente se o joelho estiver flexionado a partir de 30 graus. A amplitude de movimento máxima ocorre em torno de 140 graus para flexão e de 5 à 10 graus para hiperextensão do joelho (KAPANDJI, 2008). A estabilidade funcional da articulação é realizada pela contenção passiva dos ligamentos, da geometria articular, da ativação da musculatura e das forças compressivas que mantêm os ossos unidos (HAMILL; KNUTZEN; DERRICK, 2016).

A musculatura do joelho é responsável pela estabilização ativa da articulação, e se divide em dois grupos musculares: os extensores (quadríceps femoral) e os flexores- rotadores de joelho. A musculatura extensora é formada pelos músculos vasto medial, vasto lateral, vasto intermédio e reto femoral. Todas musculaturas se unem e formam o tendão quadriciptal que se insere na base e nas laterais da patela, gerando assim o mecanismo extensor do joelho. O grupo flexor-rotador é constituído dos músculos isquiotibiais, sartório, grácil e poplíteo. A interação destes com os músculos anteriores e posteriores da coxa é de extrema importância para manter a biomecânica da articulação do joelho (NEUMANN, 2018).

Os principais estabilizadores passivos da articulação são os ligamentos colateral medial e lateral, e os ligamentos cruzado anterior e posterior, que são responsáveis pela manutenção da posição da tíbia e do fêmur. As funções gerais dos ligamentos são proporcionar a estabilidade em vários planos de movimento, guiar a artrocinemática normal da articulação e contribuir para a propriocepção do joelho (NEUMANN, 2018)

Com isso, a cinemática e a biomecânica do joelho dependem da relação de uma complexa estrutura articular, qualquer dano que cause desequilíbrios ou instabilidade pode prejudicar a articulação do joelho, e gerar possíveis comprometimentos articulares (JUNIOR et al., 2009).

2.2 LESÃO DO LIGAMENTO CRUZADO ANTERIOR

Dentre os ligamentos que realizam a estabilidade passiva do joelho, o LCA possui um papel fundamental nesta articulação, devido à sua origem na parte anterior da eminência intercondílica da tíbia e inserção no côndilo externo do fêmur, possui a função de controlar o movimento rotacional da articulação e de conter a translação anterior da tíbia em relação ao fêmur, servindo também como limitador da hiperextensão do joelho. Esse ligamento é descrito contendo dois feixes de fibras, as fibras anteriores estão em tensão durante a flexão e as fibras posteriores se tencionam no momento de exntesão do joelho (HAMILL; KNUTZEN; DERRICK, 2016).

Mesmo sendo um grande estabilizador articular, sua lesão está entre as mais prevalentes na articulação do joelho, e a alta taxa de ruptura deste ligamento tem sido reportada em esportes caracterizados por saltos, giros e mudanças de direções, como futebol, handebol, basquete e voleibol (RENSTROM et al., 2014). A literatura relata que, aproximadamente, 70% das lesões ocorrem por não contato (HEWETT et al., 2006), ou seja, a ausência de contato com outro jogador, ou como uma perturbação física sem um contato direto na articulação (MYKLEBUST et al., 2003). A biomecânica da lesão está relacionada com um valgo dinâmico da extremidade inferior, ou seja, uma combinação entre movimentos rotacionais, incluindo a adução e rotação interna de quadril, valgo do joelho, rotação externa e translação anterior da tíbia e eversão do tornozelo. A causa da ruptura do LCA é considerada multifatorial, mas possivelmente está associada à uma instabilidade dinâmica do joelho devido a déficits no controle neuromuscular (HEWETT et al., 2006).

Além do fator social, a ruptura de LCA acarreta impactos significativos a curto prazo como derrame articular, fraqueza muscular, déficits no controle neuromuscular, e longo período de tempo afastado das práticas esportivas, bem como complicações psicológicas. As sequelas a longo prazo estão associadas com lesões meniscais, lesões condrais e aumento do risco precoce de osteoartrite pós-traumática (LEVEY, 2010). O diagnóstico clínico desta lesão é realizado por meio de testes ortopédicos (teste de Lachman e teste Pivot-shif) e pelo exame de ressonância magnética, que apresenta alta acurácia para diagnóstico (BENJAMISE; GOKELER; VAN DER SCHANS, 2006).

2.2.1 Tratamento do pós-ruptura do ligamento cruzado anterior

O tratamento da lesão de LCA divide-se em tratamento conservador, por meio de intervenções fisioterapêuticas, e o tratamento cirúrgico. O tipo de tratamento está relacionado a idade, nível de atividade física e lesões associadas de outros ligamentos e/ou lesões meniscais (RAJGOPAL, 2014). No entanto, o tratamento cirúrgico para reconstrução do LCA está indicado para melhorar a instabilidade articular. Estudos demonstram que os pacientes com reconstrução ligamentar apresentam melhores resultados para retorno à maiores níveis de exercício físico comparado aos pacientes submetidos ao tratamento conservador (MEUFFELS et al., 2009; FARSHARD et al., 2011).

A ligamentoplastia é o procedimento cirúrgico para reconstrução ligamentar, realizado através de técnicas artroscópicas. Os procedimentos cirúrgicos para a reconstrução do LCA, dividem-se em autoenxertos e aloenxertos, contudo os autoenxertos são os mais utilizados, pois apresentam melhores resultados, maior satisfação dos pacientes, menor chance de revisão cirúrgica e melhor revascularização comparado aos aloenxertos (ANDERSON et al., 2016; EBNEZAR, 2010). Os autoenxertos são retirados do membro ipsilateral do paciente e,atualmente, existem dois tipos de enxertos: terço central do tendão patelar e tendões do semitendíneo e do grácil (músculos flexores) (KANE et al., 2016). Estudos que compararam esses dois procedimentos afirmam que o autoenxerto do tendão patelar promove mais estabilidade articular, porém está associado ao aumento da taxa de dor anterior do joelho, diante disso o enxerto dos músculos flexores está sendo o mais frequentemente utilizado para a reconstrução de LCA (FISCHER et al.,2018).

A fisioterapia no pós-operatório possui uma grande importância em reabilitar a funcionalidade e avaliar esses pacientes para o retorno ao esporte (O'SULLIVAN & SCHMITZ, 2010). Na fase pós-operatória precoce (0-6 semanas), o objetivo da reabilitação é eliminar o derrame articular, recuperar a amplitude de movimento e minimizar a atrofia muscular. Já na fase tardia do pós-operatório, entre 2 a 6 meses, o objetivo da reabilitação é recuperar a força muscular adequada e a estabilidade dinâmica do joelho (GRINDEM et al., 2012).

