

## The relationship between y balance performance and hip strength in recreationally trained women

Relação entre desempenho no y *balance test* e força de quadril em mulheres recreacionalmente treinadas

Relación entre y *balance test* y fuerza em mujeres recreacionalmente entrenadas

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### Abstract

This study set one's sight on the relationship between lower quarter y balance test (YBT-LQ) score with hip isometric strength with recreationally resistance-trained women. Utilizing dynamic balance as a screening tool for lower extremity injury risk has been proposed as a potential solution in injury prevention and injury assessment. A convenience sample of twenty young college females ( $22.3 \pm 2.1$  years) with a background in regular strength or plyometric training volunteered to participate in this study. The scores of YBT-LQ for each direction were calculated. A hand-held dynamometer was used to measure the maximum voluntary isometric strength of each participant's unilateral hip extensors, flexors, adductors, abductors, internal and external rotation muscles. Significant lower normalized score was noted for the dominant limb ( $81.2 \pm 11.7$ ) when compared to non-dominant limb ( $83.6 \pm 12.4$ ) for anterior distance. For the composite score of YBT-LQ, a weak association was noted for hip extension and internal rotation, and moderate association was observed for hip flexion, adduction, and abduction. On the other hand, a strong association was observed between hip external rotators strength ( $r = 0.516$ ). Thus, the main finding of the current study was the strong association observed between hip external rotators strength and composite score of YBT-LQ.

**Keywords:** Dynamic balance; Injury risk; Resistance training.

### Resumo

O texto objetivou avaliar a relação entre o desempenho no *Y balance test* para membros inferiores (YBT-LQ) com a força isométrica da musculatura do quadril em mulheres recreacionalmente treinadas no treinamento de força. Utilizar o equilíbrio dinâmico como ferramenta de avaliação para risco de lesão dos membros inferiores tem sido proposto como possível solução para prevenção ou avaliação de lesões. Uma amostra selecionada por conveniência composta por 20 mulheres em idade universitária ( $22.3 \pm 2.1$  years) com histórico regular de prática em exercícios de força e

pliométricos voluntariaram-se para este estudo. As pontuações no YBT-LQ foram aferidas nas três direções. Um dinamômetro portátil foi utilizado para aferir a contração isométrica voluntária máxima dos extensores, flexores, adutores, abdutores, rotadores internos e externos do quadril. Um *score* normalizado significativamente inferior foi observado para o membro dominante ( $81,2 \pm 11,7$ ) comparado ao não dominante para o alcance anterior. Para o *score* composto uma associação fraca foi observada junto aos extensores e rotadores internos de quadril e uma moderada associação observada para flexores, adutores e abdutores de quadril. Por outro lado, uma forte associação foi observada para os rotadores externos ( $r = 0,516$ ). Portanto, o principal achado do presente estudo foi a forte associação entre rotadores externos do quadril e o *score* composto do YBT-LQ.

**Palavras-chave:** Equilíbrio dinâmico; Lesão; Treinamento de força.

### Resumen

El texto tuvo como objetivo evaluar la relación entre el *Y balance test* ( $ybt=lq$ ) y fuerza isométrica de las caderas en mujeres entrenadas en entrenamiento de fuerza. Utilizar el equilibrio dinámico como una herramienta de evaluación del riesgo de lesiones en las extremidades inferiores. Una muestra de conveniencia con 20 mujeres estudiantes universitarias con experiencia en entrenamiento de fuerza y pliometría participaron en el estudio. Se calcularon las puntuaciones de YBT-LQ para cada dirección. Se utilizó un dinamómetro de mano para medir la fuerza isométrica voluntaria máxima de los extensores, flexores, adutores, abductores y músculos de rotación internos y externos de la cadera unilaterales de cada participante. Se observó una puntuación normalizada significativamente más baja para el miembro dominante ( $81,2 \pm 11,7$ ) en comparación con el miembro no dominante ( $83,6 \pm 12,4$ ) para la distancia anterior. Para la puntuación compuesta de YBT-LQ, se observó una asociación débil para la extensión de la cadera y la rotación interna, y se observó una asociación moderada para la flexión, aducción y abducción de la cadera. Por otro lado, se observó una fuerte asociación entre la fuerza de los rotadores externos de la cadera ( $r = 0,516$ ). Por tanto, el principal hallazgo del presente estudio fue la fuerte asociación observada entre la fuerza de los rotadores externos de la cadera y la puntuación compuesta de YBT-LQ.

