FUNCTIONAL TESTS AND ISOKINETIC KNEE ASSESSMENT IN STREET RUNNER ATHLETES CORRELATION

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CORRELAÇÃO ENTRE TESTES FUNCIONAIS E AVALIAÇÃO ISOCINÉTICA DO JOELHO EM ATLETAS CORREDORES DE RUA

CORRELACIÓN ENTRE PRUEBAS FUNCIONALES Y EVALUACIÓN ISOKINÉTICA DE RODILLA EN PRACTICANTES DE CARRERA DE CALLE

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ABSTRACT

Introduction: The assessment of biomechanical changes related to the lower limbs is necessary in clinical practice to measure the potential risks of injury and the influences on existing dysfunction. Biomechanical changes related to previous ankle injuries are known to influence the performance of the entire lower limb. Objective: The aim of this study was to correlate muscle strength tests, performance tests and ankle stability with the Single Hop Test (SHT). Methods: 82 amateur runners were evaluated with isokinetic tests of quadriceps and hamstring muscle strength, as well as Y Balance Test (YBT), Weight-bearing Lung Test (WBLT), and the SHT. Results: The results showed there was a significant correlation between the SHT and the YBT in subjects with hamstring/quadriceps ratio (I/Q ratio) <0.55, and the length of the unilateral SHT with the peak torque of ipsilateral knee extensors. Conclusion: The study was successful in correlating the functional tests in question with the results obtained in isokinetic dynamometry. ***Level of Evidence V; Cross-Sectional Study.***

Keywords: Muscle Strength; Postural Balance; Ankle; Biomechanical Phenomena; Musculoskeletal Injuries; Movement Capture, Biomechanical.

RESUMO

Introdução: A avaliação de alterações biomecânicas relacionadas aos membros inferiores é necessária na prática clínica para mensurar os riscos potenciais de alguma lesão e as influencias sobre uma disfunção existente. As alterações biomecânicas relacionadas a lesões prévias de tornozelo são conhecidas pela influência na performance de todo o membro inferior. Objetivo: Correlacionar testes de força muscular, testes de performance e estabilidade do tornozelo com o teste de salto simples (Single Hop Test - SHT). Métodos: Foram avaliados 82 corredores amadores com testes isocinéticos de força muscular de quadríceps e isquiotibiais, além de testes Y Balance Test (YBT), Weight-bearing Lung Test (WBLT), e o SHT. Resultados: Os resultados demonstraram haver correlação significativa entre o SHT e o YBT nos indivíduos com relação Isquiotibiais/Quadríceps (relação I/Q) <0,55, e o comprimento do SHT unilateral com o pico de torque de extensores de joelho ipsilateral. Conclusão: O estudo foi bem sucedido em correlacionar os testes funcionais em questão com os resultados obtidos na dinamometria isocinética. ***Nível de Evidência V; Estudo Transversal.***

Descritores: *Força Muscular; Equilíbrio Postural; Tornozelo; Fenômenos Biomecânicos; Lesões Musculoesqueléticas; Captura de Movimento Biomecânico.*

RESUMEN

Introducción: La evaluación de los cambios biomecánicos relacionados con las extremidades inferiores es necesaria en la práctica clínica para medir los riesgos potenciales de lesión y las influencias sobre la disfunción existente. Se sabe que los cambios biomecánicos relacionados con lesiones previas de tobillo influyen en el rendimiento de toda la extremidad inferior. Objetivo: Correlacionar las pruebas de fuerza muscular, las pruebas de rendimiento y la estabilidad del tobillo con la prueba de salto simple (Single Hop Test, SHT). Métodos: Se evaluó a 82 corredores aficionados con pruebas isocinéticas de fuerza muscular de cuádriceps e isquiotibiales, además de pruebas como Y Balance Test (YBT), Weight-bearing Lung Test (WBLT) y la prueba SHT. Resultados: Los resultados mostraron que existía una correlación significativa entre el SHT y el YBT en sujetos con ratio isquiotibiales/cuádriceps (ratio I/Q) <0,55, y la longitud del SHT unilateral con el par máximo de los extensores de la rodilla ipsilateral. Conclusión: El estudio logró correlacionar las pruebas funcionales en cuestión con los resultados obtenidos en la dinamometría isocinética. ***Nivel de Evidencia V; Estudio Transversal.***

