CORRELATION BETWEEN ECCENTRIC TRAINING AND FUNCTIONAL TESTS IN SUBJECTS WITH RECONSTRUCTED ACL

CORRELAÇÃO ENTRE TREINO EXCÊNTRICO E TESTES FUNCIONAIS EM SUJEITOS COM LCA RECONSTRUÍDO

CORRELACIÓN ENTRE ENTRENAMIENTO EXCÉNTRICO Y PRUEBAS FUNCIONALES EN SUJETOS CON LCA RECONSTRUIDO

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ABSTRACT

Introduction: Eccentric training and jump tests are widely used to recover and measure deficits in knee strength and functionality after anterior cruciate ligament (ACL) reconstruction. Objective: To correlate knee extension and flexion torque generated by eccentric isokinetic training, with functional jump tests in subjects with reconstructed ACL. Method: Sixteen men with unilateral ACL reconstruction were assessed before and after 12 weeks of eccentric isokinetic training of knee flexors and extensors (3x10 MVC, 2x/week) at 30°/s for extension and flexion torque (isometric; concentric and eccentric at 30 and 120°/s) and functional jump tests (single, triple, cross and figure of 8). Inter- and intra-limb pre- and post-training mean peak torque (MPT), distance and jump test times were compared along with the correlations between these variables, considering P≤0.05. Results: The affected limb (AL) showed significant gain of extension and flexion torque (P<0.01) in the different test categories and velocities evaluated. In the non-affected limb (NAL), this only occurred in the eccentric category (30 and 120°/s), in the extension (P<0.01) and flexion (P<0.05 and P<0.01) torques, respectively. In the jumps, there was an increase in distance (single and triple; P<0.05) and a decrease in time (crossed and figure of 8; P<0.01), however, MPT x Jump correlations were weak (r<0.3) in the pre and post-training period in both limbs. Conclusion: Despite the gain in knee extension and flexion torque and jumping performance, the expected correlation was not satisfactory, suggesting that knee functionality involves other variables inherent to motor control. ***Level of Evidence IV; Type of study: Case series.***

Keywords: Muscle strength; Performance tests; Rehabilitation.

RESUMO

Introdução: O treino excêntrico e testes de saltos são muito utilizados para recuperar e aferir déficits de força e funcionalidade do joelho, após reconstrução do ligamento cruzado anterior (LCA). Objetivo: Correlacionar o torque extensor e flexor do joelho, gerados pelo treino isocinético excêntrico, com testes funcionais de saltos em sujeitos com LCA reconstruído. Método: Foram avaliados 16 homens, com reconstrução unilateral do LCA, antes e depois de 12 semanas de treino isocinético excêntrico de extensores e flexores do joelho (3 x 10 CEVM, 2x/semana) a 30º/s, quanto ao torque extensor e flexor (isométrico; concêntrico e excêntrico a 30º/s e 120º/s) e aos testes funcionais de saltos (simples, triplo, cruzado e figura em 8). As médias dos picos de torque (MPT), a distância e os tempos dos testes de salto inter e intramembros, pré e pós-treino foram comparados, além das correlações entre essas variáveis, considerando P≤ 0,05. Resultados: O membro acometido (MA) mostrou ganho significativo de torque extensor e flexor (P< 0,01) nos modos e velocidades avaliados. No membro não acometido (MNA), isso ocorreu apenas para o modo excêntrico (30º/s e 120º/s), do torque extensor (P< 0,01) e flexor (P< 0,05 e P<0,01), respectivamente. Nos saltos, houve aumento da distância (simples e triplo; P< 0,05) e diminuição do tempo (cruzado e figura em 8; P< 0,01), porém, as correlações entre MPT e saltos mostraram-se fracas nos dois membros (r< 0,3) antes e depois do treino. Conclusão: Apesar do ganho no torque extensor e flexor do joelho e no rendimento dos saltos, a correlação esperada não foi satisfatória, sugerindo que a funcionalidade do joelho envolve outras variáveis inerentes ao controle motor. ***Nível de evidência IV; Tipo de estudo: Série de casos.***