**Palabras clave:** Balance dinámico; Lesión; Entrenamiento de fuerza.

## 1. Introduction

Dynamic balance is an integral component when examining lower extremity injury risk considering that the neuromuscular system has an important role in dynamic stability (Riemann & Lephart, 2002). Utilizing dynamic balance as a screening tool for lower extremity injuries has been proposed as a potential solution in injury avoidance and injury assessment (Brech, et al., 2013). Hip abductor and external rotator muscle strength play a major role in reducing knee adduction and internal rotation torque (Kendall, et al., 2005). Specifically, hip abductor and external rotator muscle strength deficits are associated with the femoral position of adduction and internal rotation torque at the knee (dynamic knee valgus) and consequently affect hip dynamic balance (Gordon, et al., 2013).

An increasing number of studies have attempted to identify variables related to dynamic balance, static balance, and ankle range of motion (ROM) aiming to predict lower extremity injuries in physically active populations (Paz, et al., 2016, Williams, et al., 2016). One instrument utilized to examine dynamic balance is the Lower Quarter Y Balance Test (YBT-LQ). The YBT-LQ is a platform apparatus variant of the Star Excursion Balance Test (SEBT), employing three of the original eight reaching directions: anterior, posteromedial and posterolateral (Wilson, et al., 2018). This dynamic balance instrument incorporates standardized height, stance foot placement and reaching measurements. The YBT-LQ has been verified as a reliable test with a high proficiency of inter and intra-rater reliability (McCann, et al., 2017). The benefits of the YBT are that it has a standard protocol and high inter-rater (0.99-1.00) and intra-rater (0.85-0.91) reliabilities (Linek, et al., 2017).

Wilson et al. (2018) examined the relationship between elements of isometric hip strength and the Y Balance Test, to provide clinicians better guidance as to specific areas of muscle performance to address in the event of poor performance on the Y Balance Test. The authors found significant positive correlations between Y-Balance Test performance and hip abduction strength. They also found correlations between the Y-Balance Test and hip extension and external rotation strengths. Hartley et al. (2018) investigated static balance, dynamic balance, ankle range of motion, body mass index (BMI), or history of an ankle sprain were all associated with ankle sprain injuries within collegiate athletes of both sexes.

They noticed that male collegiate athletes with greater BMI and lesser YBT-LQ anterior reach were at a greater risk of sustaining an ankle sprain injury.

Understanding the dynamic balance framework for each particular population allows for specific standard performance evaluation points to be established. Although the authors understand that the relationship between dynamic balance and isometric strength is already established, we consider it relevant to address this topic exclusively to recreationally. Thus, this evidence may help conditioning professionals and practitioners during the training prescription and assessment. Therefore, the purpose of this study was to identify the relationship between YBT-LQ score with hip isometric strength with recreationally resistance trained college women

## **2. Methodology**

### **2.1 Experimental design**

This was an experimental qualitative research whose sample was selected for convenience (Medronho, et al., 2009).

### **2.2 Participants**

Twenty young college females with background in regular strength or plyometric training volunteered to participate in this study (Age  $22.3 \pm 2.1$ ; Height  $161.1 \pm 5.3$  (cm); mass  $65.2 \pm 3.9$  (kg)). Power analysis was conducted to determine sample size (n) using Cohen's d (Cohen, 2013) of  $\sim 1.1-1.3$  for improvements in muscular performance. Sample size was calculated revealing that each group required between 13 and 15 participants to meet the required power of 0.8 at an alpha value of  $p < 0.05$ . All participants had at least three years of resistance training experience ( $3.5 \pm 1.2$  years), averaging 60-min per sessions three times a week. All participants were active in competitive sports training or were active in actual competition one to four times per week. The exclusion criteria adopted for the current research was: (a) potential medical problems such as joint injuries or a history of ankle, knee or back pathology that compromised their participation or performance during the proposed tests; (b) any lower extremity surgery in the prior two years.

### **2.3 Protocol**

Participants indicated their "dominant limb" by answering which leg they would use to kick a ball. Limb testing was randomized. Prior to data collection, the participants were informed about the experimental procedures and about possible risks and benefits associated with their participation in the study and signed an informed consent before any of the tests performed. Procedures were approved by the Institutional Ethics Review Committee of the University in accordance with the current national and international laws and regulations governing the use of human subjects (Declaration of Helsinki II).