Descriptores: *Fuerza Muscular; Equilibrio Postural; Tobillo; Fenómenos Biomecánicos; Lesiones Musculoesqueléticas; Captura de Movimiento Biomecánico.*

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INTRODUCTION

The biomechanical alterations of movement are known to predict musculoskeletal injuries, especially in athletes, since in these people the locomotor system is subjected to situations of greater effort and physiological limits. Among the multiple factors related to changes in the movement pattern of the lower limbs, the ankle performance be easily evaluated, thus fitting among modifiable factors by means of training interventions.[1] The sprain is the most prevalent type of ankle injury and is highly incident among specific sports modalities.[2] When neglected or poorly rehabilitated, they may lead to strength, proprioceptive and neuromuscular deficits,[3] resulting in an 80% chance of recurrence of the sprain or progression to chronic instability in as much as 72% of individuals.[4] Y-Balance Test (YBT) scores statistically correlate with the incidence of ankle sprains.[5,6]

Functional tests are clinical tools widely used in assessment of lower limb function, providing qualitative and quantitative data on proprioception, strength, range of motion and balance,[7] in addition to postural control, dynamic stability and flexibility of body segments.[8] Many of the injuries experienced by physical activity practitioners, especially runners, have a possibly multifactorial etiology associated with biomechanical factors[9] among which we can mention structural alterations, joint range of motion limitations, kinematic alterations such as increased internal rotation of the knee, adduction of the hip, increased pronation of the foot,[10,11] imbalances and muscle strength deficits related to the quadriceps, hamstrings or stabilizing muscles of the pelvis.[12]

Isokinetic dynamometry is the gold standard for the evaluation of the strength of the lower limbs and can be used to record specific strength deficits, or to measure the results of interventions.[13] Strength training improves runner's performance, in either short or long distances being evidenced as it has been evidenced in individuals who performed resistance training associated with endurance training for distances between 1500m and 10,000m.[14] This is due to adaptive mechanisms generated by resistance muscle training, through greater synchronization and recruitment of the motor unit, increasing the capacity to produce strength. Furthermore, the greater recruitment of type 1 fibers reduces fatigue and increases the reactive capacity against the ground.[15,16]

The Weight-bearing Lung Test (WBLT) and the YBT are quick and accessible assessment tools used to quantify ankle performance and stability, respectively, showing good reproducibility and test-retest reliability.[17] The low performance in the WBLT is related to biomechanical changes in the entire lower limb, which may occur due to the decrease in extensibility of the gastrocnemius/soleus muscles and restriction of posterior sliding of the talus over the tibia.[18] One can add previous ankle injuries which, as a protective mechanism, reduce the range of motion by decreasing the posterior sliding of the talus.[19,20]

Despite changes in ankle biomechanics showing evidence of biomechanical changes in the entire lower limb, the literature does not correlate the results of quadriceps and hamstring muscle strength, WBLT and YBT with the Single Hop Test (SHT). In view of these facts, it is necessary to understand how relevant the evaluation of biomechanical tests correlate with isokinetic strength, performance and stability of the ankle. The hypothesis associated with this study is that lower ankle stability, observed in the YBT, combined with poor performance in the WBLT, would decrease the jumping capacity observed in the SHT, as a protective mechanism to prevent ankle sprains.

OBJECTIVES

The objective of this study is to correlate ankle performance tests with strength and stability of the ankle to the SHT.

METHODS

Ethical aspects

This project was submitted to the Research Ethics Committee of the Hospital das Clínicas da Faculdade de Medicina de Ribeirão Preto, at the University of São Paulo and the participants registered their agreement with the study by signing the informed consent form.

Participants

The study included adults aged at least 18 years, recreational or competitive runners, non-professionals, who had been running for at least six months, a minimum of 10 kilometers per week. Those with musculoskeletal disorders at the time of assessment, such as muscle and ligament injuries, soft tissue injuries, edema, musculoskeletal pain in the lower limbs, joint instability, recent postoperative period and uncontrolled cardiovascular conditions, were excluded. Recruitment first took place in the city of Ribeirão Preto, through contacts with running groups and sports advisory services.

Procedures

All participants underwent a careful physical assessment in which pain levels, range of motion of the joints involved, muscle and joint perimetries were evaluated. In order to carry out the tests in the gait laboratory, anthropometric data of the volunteers were measured (weight, height, length of lower limbs and distance between anterior superior iliac spines).