Descritores: *Força muscular; Provas de rendimento; Reabilitação.*

RESUMEN

Introducción: El entrenamiento excéntrico y las pruebas de saltos son muy utilizados para recuperar y medir los déficits de fuerza y funcionalidad de la rodilla, después de la reconstrucción del ligamento cruzado anterior (LCA). Objetivo: Correlacionar el torque extensor y flexor de la rodilla, generados por el entrenamiento isocinético excéntrico, con pruebas funcionales de saltos en sujetos con LCA reconstruido. Método: Fueron evaluados 16 hombres, con reconstrucción unilateral del LCA, antes y después de 12 semanas de entrenamiento isocinético excéntrico de extensores y flexores de la rodilla (3x10 CEVM, 2x/semana) a 30º/s, cuanto al torque extensor y flexor (isométrico, concéntrico y excéntrico a 30 y 120º/s) y a las pruebas funcionales de saltos (simple, triple, cruzado y figura en 8). Se compararon promedios de los picos de torque (MPT), distancia y tiempos de las pruebas de salto, inter e intra-miembros, pre y *post-entrenamiento, además de las correlaciones entre estas variables, considerando P≤0,05. Resultados: El miembro acometido (MA) mostró aumento significativo del torque extensor y flexor (P<0,01) en los modos y velocidades evaluados. En el miembro no acometido (MNA), eso ocurrió sólo para el modo excéntrico (30 y 120º/s), del torque extensor (P<0,01) y flexor (P<0,05 y P<0,01), respectivamente. En los saltos, hubo aumento en la distancia (simple y triple; P<0,05) y disminución del tiempo (cruzado y figura en 8; P<0,01), sin embargo, las correlaciones MPT x saltos se mostraron débiles (r<0,3) en el pre y post-entrenamiento, en los dos miembros. Conclusión: A pesar del aumento en el torque extensor y flexor de la rodilla y en el rendimiento de los saltos, la correlación esperada no fue satisfactoria, sugiriendo que la funcionalidad de la rodilla involucra otras variables inherentes al control motor.* ***Nivel de evidencia IV; Tipo de estudio: Serie de casos***

Descriptores: *Fuerza muscular; Pruebas de rendimiento; Rehabilitación.*

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INTRODUCTION

Both ACL injury and reconstruction promote decreased trophism and strength of the knee extensor apparatus[1], which may remain for to up seven years[2]. Eccentric training can trigger key morphological changes in thigh muscles during post-surgical ACL rehabilitation[3].

Recently, in addition to isokinetic tests used to evaluate the knee joint torque, hop tests are considered good indicators of the combined knee joint and lower limb function because acceleration, deceleration and thrust movements are performed in sports[3-8].

Although hop tests provide safety and efficiency parameters[8] and are considered fairly reliable (>80%) and sensitive (>82%), their correlation with knee extensor and flexor torque is still controversial[9,10]. This study aimed to correlate possible gains in knee extensor and flexor torque generated by eccentric isokinetic training with some types of long jumps in subjects with reconstructed ACLs, given the hypothesis that knee extensor and flexor strengthening should improve the performance of functional hop tests.

METHOD

Sample

Of the 54 eligible subjects in this study, 40 were evaluated for compliance with the following inclusion criteria: 20 to 50 years; BMI≤28 kg/m²; unilateral ACL reconstruction; patellar tendon graft; two and five years post-reconstruction; post-operative rehabilitation ≥ six months; without knee pain or edema; having resumed the practice of sports; and availability to participate in the study.

After conducting the initial evaluations (dynamometry and functional hop tests) and training protocol, so 16 subjects (30.6±9.3 years; 78.1±12.1 kg; 1.75±0.1 m; BMI=25.5±3.0 kg/m²; injury time=50.4±34.9 months; surgery time=27.0±23.7 months) completed the study.

Sample size was determined by software G* Power 3.1.0 adopting a power of 0.8, considering 5% level of significance, 0.5 coefficient of correlation, and a 0.5 size effect, based on a pilot study[11] and 16 subjects was computed with size sufficed to provide 81.7% statistical power. (Figure 1)

The study was approved by the Research Ethics Committee of the Federal University of São Carlos (REC/UFSCar Opinion nº. 350/2006), and all subjects freely signed an Informed Consent Form, according to Resolution 196/96 of the National Health Council.