2.3 RETORNO AO ESPORTE

Após a reabilitação, o retorno dos indivíduos para as atividades pré-lesão é um fator muito discutido pelos autores, e ainda não há um consenso na literatura de quais critérios devem ser aplicados (ANDERSON et al., 2016). Segundo Kyritsis et al. (2016), um dos fatores que pode ser considerado como risco ao indivíduo é o retorno precoce ao esporte sem critérios específicos.

Somente 13% dos recentes estudos adotaram critérios objetivos (ANDERSON et al., 2016). A maioria dos estudos utilizam critérios subjetivos, e consideram o tempo de 6 meses de pós-operatório como fator determinante para retorno ao esporte, entretanto recentes pesquisas sugerem que o retorno antes dos 9 meses de pós-cirúrgico pode aumentar o risco de re-ruptura de LCA (DINGENEN & GOKELER, 2017). Schmitt et al.(2016) afirmam, que o desenvolvimento de recomendações padronizadas, objetivas e baseadas em evidências são cruciais para as tomadas de decisões clínicas e para minimizar o risco de uma segunda lesão nesta população.

A avaliação da funcionalidade, após a reconstrução de LCA é um importante fator para o retorno seguro ao exercício físico, entretanto 90% dos pacientes voltam a praticar esportes sem nenhuma avaliação objetiva. Esse fator pode estar associado com a alta taxa de recidiva de lesão nos primeiros 7 à 12 meses após o retorno às atividades esportivas (ARDERN et al., 2016). A literatura recomenda que deve ser realizada uma bateria de testes, que avaliem qualitativamente e quantitativamente a performance muscular destes pacientes após reconstrução ligamentar (BARBER-WESTIN & NOYES, 2011).

Dentre os métodos para a avaliação da performance e dos desequilíbrios musculares o equipamento considerado padrão ouro é o dinamômetro isocinético (DROUIN et al., 2004). Este aparelho é frequentemente usado para avaliar os déficits do torque muscular em pacientes com lesão de LCA, sendo considerado uma prática útil para analisar a progressão da reabilitação nessa população (FISCHER et al., 2018). As variáveis isocinéticas permitem identificar as diferenças entre o membro lesionado e o membro não lesionado, e a relação entre os músculos agonista e antagonista (HILDEBRANDT et al., 2015).

Também se faz necessário avaliar a presença de déficits no controle neuromuscular da extremidade inferior, o que pode ser considerado um risco para uma lesão secundária do ligamento, decorrente das alterações biomecânicas e da diminuição da aferência proprioceptiva que ocorre na lesão primária. Devido a essas alterações, as funções neuromusculares da articulação do joelho são acometidas e, portanto, testes que avaliem o controle neuromuscular são frequentemente utilizados para avaliar a estabilidade dinâmica dos indivíduos (PATERNO et al., 2010). Os testes mais utilizados são os testes funcionais, que têm como objetivo desafiar a estabilidade do joelho e simular exigências impostas à articulação durante os exercícios físicos (ZWOLSKI et al., 2016).

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4 OBJETIVOS

4.1 OBJETIVO GERAL

Correlacionar a performance muscular dos extensores e flexores dos joelhos com o desempenho nos testes funcionais em atletas recreacionais submetidos à reconstrução de LCA.

4.2 OBJETIVOS ESPECÍFICOS

- Analisar o desempenho muscular dos extensores e flexores dos joelhos por meio da dinamômetria isocinética computadorizada;
- Avaliar a estabilidade dinâmica do joelho por meios dos testes funcionais;
- Identificar a percepção do paciente em relação a funcionalidade da articulação do joelho através de questionários específicos.

5 ARTIGO

Relationship between muscle function and functional performance in recreational athletes following anterior cruciate ligament reconstruction

(Será submetido ao periódico Physical Therapy in Sport; Qualis: A2; Fator de Impacto: 1,919)

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Ethics committee

Consolidated opinion of the UFCSPA Research Ethics Committee n°. 2.547.728

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ABSTRACT

Objective: To evaluate the relationship between muscle strength and performance in functional tests after anterior cruciate ligament reconstruction (ACLR).

Design: Cross-sectional study.

Setting: Laboratory setting

Methods: Thirty-five male recreational athletes (29.5±6.0 years old) at 6 to 8 months (7.2±0.6 months) after ACL reconstruction performed a jump-landing task assessed with the landing error score system (LESS), the single-leg hop test (SLHT), the Y balance test (YBT), and quadriceps and hamstring isokinetic dynamometry at 60 and 300º/s. The International Knee Documentation Committee (IKDC) and the Anterior Cruciate Ligament Return to Sport after Injury (ACL-RSI) were also applied. The limb symmetry index (LSI) was used to estimate the ratio between limbs.

Results: Correlations were found between the LSI for SLHT test and the LSI for quadriceps peak torque at 60º/s ($r = 0.48$, $p<0.003$) and 300º/s ($p<0.001$, $r=0.55$). The LSI of YBT composite score was associated with LSI of hamstring peak torque at 300º/s ($p<0.02$, $r=0.3$). The operated limbs showed lower knee flexor and extensor muscle strength, worse SLHT and YBT composite score performance compared to non-opertatd limb ($p<0.001$).

Conclusion: The present study found that quadriceps strength is correlated to SLHT, and hamstring strength is associated with YBT scores.

Keywords: ACL injury, muscle strength, functional test, return to sport.

INTRODUCTION

The anterior cruciate ligament (ACL) function as a passive stabilizer of the knee, providing restriction to anterior displacement of the tibia relative to the femur (Neumann, 2018). Non-contact ACL rupture is the most common mechanism of injury that affects athletes performing jumping, pivoting and cutting maneuvers in their sports routine (Spindler & Wright, 2008). Following an ACL injury, the knee may suffer meniscal tears, develop functional instability, and subsequent osteoarthritis. To restore knee stability and regain pre-injury level of sport, ACL reconstruction (ACLR) surgery is often performed (Matava, Howard, Polakof, & Brophy, 2014). However, previous studies showed that up to 35% of intervened athletes did not return to their preinjury sports level (Ardern, Webster, Taylor, & Feller, 2011) and indicated an increased rate of re-injury (contralateral or graft re-tear) in the first 12 months post-surgery (Paterno, Rauh, Schmitt, Ford & Hewett, 2012).