Single Hop Tests

The single long jump test (Single Hop Test – figure 1) started from the static position, the individual performs a jump in the anterior direction with the right foot, aiming at the greatest horizontal distance. The test was repeated 3 times for each limb, 30 seconds apart, and valid attempts were only considered when the landing was stable.

Tests were also performed to verify ankle stability and performance (Y-Balance Test (YBT)) and Weight-bearing Lung Test (WBLT)), shown in Figures 2 and 3.[5] The YBT is a battery of maximal reach tests of the lower extremities while the contralateral limb attempts to maintain single-leg balance. In this test, the distance achieved serves as a performance measure. Shorter distances are associated with mechanical restriction or sensorimotor system deficit. Like the WBLT, it is also used to assess performance and joint restrictions related to muscle shortening.[5]

Strength evaluation

Biodex® isokinetic dynamometer (figure 4) quantified (Newton-meter - Nm) the peak torque of the knee extensor and flexor muscles. These measurements allowed the transversal comparison between both lower limbs as well as to normative data in the literature.[22]

Figure 1. Performing the Single Hop Test.

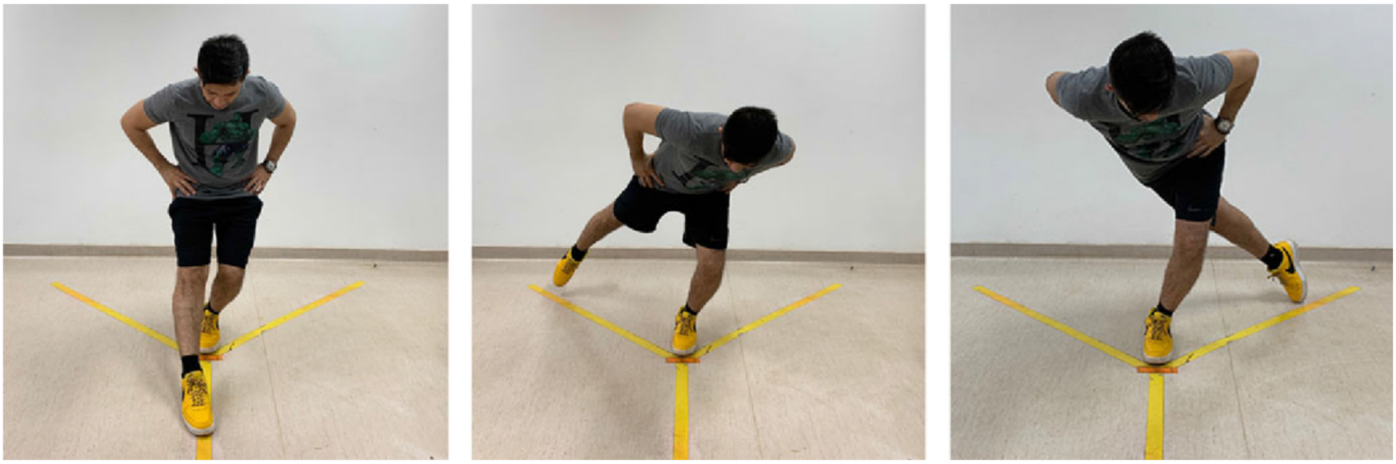

Figure 2. Performing the Y-Balance Test in anterior, posteromedial and posterolateral directions

Figure 3. Performing the Weight-bearing Lung Test.

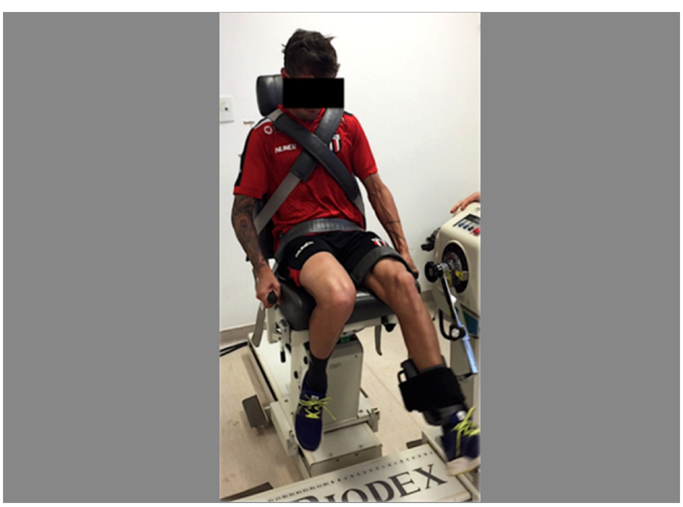

Figure 4. The isokinetic dynamometer.