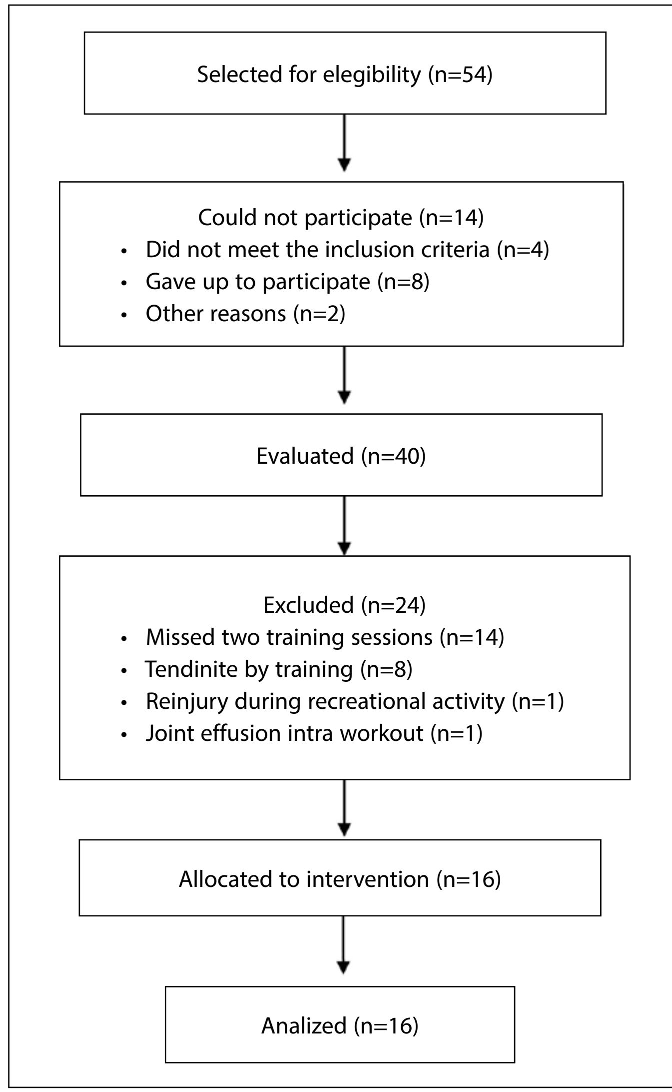

Figure 1. Sample flowchart.

Dynamometry

Knee extensor and flexor torque were evaluated using an isokinetic dynamometer (Biodex Multi-Joint System 3, Shirley, NY-USA) 72 hours pre- and post-isokinetic training, and all subjects were evaluated by the same examiner, always starting with the non-affected limb (NAL) followed by the affected limb (AL)[3]: 1) isometric; 2) concentric; and 3) eccentric test at 30 and 120°/s.

After five minutes of warm-up on an bicycle at 20 km/h (75 W)[6] and then, the subjects sat on the isokinetic dynamometer with trunk and knees flexed at 85 and 90°, respectively, with the trunk, pelvis and distal aspect of the thigh stabilized by straps.

The test consisted of three maximal voluntary isometric contractions (MVIC) of five seconds, with one minute interval between them[6] at 60° for extensors and 30° for flexors. Concentric and eccentric tests (30°/s and 120°/s) consisted of five consecutive maximal voluntary contractions (MVC), with three minutes rest between tests and calculated the MPT in each test[6].

Functional tests

A total of 72 hours after the isokinetic evaluations (pre- and post-training), the subjects performed five minutes warm-up, running at low speed followed by four hop tests: single/SH, triple/TH), crossover/CH and Figure-8 hops/F8H.

In the SH and TH (Figures 2.1; 2.2), the distance covered using the same foot was measured from the starting to the landing point (heel)[3]. In the CH, the subjects hopped over six meters x 15 cm straight line from one side to the other (Figure 2.3), using the same foot[12]. In the F8H, there were two rows of three cones each, with one meter between the cones and five meters between the rows (Figure 2.4) and they completed a circuit hopping around both rows, in the shape of the number eight[4]. The time spent (in seconds) to complete the whole circuit was clocked in both the CH and F8H[3].