After ACLR, patients may naturally exhibit alterations in joint receptors and disruption of the neuromuscular system, which can lead to diminished proprioception, abnormal patterns of muscle activity and reduced dynamic joint stability (Noyes, 2010). The goal of post-surgery rehabilitation is to prevent, minimize and treat these disorders. Nonetheless, strength deficits in extensor and flexor muscle groups (of the injured limb compared to non-injured), loss of neuromuscular control, changes in landing kinematics, and abnormal psychological readiness and perception of knee function can persist for several months following surgery (Langford, Webster & Feller, 2009; Padua et al., 2015; Schmitt, Paterno & Hewett, 2012). These factors may be fundamental when predetermining the potential success of athletes at return to sport (RTS) (Ithurburn, Longfellow, Thomas, Paterno, & Schmitt, 2019).

The decision to RTS after ACLR is difficult and challenging, since scientific consensus is lacking on the criteria used to release a patient to unrestricted sports activity (Dingenen & Gokeler, 2017). The athletes' ability to return to their pre-injury level of sport is multifactorial, although there is insufficient current evidence to make strong recommendations about RTS criteria. Barber-Westin and Noyes, (2011) found that RTS decision is mostly based on subjective non-specific criteria and the majority of studies have used time-based decision. Thus, new testing protocols involving objective criteria have been proposed in order to determine the mechanisms by which athletes become more susceptible to a second injury, and to develop screening tools to quantify risk levels (Gokeler, Welling, Zaffagnini, Seil, & Padua, 2017; Hewett, Myer, Ford, Paterno, & Quatman, 2016; Welling, Benjaminse, Seil, Lemmink, Zaffagnini, et al., 2018). To make a safe RTS, various strength tests, functional tests, i.e., including hop tests, and patient-reported outcomes have been used as assessment tools, typically between 6 and 12 months after surgery. These tests quantify both muscular and functional performance to identify limb-to-limb differences. Given that limb symmetry appears to be an important component of the functional recovery after ACLR, deficits up to 10% compared to un-involved knee are currently accepted and used to classify patients with satisfactory functional recovery (Gokeler et al., 2017).

To progress toward evidence-based recommendations for RTS decision-making, identifying the impact of major impairments at the time of return to sport is important. Therefore, the primary purpose of this study was to investigate the relationship between muscle strength and performance in functional tests. We also intended to compare the symmetry between the operated and non-operated limb and to evaluate patient-reported outcomes.

MATERIAL AND METHODS

Study Design

A correlational, comparative cross-sectional study was conducted. The study was approved by the University's Research Ethics Committee (protocol number 2.547.728). Prior to data collection, all participants read and agreed to sign a consent form.

Patients

Participants were recruited, between March 2018 and May 2019. To be included, participants had to be aged between 18 and 45 years, submitted to reconstruction surgery for isolated ACL tear (without other concomitant ligament injury) in the previous 6 to 8 months, using hamstring tendon autograft, with intact or partially resected meniscus. Also, they had to have completed rehabilitation and be cleared to return to sport by their surgeon and rehabilitation team. Their pre-injury physical activity level should be of 5 to 7 on the Tegner Activity Scale. Although all subjects were released from formal rehabilitation before entering the study, standardization of the programs was not possible. The exclusion criteria for this study was previous injury to the contralateral knee, associated patellofemoral pain syndrome, lower limb muscle injury in the previous 6 months, and respiratory or cardiovascular limiting conditions

Procedures

All participants completed two questionnaires: the International Knee Documentation Committee (IKDC) and the Anterior Cruciate Ligament Return to Sport after Injury (ACL-RSI). The IKDC is a patient-oriented outcome that measures symptoms, function, and sports activity. The values of the IKDC score within 15th percentile of healthy gender-age- matched subjects classify the normal function of the knee (Anderson et al., 2006). The ACL-RSI is a patient-reported outcome of emotions, confidence in performance and risk appraisal. Scores are summed and averaged for a total score between 0 and 100 points (Webster, Feller, & Lambros, 2008). A higher total score indicates greater psychological readiness.

Before testing, all subjects went through a 5-min stationary cycling warm-up. Next, a jump landing task assessment was performed using the landing error scoring system (LESS) in order to identify movement patterns. Participants started the test standing on a 30-cm box with a target line drawn on the floor at a distance of half the individual’s height. They were instructed to jump forward from the box and land just past the marked line with both feet reaching the ground simultaneously, then immediately perform a maximal vertical jump. Before the trials, they practiced three jump landings for familiarization. Trials were excluded and repeated if the participants jumped vertically from the box or if they did not jump for maximal height upon landing. Three successful trials were recorded by two digital video cameras placed 3 meters away from the landing spot, getting frontal and sagittal images of all trials. Participants were allowed to rest for 30 seconds between trials. The operated limb was evaluated by the LESS video using the freeware motion-analysis Kinovea software (version 0.8.26) (Padua et al., 2015).

After, participants performed a single-leg hop test (SLHT). For this test, individuals started from a single-legged, semi-squad standing position and were instructed to hop forward as far as possible and land on the same foot from which they took off. The distance between the initial and final standing position was measured. Two practice trials followed by two record trials were taken for each leg. The non-operated limb was tested first and no restrictions were given for arm movements. (Myers, Jenkins, Killian, & Rundquist, 2014).

Before commencing the Y Balance Test (YBT), each leg length i.e. distance from the most distant aspect of the anterior superior iliac spine to the most distal aspect of the medial malleolus was measured with the participant in supine on a mat table. For this test, the participants watched an instructional video demonstrating the test and testing procedures. Then, they were instructed to stand in single-limb position at the center of a grid laid on the floor with three reach lines in the form of a Y, with the most distal aspect of the great toe at the starting line. While maintaining single-leg stance and hands on the hips, participants had to reach with the suspended limb as far as possible in anterior (ANT), posteromedial (PM), and posterolateral (PL) directions in relation to the stance foot. Six practice trials were performed for each leg in each of the three directions for familiarization. Trials were discarded and repeated if participants failed to maintain unilateral stance, lifted or moved the stance foot from the grid, touched down with the reach foot, or failed to return the reach foot to the starting position. Reach distance was defined by the most distal aspect of the great toe (Plisky, Rauh, Kaminski, & Underwood, 2006).

Muscular performance for isokinetic strength of the quadriceps and hamstring muscle groups was assessed using an isokinetic dynamometry device Biodex™ Multi Joint System 4 Pro (Biodex Medical Systems, New York, USA). Prior to each assessment, the equipment was calibrated and participants were positioned according to manufacturer’s recommendations (Biodex, 2002). The non-affected side was always tested first, and tests for both legs were performed at angular velocities of 60°/s and 300°/s with 5 and 20 maximal concentric repetitions for flexion and extension, respectively. All participants performed a familiarization session before the formal test to minimize learning effects. Standard instructions, feedback, and verbal encouragement were provided during tests.