Statistical analyzes

Descriptive analysis was performed using mean and standard deviation for continuous variables: age, body mass index, percentage of deficit in knee extension and flexion strength at a speed of 60°/second, hamstring-quadriceps strength ratio at a speed of 60 °/second, performance on the Hop Test, mobility in dorsiflexion on the WBLT and balance on the YBT. The categorical variables were presented in absolute and relative frequency.

Spearman's correlation coefficient considered the non-normal distribution of data residues, with a significance level of $p<0.05$. Spearman's correlation was interpreted as low ($r_s <0.40$), moderate ($r_s \geq 0.40$ to $r_s <0.70$), and high ($r_s \geq 0.70$).[23]

RESULTS

Anthropometric data

Eighty-two volunteers were recruited, 57 men and 25 women. In general, men and women had similar mean age and differed in terms of weight and height, which were both higher in males. Table 1 presents the anthropometric data.

Table 2 presents the results obtained in the SHT. The distance obtained by men was greater, but no difference was observed between right and left lower limbs.

Table 3 shows the results of isokinetic knee dynamometry at 60º/s. Despite the mean peak torque value of the right and left lower limbs in both sexes not differing by more than 2.5%, the high standard deviation suggests that this type of imbalance, greater than 10% between limbs, could be more frequent and characterize a risk factor for the occurrence of injuries.[22]

The last column of table 3 displays the number of individuals with imbalance greater than 10% between the sides of the body for knee extension (31.6% men and 28% women) and knee flexion (33.3% men and 64% women), indicating a considerable number of participants with some type of muscle imbalance.

When a knee extensor peak torque difference greater than 10% was identified, the mean length of the STH on the stronger side was 181.7 ± 32.4 cm, while on the weaker side the value was 177.8 ± 33.7 cm ($p = 0.05$). This difference was not observed when peak torque extension difference was smaller than 10%. Figure 5 expresses the positive and strong correlation ($r = 0.577$) between the length of the unilateral SHT with ipsilateral knee extension peak torque.

Table 4 presents the results obtained in the WBLT. Participants showed good ankle mobility without significant differences between genders.

Table 5 presents the results obtained in the 3 dimensions of the YBT. In general, the result was similar between the right and left limbs, with the distance obtained by women being smaller in all directions.

Table 1. Anthropometric data.

	n	Age (years)	Weight (Kg)	Heigh (cm)
Men	57	30.1 ± 10.0	75.8 ± 12.0	176.5 ± 7.9
Women	25	31.0 ± 10.0	61.9 ± 7.9	165.2 ± 6.4
Total	82	30.4 ± 9.9	71.5 ± 12.6	173.0 ± 9.1

Table 2. SHT mean and standard deviation.

	SHT (cm)		
	Right	Left	Index
Men (n=57)	193.6 ± 34.1	197.5 ± 28.4	0.98 ± 0.08
Women (n=25)	143.7 ± 22.0	146.1 ± 23.1	0.99 ± 0.08
TOTAL	178.4 ± 38.5	181.8 ± 3.9	0.98 ± 0.08

Table 3. Isokinetic knee torque variables at ***60˚/seg*** (Newton-meter – Nm).

Isokinetic torque				
Extension				
	Right	Left	Deficit	Lower limb difference >10%
Men (n=57)	234.6 ± 54.3	235.1 ± 55.1	0.4 ± 11.7	19 (33.3%)
Women (n=25)	153.7 ± 30.6	149.6 ± 32.4	1.7 ± 11.4	7 (28.0%)
TOTAL	209.9 ± 61.0	209.0 ± 63.1	0.2 ± 11.6	26
Flexion				
	Right	Left	Deficit	Lower limb difference >10%
Men (n=57)	123.4 ± 31.4	123.8 ± 32.0	0.1 ± 12.8	19 (33.3%)
Women (n=25)	75.3 ± 14.6	75.6 ± 14.3	2.5 ± 12.8	16 (64.0%)
TOTAL	108.7 ± 35.2	109.1 ± 35.6	0.6 ± 12.8	35