The horizontal thrust tests were performed in the same order (SH, TH, CH and F8H) and starting with the NAL, similarly to the torque evaluations[12], pre- and post-training.

Isokinetic training

After warm-up, the subjects completed an eccentric isokinetic training program, exclusively using the AL, at 30°/s (3x10 MVEC; interval between sets: three minutes; interval between sessions: 48 hours; frequency: 2x/week; duration: 12 weeks) for knee flexors and extensors[3]. Only, the subjects performed normal ADLs, including their recreational activities. The same physiotherapist guided the training to maintain a uniform exposure to verbal commands during the 24 sessions.

Data analysis

Statistical procedures were performed in the SPSS (20.0) using the Shapiro-Wilk, Student's t (paired and independent) and Pearson's correlation test. The following data were compared: 1) MPT; 2) time and hop distance means between the AL and NAL; and 3) MPT versus hop tests correlations for each limb in the pre- and post-training. The classification adopted for the correlation analysis was according Albuquerque et al.[13], considering a 5% significance level for all comparisons.

RESULTS

Isokinetic dynamometry

In the pre-training evaluation, the inter-limb comparison of knee extensor MPT showed a deficit in the AL in the: isometric (14%; $P<0.01$), concentric at 30°/s (19%; $P<0.01$), and 120°/s (14%; $P<0.05$) and eccentric at 30°/s (10%; $P<0.01$).

In the post-training, except in the eccentric mode at 30°/s ($P=0.42$), deficits were still observed (isometric=9%, $P<0.05$; concentric at 30°/s=11%, $P<0.01$; concentric at 120°/s=13%, $P<0.01$; and eccentric at 120°/s=15%, $P<0.01$). The knee flexors showed a 14% and 10% increase in the AL compared with the NAL in the eccentric mode at 30 and 120°/s ($P<0.01$), respectively.

There was 9% gain in the isometric ($P<0.05$) and concentric modes at 30°/s ($P<0.01$); 7% in the concentric at 120°/s ($P<0.05$) and 19% in the eccentric mode at 30°/s ($P<0.01$) of the AL, and 13% and 19% in the eccentric mode at 30 and 120°/s ($P<0.01$), respectively, of the NAL, when comparing the pre- and post-training (intra-limb) knee extensor MPT.

Gains also occurred in the: isometric mode (11%; $P<0.01$), concentric mode at 30°/s (10%; $P<0.01$), eccentric mode at 30°/s (24%; $P<0.01$) and at 120°/s (19%; $P<0.01$) of the AL. There were 9% and 11% gains in the eccentric mode at 30°/s ($P<0.05$) and 120°/s ($P<0.01$), respectively, of the NAL in the knee flexors.

Comparing the MPT of NAL extensors pre- *versus* the AL post-training, an 11% deficit ($P<0.05$) occurred in the concentric mode at 30°/s, and a 10% increase ($P<0.01$) in the eccentric mode at 30°/s (Table 1).

A widespread and significant increase (isometric: 7%, $P<0.05$; concentric at 120°/s: 9%, $P<0.05$; eccentric at 30°/s: 21%, $P<0.01$; and eccentric at 120°/s: 20%, $P<0.01$) of the knee flexors occurred when comparing with the extensors, which surpassed the pre-training values of the NAL.

Functional tests

Three hop tests (SH, TH and F8H) showed a significant increase ($P<0.01$, $P<0.01$ and $P<0.05$, respectively) in the pre-training period (Table 2), whereas only the SH and TH showed improved performance ($P<0.01$) in the post-training, in the inter-limb comparison.