Data Management

The average LESS score from the three trials at each testing session was used for data analyses. The mean LESS score > 6 is considered as poor jump-landing biomechanics (Bell, Smith, Pennuto, Stiffler, & Olson, 2014). The single-leg hop test values were considered as the average of the two recorded trials. For the YBT test, each reach distances were normalized by lower-limb length, and for each limb, the YBT composite score was calculated as the sum of the ANT, PM, and PL reach distances divided by 3 times the leg length and multiplied by 100. The normal value for the composite reach distance was ≤ 94.0% (Plisky et al., 2006). The LSI (limb symmetry index) was calculated to determine whether side to side differences in the strength test, the SLHT, and the YBT composite score existed. The LSI was defined as the ratio of the operated side and the non-operated side expressed in percentages (LSI = operated /non-operated x 100). The patients were classified as normal with LSI ≥ 90% (Grindem, Lynn, Moksnes, Engebretsen, & Risberg, 2017).

Statistical Analysis

Data normality was determined by the Shapiro-Wilk test. Mean and standard deviation was adopted as central tendency and dispersion measures. Spearman’s correlation was calculated for examining the association between the LSI of knee extension and flexion strength and the LSI of SLHT, LSI of YBT composite score, and LESS score. Values close to -1 or +1 suggested a strong association, whereas value closer to 0 suggested no relationship, as defined are 0.01-0.3 (weak), 0.3-0.5 (moderate), and 0.5-0.99 (strong) (Cohen, 1998).The paired Student's t test was employed to determine differences between legs (operated leg and non-operated limb), statistical significance was established a priori ($p \leq .0.05$). The analysis was performed using IBM SPSS version 23.0.

RESULTS

Twenty-five men, age 29.5±6.0 were included (see detailed sociodemographic description in Table 1).

INSERT TABLE 1 HERE

No correlation were observed between the LSI of hamstring strength at 60º/s ($r = 0.08$, $p = 0.61$) and 300º/s ($r = -0.06$, $p = 0.71$) and the LSI of SLHT. However, there were moderated correlations between the LSI of hop test and the LSI of quadriceps peak torque at both 60º/s ($r = 0.48$, $p < 0.003$) (Figure 1) and 300º/s ($p < 0.001$, $r = 0.55$) (Figure 2). The association between YBT composite score was observed with the hamstring peak torque at 300º/s ($r = 0.3$, $p < 0.02$) (Figure 3). There were no significant correlations between the extension and flexion strength and the LESS score.

INSERT FIGURE 1

INSERT FIGURE 2

INSERT FIGURE 3

The absolute scores from the unaffected limb were significantly higher ($p < 0.001$) than the operated limb for both quadriceps and hamstring isokinetic peak torque in both velocities, as well as for hop test and YBT composite score. While the mean LSI for hamstring peak torque at 300º/s, SLHT, and YBT composite score were higher than 90%, the mean LSI for quadriceps peak torque and hamstring peak torque both at 60º/s were lower than 90% (Table 2).

INSERT TABLE 2 HERE

DISCUSSION

The main finding of the present study was that muscle deficits were correlated with functional tests in individuals returning to sport following ACLR. The major results were that quadriceps strength deficits significantly impacted the performance of the SLHT and the imbalances in the hamstring muscles were associated with the YBT composite score. Therefore, imbalances of muscle strength seem to influence the biomechanics of the knee joint. After ACLR, the operated limb demonstrated decreased muscle strength and impaired function compared to the uninjured limb, as well a poorer LESS scores. Besides, participants reported low scores in the ACL-RSI and high scores in the questionnaire IKDC.

The relationship between muscle strength and functional tests is inconsistent among previous works (Fitzgerald, Lephart, Hwang, & Wainner, 2001; Harput et al., 2016; Myers et al., 2018; Noyes, Barber, & Mangine, 1991; Harput, Howard, & Mattacola, 2016; Myers, Christopherson, & Butler, 2018; Welling, Benjaminse, Seil, Lemmink, & Gokeler, 2018). This inconsistency can be explained by the methodological heterogeneity, considering time post-surgery, ACLR graft type, isokinetic test, and hop performance (Fitzgerald et al., 2001; Harput et al., 2016; H. Myers et al., 2018; Noyes et al., 1991). In our study, we found a significant correlation between the quadriceps concentric muscle isokitenic testing and SLTH. Likewise, Schmitt et al., (2012) showed that quadriceps isometric strength is a predictor for hop test performance. Similar findings demonstrated that patients with quadriceps isometric strength asymmetry performed worse in hop tests. (Palmieri-Smith & Lepley, 2015). Others studies detected significant relationships of the SLTH with either low or high velocities in the isokinetic strength (Noyes et al., 1991; Xergia, Pappas, & Georgoulis, 2015). However, our study found significant associations of hop test with both the angular velocities,i.e. 60º and 300º/s, during extensor muscle isokinetic tests. Such, results indicated that imbalances in concentric quadriceps strength may impact the asymmetry of the SLHT. In a practical context, the implies on the use of single-leg performance to evaluate quadriceps impairment when dynamometry devices are not available.

Previous studies investigated the correlation between muscle strength and YBT scores (Clagg, Paterno, Hewett, & Schmitt, 2015; Domingues et al., 2018; H. Myers et al., 2018). In our study, YBT composite scores were associated only with hamstring muscles strength, distinctly from recent study that no found associations between LSI and strength (Clagg et al., 2015). Comparable to our findings, previues studies (Domingues et al., 2018; Myers et al., 2018) found significant correlations between knee flexor muscle strength and the YBT composite score. This may be explained by the high activity of the femoral biceps in the PM and PL directions. The activation can occur when the leg is extended backward, the trunk flexes to maintain balance, and the hamstring acts to resist the hip-flexion moment (Herrington, Hatcher, Hatcher, & McNicholas, 2009). However, the correlation was weak and further studies should be conducted to confirm these findings.