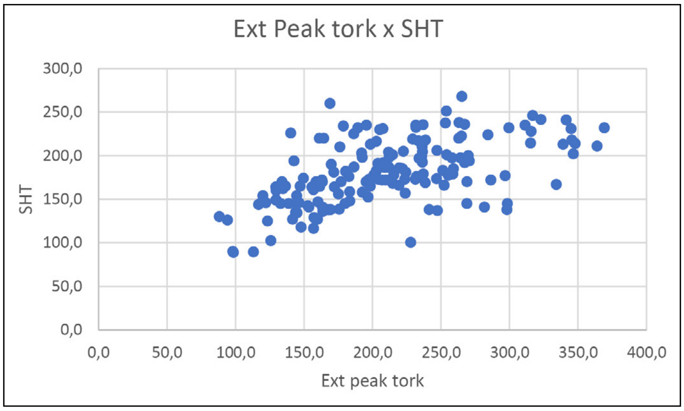

Figure 5. Correlation between the unilateral value of the SHT and the peak torque of the ipsilateral extensors.

Table 4. Mean and standard deviation WBLT.

WBLT (cm)			
	Right	Left	Index
Men (n=57)	11.2 ± 3.0	11.3 ± 3.5	1.0 ± 0.2
Women (n=25)	10.7 ± 2.1	10.6 ± 2.4	1.0 ± 0.1
TOTAL	11.0 ± 2.8	11.1 ± 3.2	1.0 ± 0.1

Table 5. Results of the Y Test in both sexes.

Y Test (cm)			
Right			
	Frontal	Posteromedial	Posterolateral
Men (n=57)	60.1 ± 7.4	101.1 ± 20.3	106.4 ± 15.9
Women (n=25)	56.6 ± 6.3	88.1 ± 10.6	92.6 ± 10.4
TOTAL	59.1 ± 7.2	97.1 ± 18.8	102.2 ± 15.8
Left			
	Frontal	Posteromedial	Posterolateral
Men (n=57)	59.7 ± 7.4	100.4 ± 19.7	106.4 ± 16.4
Women (n=25)	56.5 ± 5.5	89.9 ± 10.4	94.0 ± 10.6
TOTAL	58.7 ± 7.0	97.2 ± 18.0	102.6 ± 15.9

The correlation between the SHT and the YBT dimensions were small and not statistically significant when considering both men and women and right and left limbs together (SHT x YBT – for the Anterior direction coef = -0.069 p=0.54; posteromedial direction coef= 0.035; posterolateral direction coef= -0.127 and SHT x WBLT coef= -0.044).

In Table 6, the knees of these athletes were classified according to the presence of muscle imbalances based on the isokinetic torque ratio of flexors and extensors at 60º/s (F/E ratio). When this ratio was less than 0.55 or greater than 0.64, the presence of muscle imbalance was considered.[22] With this stratification, it was possible to calculate more expressive values of the correlation coefficient between SHT and the YBT components, which can still be classified as weak or moderate correlations. These correlations were always lower with the anterior component of the YBT, regardless of the I/Q rating group. Most of the limbs studied had an F/E ratio lower than 0.55, indicating relative weakness of the flexors of the knee in relation to the extensors.

Table 7 presents the correlations between the flexion and extension strength deficits of the lower limbs with the studied variables and shows very low correlations as well as any statistical significance.

DISCUSSION

This study was successful in confirming the relationship between SHT and isokinetic knee assessment and YBT, but not for WBLT. This is an original study and had a large sample of non-professional athletes. We believe that it can be a good starting point for studies of biomechanics applied to rehabilitation and injury prevention in running athletes.

In general, performance in the SHT was higher in men and similar between the sides of the body, which can be explained in Table 1 by the lower average height of women. When stratified by peak torque at 60º/s and >10% differences between limbs for knee extension, it was possible to identify that the SHT mean was lower for the side that presented deficit, demonstrating that the propulsive force of the jump is related to the results found in the isokinetic evaluation. Factors other than muscle strength, such as stability, neuromuscular control, individual confidence in performing the task, potentiation by eccentric work prior to the jump, as well as the use of trunk and upper limb strategies to achieve a greater distance,[24] can influence the distance achieved in the SHT.