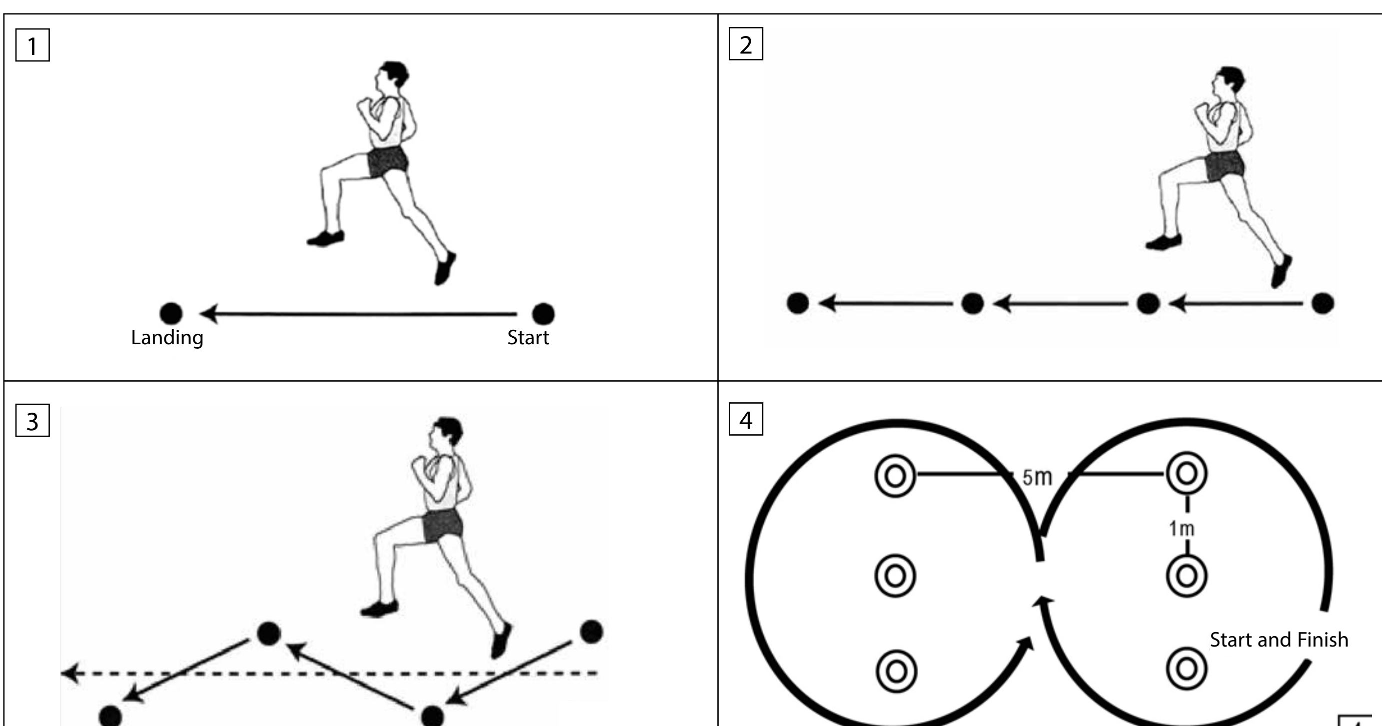

Figure 2. Functional tests: single hop (1); triple hop (2); crossover hop (3); figure-8 hop (4).

Table 1. Comparisons of PTA (Nm) between the AL_Post and NAL Pre- training of the extensors and flexors knee.

Contractions Modes	MPT of the Extensors				MPT of the Flexors			
	AL_Pre	NAL_Post	Dif.(%)	P Valor	AL_Pre	NAL_Post	Diff.(%)	P Valor
Isometric	268.4±66.2	253.4±52.0	6%	0.21	146.2±31.1	157.4±30.3	7%	<0.05
Con_30º/s	238.4±48.7	212.2±46.7	11%	<0.05	128.3±25.1	134.2±23.7	4%	0.25
Con_120º/s	173.4±44.2	161.3±30.5	7%	0.23	101.6±20.7	111.4±21.6	9%	<0.05
Ecc_30º/s	281.9±74.2	313.4±58.0	10%	<0.05	137.9±32.7	175.9±34.8	21%	<0.01
Ecc_120º/s	253.2±93.3	263.4±59.4	4%	0.55	138.6±30.3	172.8±30.4	20%	<0.01

PTA = Peak torque average; Nm = Newton.metro; Con = concentric; Ecc = eccentric; AL = affected limb; NAL = non affected limb; MPT = mean peak torque; Diff = difference. t Student (independent) test.