According to studies that evaluated patients suffering a reicident ACL injury, and who returned to pre-injury activities, measures of LSI lower than 90% have been considered as cut off values (Webster & Hewett, 2019). Individuals demonstrated persistent deficits in extensor and flexor muscle concentric strength following surgery, with significantly higher values on the unaffected relative to the affected limb. In our sample, one key finding was that only 17.14% of all participants passed the criterion for LSI for quadriceps peak torque at 60º/s and achieved a low average LSI concerning the other muscle indexes (76.9±15.3). Grindem et al., (2017) found that individuals with more than 10% LSI are significantly increaseds the rate of knee reinjury. Our results are consistent with previous reports similar quadriceps strength deficits after a long period undergoing reconstruction (Gokeler et al., 2017). These imbalances in the quadriceps strength can be based on corticospinal excitability deficits present post-surgery, which contribute to quadriceps weakness and disability in voluntary activation (Lepley et al., 2015). Variability of rehabilitation programs in which patients were enrolled is another factor that may influence knee flexor strength (Ebert et al., 2018), in our study the post-reconstruction recovery was not possible to be standardized. Likewise, hamstring strength deficits may also be a risk factor for ACL (Thomas, Villwock, Wojtys, & Palmieri-Smith, 2013). Such asymmetries may be justifiable, as deficits in hamstring strength may occur when their tendons are used as graft for ACL reconstruction (Janssen, van der Velden, Pasmans, & Sala, 2013). Hence, diminished flexors strength may harm the mechanisms that protect ligaments, as this muscle group acts as agonists to the ACL resisting to anterior tibial displacements (Hewett, Myer, & Zazulak, 2008). Nevertheless, since the literature does not show a clear standardized strength evaluation protocol following ACLR (Undheim et al., 2015), the recovery of muscle function per se is not regarded sufficient to promote a success RTS (Thomee et al., 2011).

Safe RTS can also be predicted by SLHT (Müller, Krüger-Franke, Schmidt, & Rosemeyer, 2015). This test was has been used because of it is clinical applicability to evaluate dynamic mechanisms of neuromuscular control, mimicking to dynamic activities that challenge the knee joint (Hegedus, McDonough, Bleakley, Cook, & Baxter, 2015). Previous studies reported that patients with symmetric results in the hop test were more likely to return to play (Ardern et al., 2011; Ithurburn et al., 2019). In the present study, the mean LSI's score was 90.8±13.9, so that 65.7% of the participants passed on this criterion. In contrast, imbalances between the operated and non- operated limb demonstrated significant differences, which is in accordance with the study by Hopper et al., (2008). Based on these persistent asymmetries, caution is necessary when interpreting LSI score for recovery after ACLR, since functional impairments may be bilateral (Wellsandt, Failla, & Snyder-Mackler, 2017).

The YBT is a functional test to evaluate neuromuscular control (Gribble, Hertel, & Plisky, 2012). Others studies have evaluated YBT performance in patients following ACLR; however, only one assessed YBT at the time of return to sport (Clagg et al., 2015). In our study, patients demonstrated LSI close to 100% in the composite score, similarly to findings of Dobija et al., 2019. Although, in contrast to results from previous studies, our findings from both the operated and non-operated limb differ significantly in the composite score. Likewise, participants in our study performed lower composite reach distance score means in both limbs (86.0% and 84.6%, respectively), which is comparable to the athletes studied by Plisky et al., (2006), that had composite reach distance lower than 94.0% and were more likely to develop lower extremity injury. It has been suggested that these patients seem to be affected in the dynamic postural control of both legs, since uninjured legs of ACLR patients also showed deficits compared to the limbs of uninjured individuals (Herrington et al., 2009). However, it is unclear if the LSI is a reliable screening tool for successful RTS in this population.

The LESS appears to be a valid and reliable clinical assessment tool for detecting disturbed jump-landing biomechanics. The mean LESS score of 6.7 found in our study is higher than those reported in previous studies and similar to athletes who sustained ACL injuries (Bell, Smith, Pennuto, Stiffler, & Olson, 2014; Padua et al., 2015; Smith et al., 2012). High mean LESS score is considered as poor jump-landing biomechanics. Previous investigations showed that patients following ACLR had a higher score than healthy individuals, suggesting that ACL injuries lead to alteration in landing (Bell et al., 2014). In the study by Padua et al. (2009), poor LESS scores were associated with changes in sagittal, frontal and transverse plane kinematics, especially with increased internal knee valgus and hip adduction moment, a major predictor for ACL injury. Thus, the implementation of neuromuscular training is necessary for this population (Hewett & Bates, 2017; Hewett et al., 2005).

To evaluate patient-reported of symptoms, function, and activity participation, self- reported are used in variety of studies (Bodkin, Goetschius, Hertel, & Hart, 2017; Rosso, Bonasia, Cottino, Cambursano, Dettoni, & Rossi, 2018; Logerstedt et al., 2014). In our study, the average IKDC score was 79.8, which represents a normal functionality observed in our patients. However, this questionnaire showed is not sufficient to make a decision, and high scores are not supported success for RTS (Logerstedt et al., 2014). Perhaps, comparably to previuos investigations, a high percentage of participants passed the cut off criterion in the IKDC questionaire, although a low percentage of them obtained optimal values in muscle strength or in neuromuscular control for returning to sports practice (Gokeler et al., 2017; Welling et al., 2018). The normal knee function in these participants could be explained by increased IKDC scores in the first year after post-surgery that is influenced by hamstring graft and age below 30 years (Magnitskaya et al., 2019).

Another relevant patient-reported outcome in the prediction of RTS is the ACL-RSI, used to measure the psychological factors (Webster et al., 2008). The mean ACL-RSI score (52.9±15.3) found in our study was lower than with previous studies (Gokeler et al., 2017; Raoul et al., 2019; Welling et al., 2018). Welling et al., 2018 indicated that score of 67.0 at 6 months predicted successful RTS at 9 months after reconstruction. One recent study showed that patients with the second injury within 12 months after RTS demonstrated worse improvement in the ACL-RSI in relation to non-injured subjects, suggesting negative psychological responses are associated to a second ACL injury (McPherson, Feller, Hewett, & Webster, 2019). In the present study, all patients were released to return pre-injury sports, which raises the attention to psychological factors during the rehabilitation and return to sports process (Langford et al., 2009).

Limitations should be addressed in the present study. First, only males subjects undergoing to ACLR with hamstring graft were included, therefore our findings cannot be generalized to all ACLR patients. Another weakness is that kinematic data was not analyzed in the SLH and YBT, and such information could be useful to evaluate the quality of movement. In the YBT, there are numerous factors influencing the performance during the test, for example, the limitation in ankle dorsiflexion range of motion is correlated with ANT reach distance. Also, it was not possible to standardize the rehabilitation protocol and the surgical procedure, as we intended to evaluate patients at a late phase of rehabilitation process (6 to 8 months postoperatively), that were receiving typical care and were released to pre-injury sports practice. Finally, our findings are related to adults and active individuals following ACLR at the time of their return to sport, so they may not be generalizable to populations of different age groups or activity levels.

CONCLUSION

Our results allow us to state that practical functional tests are associated with knee flexion and extension strength. These are important findings since functional tests are cost-effective and an easy method to implement in the clinical practice. Additional research is encouraged attempting to normalized strength and neuromuscular control. The imbalances found between the injured and un-injured limbs for muscle strength and neuromuscular control tests, as well, impaired psychological readiness affect these patients. Hence, additional interventions to minimize these deficits along with psychological counseling may be necessary to assist ACLR patients for successful RTS.