To perform the YBT, good neuromuscular control is required, such as coordination of the lower limbs, balance, flexibility and strength. The first correlations established between the SHT and YBT components were low since data pooled both gender and body sides. However, when individuals were stratified according to muscle imbalance (F/E ratio < 0.55 or F/E ratio > 0.64) it was possible to verify an increase in correlations for the posteromedial and posterolateral directions, mainly in individuals who had a predominance of quadriceps strngth (F/E < 0.55), reaching greater distances in the posteromedial and posterolateral direction and greater

Table 6. Correlations between SHT and YBT components according to muscle balance in the knee between hamstrings and quadriceps (F/E ratio).

		SHT		
		F/E < 0,55	0,64 ≤ F/E ≤ 0,55	F/E > 0,64
	n	104 limbs	47 limbs	13 limbs
YBT	Anterior	0.293	0.199	0.084
	Posteromedial	0.408	0.260	0.255
	Posterolateral	0.482	0.253	0.601

Table 7. Correlation between extension (quadriceps) and flexion (hamstrings) isokinetic strength deficits at 60°/s with studied variables.

Variable	Extension deficit		Flexion deficit	
	R	p	R	p
Age	0.02	0.44	0.04	0.35
Body mass index	0.02	0.42	-0.02	0.43
Sex	-0.01	0.46	0.05	0.33
Knee extension deficit	-	-	0.07	0.26
Knee flexion deficit	0.07	0.26	-	-
Flexion/extension ratio (F/E)	0.18	0.05	-0.05	0.34
Single Hop Test	-0.06	0.30	-0.04	0.38
WBLT	0.04	0.37	-0.14	0.10
YBT				
Frontal	-0.04	0.35	0.01	0.47
Posteromedial	0.08	0.23	-0.04	0.37
Posterolateral	0.07	0.26	-0.01	0.46

distance in the SHT. Using the biomechanical explanation, the landing phase of the SHT and the performance of the YBT are similar since they use trunk and lower limb strategies to perform stabilization and reach.[25]

The number of lower limbs with muscle imbalances is noteworthy, especially in the F/E ratio <0.55, in which 63% had a predominance of quadriceps over hamstrings. An in-depth investigation into the training routine and activities of daily living could provide explanations for such findings, which was not carried out in our study. In addition, 31% and 42% had asymmetries greater than 10% between the limbs for quadriceps and hamstrings, respectively, suggesting that despite being athletes and following training routines, muscle imbalances were present, predisposing them to injuries. Therefore, individualized assessments before and between seasons should be necessary.

The lack of correlation between WBLT and SHT is a possible result of selection bias due to range of motion for normal dorsiflexion in the studied athletes. Our hypothesis was that such correlations could exist in individuals with movement restriction for dorsiflexion and/or previous injuries,[26] the latter not being the objective of the study. Although the study excluded individuals with injuries at the time of evaluation, it is important to identify previous injuries since they further signal the importance of objective parameters, represented by functional and/or isokinetic tests, for defining rehabilitation and training strategies as well as the return to sports activities. Isokinetic evaluation is a laboratory resource for biomechanical and clinical studies that is expensive and not always available. It would be desirable that a normative table for the SHT and WBLT values was sufficient to reach more robust conclusions about the individual's conditions. However, this was not the objective of this study, posing as a suggestion for future studies.

Selection bias is a major limitation of this study since it only included athletes. The test-retest agreement was not assessed which is also a limitation. Despite being considered the gold standard of strength assessment, the accessibility of clubs, clinics and other evaluation centers to the isokinetic apparatus is hampered by the high investment value to acquire it, which reduces external validity. Finally, the absence of variables known to influence the athletes evaluation, such as training information (frequency, duration, type of training), activities of daily living and previous injuries might have provide additional explanatory information.

CONCLUSION

This study showed that lower limb strength quantified by isokinetic assessment influences SHT. The isokinetic evaluation also served to stratify the peak torque magnitude and, in individuals with imbalances >10%, the performance in the SHT was lower for the limb with the lowest isokinetic knee extension peak torque.

Isokinetic knee F/E ratio at 60º/s identified weak or moderate correlations between the YBT components and the performance in the SHT. WBLT and the SHT were not correlated. Therefore, the study was successful in correlating the functional tests in question.

All authors declare no potential conflict of interest related to this article

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