Table 2. Comparison of the averages of functional tests pre and post-isokinetic eccentric training of the extensors and flexors knee.

Hop kinds	Pre-training			Post-training		
	AL	NAL	P Valor	AL	NAL	P Valor
Single hop (m)	1.71±0.29	1.90±0.20	<0.01‡	1.84±0.21	1.98±0.19	<0.01‡
Triple hop (m)	5.36±0.81	5.83±0.63	<0.01‡	5.63±0.68	5.97±0.63	<0.01‡
Crossover hop (s)	2.61±0.59	2.44±0.48	0.06‡	2.21±0.37	2.16±0.27	0.23‡
Figure-8 hop (s)	7.49±0.73	7.16±0.50	<0.05‡	6.85±0.56	6.76±0.48	0.13‡
	AL			NAL		
	Pre-training	Post-training	P Valor	Pre-training	Post-training	P Valor
Single hop (m)	1.71±0.29	1.84±0.21	<0.05†	1.90±0.20	1.98±0.19	0.06†
Triple hop (m)	5.36±0.81	5.63±0.68	<0.05†	5.83±0.63	5.97±0.63	0.13†
Crossover hop (s)	2.61±0.59	2.21±0.37	<0.01†	2.44±0.48	2.16±0.27	<0.05†
Figure-8 hop (s)	7.49±0.73	6.85±0.56	<0.01†	7.16±0.50	6.76±0.48	<0.01†

m = meter; s = second. t Student independent (‡) and paired (†) tests.

Also showed a significant increase in performance in all tests conducted (SH and TH: P<0.05; CH and F8H: P<0.01) in the AL and in the CH (P<0.05) and F8H (P<0.01) in the NAL, when comparing the pre- and post-training (intra-limb) means.

A significant improvement in CH and F8H performance occurred in the AL (P<0.05) when comparing the pre-training NAL versus post--training AL values.

The correlations (MPT *versus* functional tests) regarding the knee extensors and flexors were mostly weak (r<0.3) in the pre- and post-training, in the AL and NAL. However, the correlations for the knee extensors were moderate (0.31<r<0.6) and strong (0.61<r<0.9) in the: SH (pre- and post-training), in the AL and NAL; TH (all pre-training comparisons, some post-training AL comparisons and in the concentric mode at 120°/s in the pre-training NAL); CH (concentric and eccentric modes at 30°/s in the post-training AL, in the concentric mode at 30°/s and in the eccentric mode at 30 and 120°/s the pre-training) in NAL; and F8H (concentric and eccentric modes at 30 and 120°/s) in the AL .

The correlations regarding the knee flexors were moderate (0.31<r<0.6) in the SH: concentric at 120°/s, pre-training; concentric at 30°/s and 120°/s and eccentric at 120°/s, in the post-training AL and eccentric at 30 and 120°/s in the pre-training NAL; TH: isometric and eccentric at 30°/s, pre-training; concentric at 30 and 120°/s in the post-training AL and in the concentric and eccentric at 30 and 120°/s in the pre-training AL; and F8H: eccentric at 120°/s pre-training, in the concentric at 30 and 120°/s in the post-training AL and in the isometric and concentric at 30°/s and eccentric at 30 and 120°/s in the post-training NAL (Table 3).

DISCUSSION

Eccentric Isokinetic Training

The deficit in pre-training AL extensor torque shown in all tested modes and speeds may be attributed to two factors: 1) decline in gamma motor neuron activation, resulting in efferent *Ia* attenuation, leading to quadriceps weakness and dyskinesia, after ACL rupture[14]; and 2) predominant quadriceps atrophy after ACL reconstruction[15], which persists for years, with a 10 to 20% loss of strength, despite the efforts focused on rehabilitation[14,16].

These results corroborate Keays et al.[17] because they also found differences (28 and 22%) when comparing the knee extensor torque inter-members, 6 months after ACL reconstruction, at 60 and 120°/s, respectively. The extensor torque deficit in the AL was expected because the tested sample consisted of subjects with chronic injuries (50.4 ± 34.9 months), and the longer the injury time is, the greater the impairment will be[18].