Conflicts of interest

The authors declare that they have no conflicts of interest.

Ethical statements

Written informed consent and permission to use information was obtained from the patient.

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Table 1: Descriptive data of subjects

Variable	Mean (SD)
Age (years)	29.5 ± 6.0
Body Mass Index (kg/m$^{2)}$	25.8 ± 2.3
Operated Limb (right/left)	18 / 17
Time post-surgery (months)	7.2 ± 0.6
Tegner Scale	6.3 ± 0.7
IKDC (0-100)	79.8 ± 11.5
ACL-RSI	52.9 ± 15.3

BMI = Body mass index; IKDC = The Internacional Knee Documentation Committe; ACL-RSI = Anterior Cruciate Ligament Return to Sport after Injury. Values are mean ± SD.

Table 2: Comparison between the injured leg and non-injured leg and mean limb symmetry indexes.

	Non-Injured Leg	Injured Leg	*p value*	LSI (%)
Quadriceps Strenght 60º/s (Nm)	229.1±38.8	175.4±43.3	0.000*	76.9±15.3
Hamstring Strenght 60º/s (Nm)	118.2±22.7	102.5±19.8	0.000*	87.2±10.2
Quadriceps Strengh 300º/s (Nm)	115.0±29.8	96.4±20.2	0.001*	84.3±13.0
Hamstring Strenght 300º/s (Nm)	77.6±16.6	70.3±13.0	0.000*	92.2±14.5
Single-leg hop test (cm)	117.6±25.6	107.5±30.2	0.000*	90.8±13.9
YBT Composite Score (%)	86.0±6.0	84.6±5.9	0.009*	98.4±3.5
LESS	6.7±1.5	-	-	-

LSI: Limb symmetry index; Nm: Newton Metre; cm: centimetre; YBT: Y Balance Test; LESS: Landing Error Score System. Values are mean ± SD, $p \leq 0.05$.

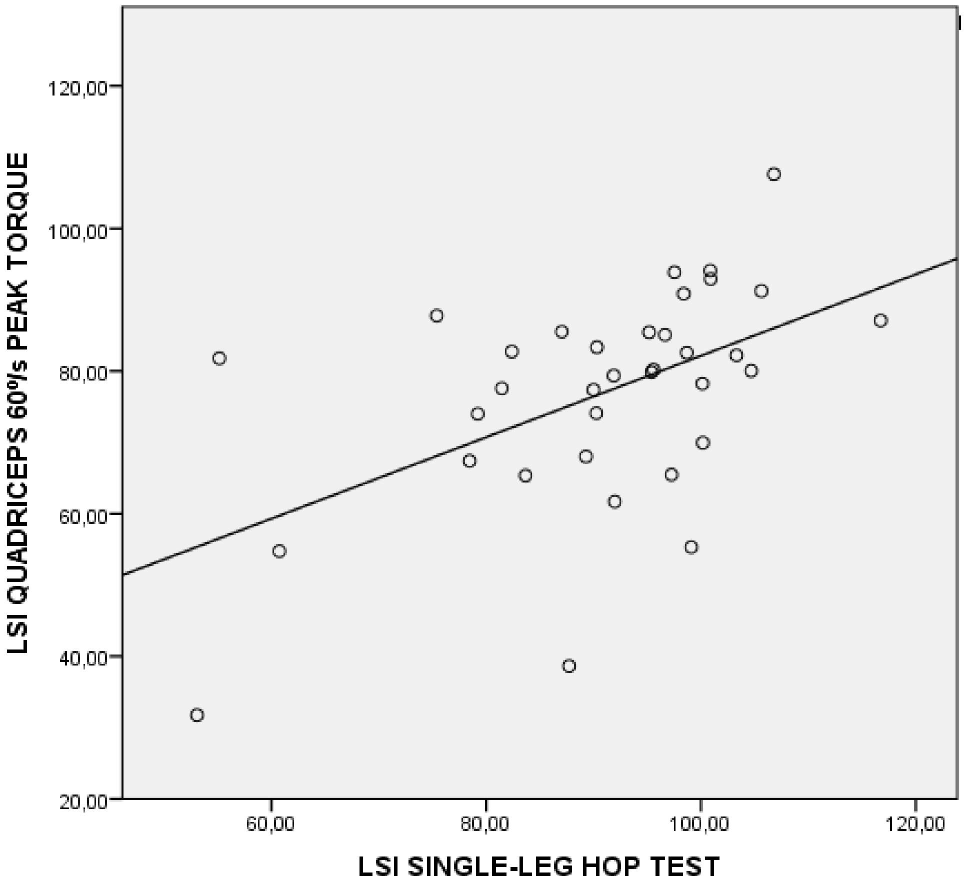

Figure 1: Correlation between the LSI of quadriceps 60º/s peak torque and single-leg hop test.

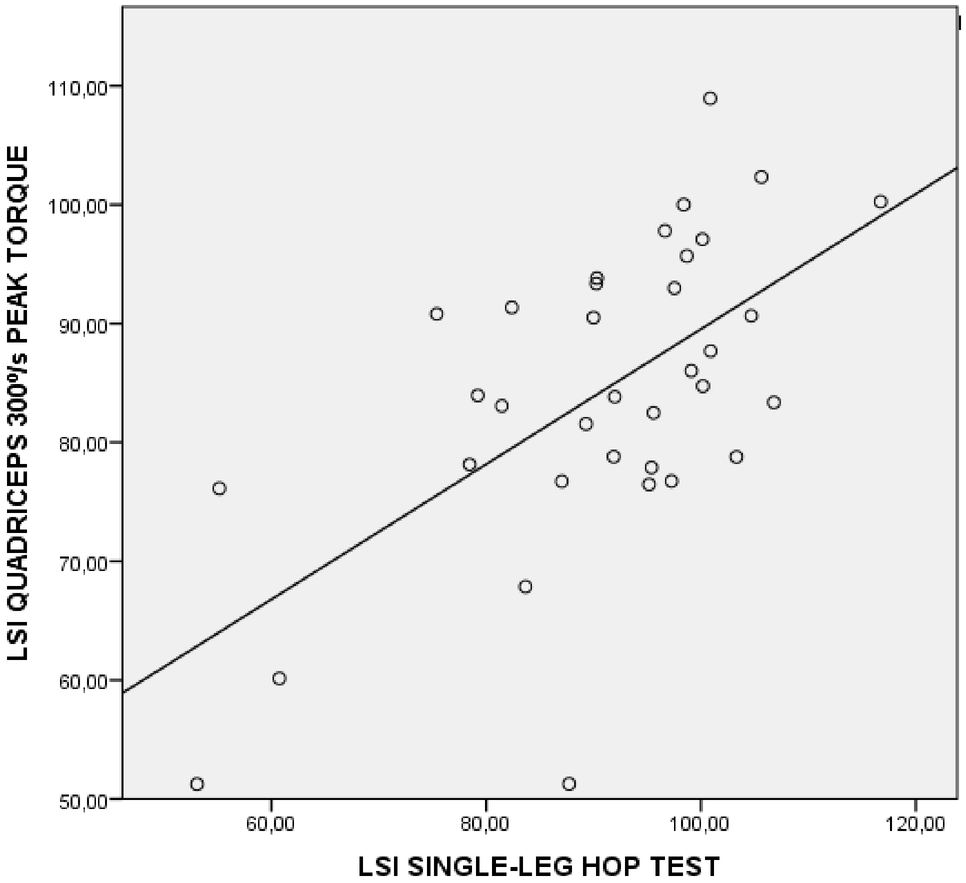

Figure 2: Correlation between the LSI of quadriceps 300º/s peak torque and single-leg hop test.

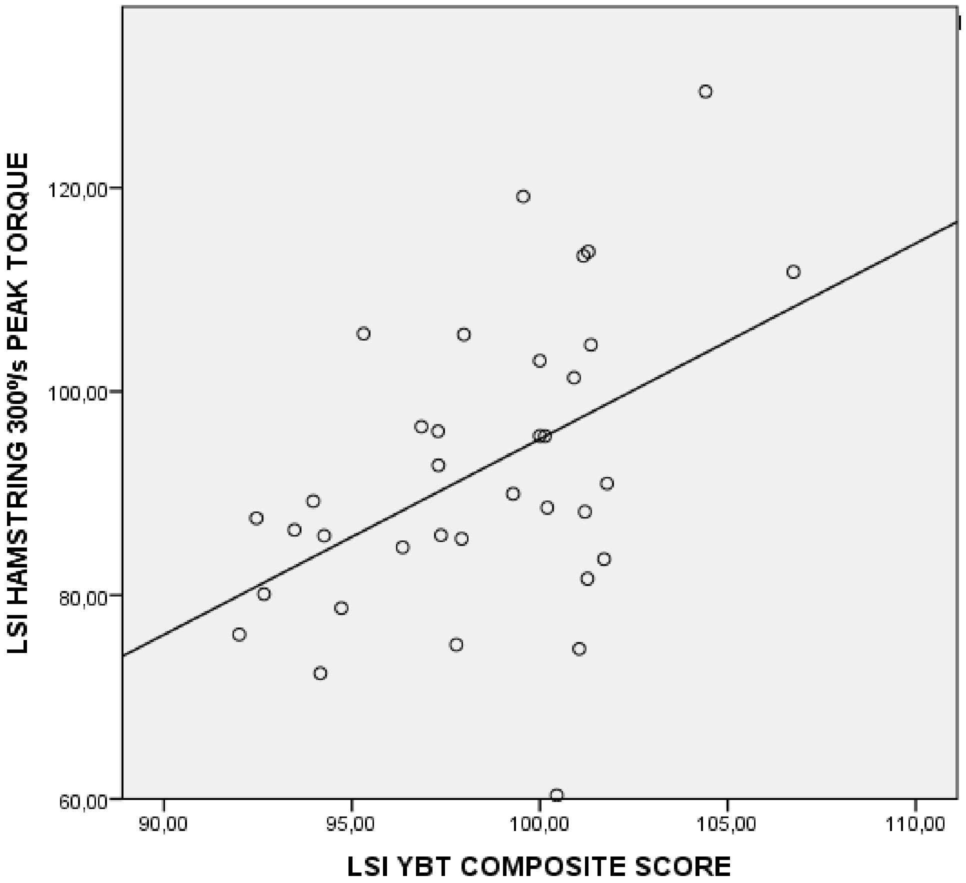

Figure 3: Correlation between the LSI of hamstring 300º/s peak torque and YBT composite score.

6 CONCLUSÃO GERAL

Os resultados no presente estudo ressaltam que pacientes após a reconstrução do LCA apresentam déficits significativos na força muscular e no controle neuromuscular no membro inferior acometido em comparação com membro inferior não acometido. Além disso, fatores psicológicos envolvendo a falta de confiança e medo de reincidência da lesão estão presentes no momento de retorno ao esporte. Portanto, intervenções adicionais para minimizar esses déficits, juntamente com acompanhamento psicológico podem ser necessárias para ajudar os pacientes no pós-operatório a alcançarem o sucesso no retorno ao esporte. Além disso, os resultados encontrados permitem afirmar que os testes funcionais apresentam associação com a força muscular de flexão e extensão do joelho. Estes são achados importantes, pois os testes funcionais apresentam baixo custo e são um método fácil de implementar na prática clínica. Entretanto, outros estudos devem ser realizados para normalizar os valores entre os testes de força e de controle neuromuscular.

ANEXO A - NORMAS DE FORMATAÇÃO DO PERIÓDICO PHYSICAL THERAPY IN SPORT

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journals http://www.icmje.org. The manuscript should contain a statement that has been approved by the appropriate ethical committees related to the institution(s) in which it was performed and that subjects gave informed consent to the work. Studies involving experiments with animals must state that their care was in accordance with institution guidelines. Patients' and volunteers' names, initials, and hospital numbers should not be used.
In a case report, the subject's written consent should be provided. It is the author's responsibility to ensure all appropriate consents have been obtained. Photographs of human participants are acceptable if the authors have received appropriate permission for publication of the photographs, or taken appropriate measures to disguise the individual's identity.

Declaration of interest

All authors must disclose any financial and personal relationships with other people or organizations that could inappropriately influence (bias) their work. Examples of potential competing interests include employment, consultancies, stock ownership, honoraria, paid expert testimony, patent applications/registrations, and grants or other funding. Authors must disclose any interests in two places: 1. A summary declaration of interest statement in the title page file (if double-blind) or the manuscript file (if single-blind). If there are no interests to declare then please state this: 'Declarations of interest: none'. This summary statement will be ultimately published if the article is accepted. 2. Detailed disclosures as part of a separate Declaration of Interest form, which forms part of the journal's official records. It is important for potential interests to be declared in both places and that the information matches. More information.

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Contributors

Those who meet some but not all of the criteria for authors can be identified as 'contributors' at the end of the manuscript with their contribution specified. All those individuals who provided help during the research (e.g., collecting data, providing language help, writing assistance or proofreading the article, etc.) that do not meet criteria for authorship should be acknowledged.