The most significant post-training gains, in both extensor and flexor torque, reached in training mode and speed (Ecc_30°/s), demonstrate the principle of specificity introduced by Santos et al.[3] and Santos et al.[6] when testing resistance training programs at various modes and speeds. Furthermore, the fact that flexor post-training AL values mostly surpassed the pre-training NAL values was expected because no difference was found when comparing pre-training inter-limbs. However, the increase in flexor torque (Ecc_30 and 120°/s) in NAL may be explained by the crossover education effect[19,20]. Unilateral resistance training may activate neural circuits

Table 3. Correlations between PTA and hops (single, triple, crossover and figure-8) in the AL and NAL, pre- and post-isokinetic eccentric training of the extensors and flexors knee.

PTA Extensors X Hop tests	Limbs				PTA Flexors X Hop tests	Limbs			
	AL		NLA			AL		NLA	
	Pre	Post	Pre	Post		Pre	Post	Pre	Post
Isom X SH	0.47	0.47	0.36	0.25	Isom X SH	0.27	0.26	0.21	0.11
Con 30º/s X SH	0.57	0.58	0.30	0.31	Con 30º/s X SH	0.19	0.39	0.13	0.13
Con 120º/s X SH	0.66	0.63	0.17	0.42	Con 120º/s X SH	0.41	0.51	0.21	0.27
Ecc 30º/s X SH	0.40	0.29	0.32	0.36	Ecc 30º/s X SH	0.27	0.29	0.41	0.27
Ecc 120º/s X SH	0.59	0.52	0.48	0.31	Ecc 120º/s X SH	0.23	0.38	0.48	0.15
Isom X TH	0.42	0.28	0.27	0.09	Isom X TH	0.34	0.22	0.30	0.09
Con 30º/s X TH	0.45	0.40	0.27	0.17	Con 30º/s X TH	0.28	0.40	0.31	0.08
Con 120º/s X TH	0.51	0.42	0.33	0.27	Con 120º/s X TH	0.24	0.54	0.33	0.21
Ecc 30º/s X TH	0.40	0.08	0.22	0.23	Ecc 30º/s X TH	0.39	0.25	0.37	0.20
Ecc 120º/s X TH	0.40	0.39	0.29	0.19	Ecc 120º/s X TH	0.29	0.31	0.37	0.05
Isom X CH	-0.06	0.20	0.05	0.14	Isom X CH	0.07	-0.15	-0.28	0.01
Con 30º/s_CH	-0.03	0.32	0.31	0.13	Con 30º/s_CH	0.26	0.03	-0.07	0.11
Con 120º/s_CH	-0.20	0.14	0.26	0.06	Con 120º/s_CH	-0.02	0.08	0.14	-0.01
Exc 30º/s_CH	0.18	0.38	0.48	0.09	Exc 30º/s_CH	-0.12	0.26	-0.19	0.06
Exc 120º/s_CH	0.07	0.30	0.47	0.16	Exc 120º/s_CH	0.07	-0.01	0.21	0.07
Isom X F8H	-0.27	0.14	-0.19	-0.02	Isom X F8H	-0.18	-0.18	-0.46	-0.09
Con 30º/s X F8H	-0.39	0.02	-0.29	-0.13	Con 30º/s X F8H	-0.28	-0.35	-0.42	-0.10
Con 120º/s X F8H	-0.35	-0.07	-0.21	-0.16	Con 120º/s X F8H	-0.03	-0.41	-0.28	-0.13
Ecc 30º/s X F8H	-0.47	0.23	-0.21	-0.12	Ecc 30º/s X F8H	-0.40	-0.11	-0.56	-0.18
Ecc 120º/s X F8H	-0.34	-0.11	-0.14	-0.11	Ecc 120º/s X F8H	-0.21	-0.18	-0.35	-0.05

PTA = peak torque average; Con = concentric; Ecc = eccentric; AL = affected limb; NAL = non affected limb; SH = single hop; TH = triple hop; CH = crossover hop; F8H = figure-8 hop. values of correlation tests (r).

with consequent increase the neural drive (cortico-spinal projections) of untrained muscles and resulting in strength gain, onto the opposite limb.