Authorship

All authors should have made substantial contributions to all of the following: (1) the conception and design of the study, or acquisition of data, or analysis and interpretation of data, (2) drafting the article or revising it critically for important intellectual content, (3) final approval of the version to be submitted.

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New guidance for randomised controlled trials

Physical Therapy in Sport has adopted the proposal from the International Committee of Medical Journal Editors (ICMJE) (see a recent Editorial in *Manual Therapy*http://www.sciencedirect.com/science/article/pii/S1356689X1200238X, Editorial: "Clinical trial registration in physiotherapy journals: Recommendations from the International Society of Physiotherapy Journal Editors"), which requires, as a condition of consideration for publication of clinical trials, registration in a public trials registry. Trials must register at or before the onset of patient enrolment. The clinical trial registration number should be included at the end of the abstract of the article. For this purpose, a clinical trial is defined as any research project that prospectively assigns human subjects to intervention or comparison groups to study the cause and effect relationship between a medical intervention and a health outcome. Studies designed for other purposes, such as to study pharmacokinetics or major toxicity (e.g. phase I trials) would be exempt. Further information can be found at http://www.icmje.org. Clinical Trials that commence after 1st June 2013 must be registered to be considered for publication in *Physical Therapy in Sport*. Authors will be asked to state the trial registration number during the submission system as well as at the end of the manuscript file. From January 2014 *Physical Therapy in Sport* will not be able to accept any unregistered Clinical Trial papers. By 2015 the journal will not be able to publish any Clinical Trials that are unregistered prior to recruitment of the first participant.

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ANEXO B - PARECER DO COMITÊ DE ÉTICA EM PESQUISA

UNIVERSIDADE FEDERAL DE CIÊNCIAS DA SAÚDE DE PORTO ALEGRE

PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: Avaliação do desempenho muscular e funcional de indivíduos submetidos a reconstrução do ligamento cruzado anterior liberados para retorno ao esporte.

Pesquisador: Marcelo Faria Silva

Área Temática:

Versão: 2

CAAE: 80287717.1.0000.5345

Instituição Proponente: Universidade Federal de Ciências da Saúde de Porto Alegre

Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 2.547.728

Apresentação do Projeto:

Avaliação do desempenho muscular e funcional de indivíduos submetidos a reconstrução do ligamento cruzado anterior liberados para retorno ao esporte.

Objetivo da Pesquisa:

O objetivo deste estudo é verificar a presença de relação entre, o desempenho muscular,representado pela força muscular com o resultado em testes funcionais em pessoas que realizaram cirurgia de reconstrução do ligamento cruzado anterior do joelho e que foram liberadas ao retorno ao esporte.

Avaliação dos Riscos e Benefícios:

Os riscos deste estudo são mínimos, podendo ocorrer algum desconforto muscular no momento das avaliações do desempenho muscular e da funcionalidade; e alguma tensão muscular após a realização dos testes. Caso o problema persista, o participante será encaminhado para atendimento com um fisioterapeuta no Laboratório de Avaliação Funcional e Nutricional da UFCSPA (Prédio 2, oitavo andar) onde serão aplicadas medidas analgésicas até controle satisfatório dos sintomas, com os custos a cargo dos pesquisadores. Um membro da equipe da pesquisa irá gerenciar a marcação desses atendimentos e acompanhará o processo até a melhora completa dos sintomas. Os benefícios que o Sr (a) terá em participar desta pesquisa é a possibilidade de avaliar

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UF: RS **Município:** PORTO ALEGRE
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o desempenho muscular, a estabilidade dinâmica e condição funcional da articulação do joelho, sendo essas avaliações importantes para os critérios de retorno ao esporte em pacientes submetidos a reconstrução do ligamento cruzado anterior.

Comentários e Considerações sobre a Pesquisa:

No exercício da minha competência considero que o pesquisador atendeu a todas as pendências tanto éticas como legais a o seu trabalho de pesquisa demonstra que a articulação do joelho possui grande importância para a funcionalidade do nosso corpo. Seu papel principal é suportar o peso do corpo e transmitir forças entre as articulações do quadril e do pé, devido ao seu posicionamento na parte intermédia do membro inferior. Desta forma o joelho está entre as articulações que mais sofre lesões, essa vulnerabilidade está relacionada as demandas mecânicas impostas a essa estrutura e pela dependência dos tecidos moles para sua estabilização.

Considerações sobre os Termos de apresentação obrigatória:

Atendeu a a Resolução número 466,de 12 de Dezembro de 2012.

Recomendações:

Todas recomendações foram atendidas.

Conclusões ou Pendências e Lista de Inadequações:

Conforme registrado na Carta Resposta todas as pendências foram atendidas.

Considerações Finais a critério do CEP:

De acordo com o parecer do Relator.

Este parecer foi elaborado baseado nos documentos abaixo relacionados:

Tipo Documento	Arquivo	Postagem	Autor	Situação
Informações Básicas do Projeto	PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_1030762.pdf	23/01/2018 00:36:31		Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	TCLE.pdf	23/01/2018 00:32:06	Marcelo Faria Silva	Aceito
Projeto Detalhado / Brochura Investigador	Projeto.docx	23/01/2018 00:06:21	Marcelo Faria Silva	Aceito
Outros	carta_resposta.pdf	23/01/2018 00:05:12	Marcelo Faria Silva	Aceito
Outros	termo_de_autorizacao_do_uso_de_imagem.pdf	23/01/2018 00:02:50	Marcelo Faria Silva	Aceito

UNIVERSIDADE FEDERAL DE CIÊNCIAS DA SAÚDE DE PORTO ALEGRE

Continuação do Parecer: 2.547.720

Outros	Iess.docx	11/01/2018 13:11:25	Marcelo Faria Silva	Aceito
Outros	Modelo_para_flyer_e_cartazes.docx	11/01/2018 12:02:27	Marcelo Faria Silva	Aceito
Outros	termo_de_compromisso.pdf	22/11/2017 16:27:54	Marcelo Faria Silva	Aceito
Outros	termo_de_anuencia_do_responsavel_pelo_setor.pdf	22/11/2017 16:26:34	Marcelo Faria Silva	Aceito
Folha de Rosto	folha_de_rosto.pdf	22/11/2017 16:25:04	Marcelo Faria Silva	Aceito

Situação do Parecer:
Aprovado

Necessita Apreciação da CONEP:
Não

PORTO ALEGRE, 16 de Março de 2018

Assinado por:
ELIANE DALLEGRAVE
(Coordenador)

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