In general, the training program had the desired effect, since, except in the extension torque Con_30º/s, conversely, the torques were statistically equivalent and even surpassed (Ecc_30º/s) the pre-training NAL values in the other tested modes and speeds.

Corroborating the study of Tomiya et al.[21], the current results show that the eccentric resistance training is more efficient in the torque gain than isometric or concentric resistance training at the respective tested speeds (30°/s and 120°/s).

Gerber et al.[22], also observed that the extensor PT in the AL of the eccentric exercise group was higher than in the standard rehabilitation group, after ACL reconstruction.

Functional tests

Before training, the AL *versus* NAL comparison showed deficits regarding three of the hops tested (SH, TH, F8H) in the AL. In the post-training period, deficits regarding the NAL remained, despite the increase in SH and TH values. The comparison between pre- and post-training values in the AL showed an increase in SH and TH (> distance) and CH and F8H (< runtime) performance. The decreased CH and F8H runtime with the NAL may be attributed to the crossed education effect during isokinetic training because the NAL was not trained[20,21], which was expressed in the functional tests. Lastly, the comparison between the means of functional tests and pre-training NAL versus post-training AL conditions suggests that the Ecc_30º training improved the performance in the functional tests because it matched the distance reached in the SH and TH and decreased the CH and F8H runtimes.

Gerber et al.[22], comparing two protocols of post-ACL reconstruction, observed interaction between extensor PT and SH of the AL showing that eccentric training directly affected the performance in the functional hop test, corroborating, in part, our results.

Santos et al.[3], also observed a weak correlation ($r<0.5$) between PT and SH and a moderate correlation ($0.51 \leq r \leq 0.75$) between PT and TH for both knee flexors and extensors, when analyzing 20 young and healthy subjects who underwent 6 weeks of eccentric isokinetic training at 30°/s, especially when performing the test in the same training mode (eccentric) and at a speed similar to that of the task (120°/s).

Conversely, Vasconcelos et al.[12] founded strong correlations ($-0.78 \leq r \leq -0.90$) with extensor PT, despite having observed weak correlations between knee flexor PT (concentric at 60 and 180°/s) and SH and CH hop distances, among post-ACL reconstruction subjects using semitendinosus and gracilis graft (ST+Gr). However, these correlations were negative, indicating that these variables moved in opposite directions.

According to several studies[23-26], hop distance (SH, TH and CH) is the most commonly used test to assess functional parameters of return to sports because it measures lower limb power[3] and expresses the effect of the integrity of neuromuscular control, strength generation capacity and confidence in the limb[27]. However, the evidence is still conflicting on which muscle group is more involved in knee functional activities. It is noteworthy that these correlations were classified from weak to strong (from r=0.25 to r=0.62) for both flexors and extensors in the present study.

Jang et al.[5] reported that isokinetic strength tests fail to quantify knee functionality because they are an open kinetic chain exercise and therefore do not faithfully reproduce the functional range of motion of the joint. This assertion may partly explain the weak and moderate correlations between isokinetic PT and functional tests found in the present study.

On the other hand, Kollock et al.[28], analyzing 62 recreational athletes of both sexes, concluded that hop tests alone did not provide enough information to make evidence-based decisions about lower extremity strength inisolated muscle groups.

Indeed, the success of ACL reconstruction may be explained mainly by a good joint functionality. This is supported by studies reporting poor functional results, despite satisfactory joint mechanics and vice-versa, according to Anders et al.[29]. Furthermore, Feller and Webster[30] reported that not only surgical and rehabilitation details but also age and injury and surgery times are involved in knee function, vice-versa to return to sports activities.

Most studies addressing the correlation of PT with functional tests exclusively assess SH, complicating the discussion of data. Although they were recorded by the same examiner, the manual timing of CH and F8H tests recorded, may have affected the results for being an examiner-dependent measure.

CONCLUSION

Although the training program proved effective in knee torque gain and functional hop tests, the expected correlation between these variables was not found. Nevertheless, functional tests are still considered a parameter required to resume the practice of competitive sports.

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