Y balance test (YBT-LQ) measurement: Participants completed the YBT-LQ using a metric tape fixed on the floor in a manner previously described in the literature (Ganesh, et al., 2015; Gordon, et al., 2013; Johnston, et al., 2018). The participants stood with one leg -the stance leg- on the starting position, and used their opposite leg, the reaching leg, to touch as far as possible with the halux in the anterior, posterolateral, and posteromedial directions sustaining the farthest reach for at least two seconds. Attempts did not count if the participant was unable to maintain a single leg stance throughout the entire movement, rested the left foot out of the mark while reaching, elevated the supporting ankle in an attempt to gain extra distance, or the participant did not return to starting position with maintained balance. Each participant completed three testing trials in each direction with each leg after completing six practicing trials, which were included to familiarize the participant with the testing maneuvers. One-minute rest between repetitions was adopted to prevent fatigue. Only values from the three testing trials were used to calculate the subject's scores.

Scores for each direction (anterior, posteromedial, and posterolateral) were calculated by dividing the average reach distance (in cm) by the participant's leg length (in cm) and multiplying by 100 (Paz, et al., 2017). The patient's leg length was measured from the most prominent aspect of the anterior-superior iliac spine to the distal tip of the ipsilateral medial malleolus. To calculate the composite score, the sum of maximum reaches in each directions was divided by three times the leg length (Paz, et al., 2017).

Handheld dynamometer: A MicroFet 2 hand-held dynamometer (Hogan Health Industries, Inc. 8020 South 1300 West, West Jordan, USA) was used to measure the maximum voluntary contraction. The rater was a physical education professional with five years of experience in testing procedures. The maximal isometric contraction of the unilateral hip extensors, flexors, adductors, abductors, internal and external rotation was adopted following procedures suggested by Kendall et al (2005). Participants were told to stop contracting when the tester finished counting to five seconds (Williams, et al., 2016). This duration was shown to be adequate for most subjects in order to reach the maximum force (Douma, et al., 2014). The mean peak value of these three trials for each muscle group was used for the data analysis.

## 2.4 Statistical Analysis

All statistical analysis were performed using SPSS 23 Statistics Software (SPSS Inc. Chicago, IL). Data were tested for normality using the Shapiro-Wilk test. Mean and standard deviations were calculated for each of the variables, on each leg. T-tests were performed to determine if there were any between limb differences of the dominant and non-dominant leg. Pearson correlation coefficients were calculated between the three hip strength measurements and the Y-Balance test scores. To describe the strength of the correlation, the following scale was used for the absolute value of the correlation coefficient ( $r$ ): strong relationship ( $0.50 \leq r \leq 1.0$ ), moderate relationship ( $0.3 \leq r < 0.5$ ), and weak relationship ( $r < 0.3$ ) (Hopkins, et al., 2009). The level of significance for all analysis was set at  $p \leq 0.05$ .

## 3. Results and Discussion

No difference between dominant and non-dominant limb was noted for posterolateral and posteromedial parameters of YBT-LQ (Table 1 provided for observation). However, a significant lower score was noted for dominant limb when compared with the non-dominant limb for anterior distance. No difference between limbs was observed for all hip strength evaluation applied in the present study.

**Table 1** – Mean and standard deviation of hip strength and Y-balance parameters between dominant and non-dominant limb

	Dominant limb	Non-dominant limb	P value
Y-balance test (% leg length)			
Anterior	81.2 (11.7)	83.6 (12.4)*	0.050
Posterolateral	111.5 (16.2)	107.5 (13.3)	0.068
Posteromedial	103.1 (16.5)	103.1 (13.2)	0.544
Composite	120.8 (21)	120.6 (19.5)	0.871
Isometric strength (N)			
Hip flexion	19.9 (7.9)	18.3 (6)	0.772
Hip extension	20.6 (9.8)	19.9 (7.9)	0.544
Hip adduction	12.2 (2.7)	11.2 (3)	0.083
Hip abduction	15 (3.1)	15.5 (3.3)	0.269
Hip internal rotators	14 (4.1)	13.3 (4.3)	0.282
Hip external rotators	11.3 (1.7)	10.9 (1.7)	0.364

\* Significant difference for dominant limb ( $p \leq 0.05$ ). Source: Authors.

A weak association was noticed between hip extension, internal rotators and anterior distance of YBT-LQ test (Table 2 provided for observatiob). On the other hand, moderate association was observed between hip extension, adduction, abduction and external rotation with anteriorreach distance. For posterolateral reach distance, a weak association was noted for hip flexion, extension, adduction and abduction (Table 3 provided for observation). However, moderate association was observed for internal and external rotators.

**Table 2** - Correlations between anterior distance of y-balance and isometric hip strength.

	r	P-value*	Classification
Anterior			
Hip flexion	0.404	0.152	Moderate
Hip extension	0.264	0.362	Weak
Hip adduction	0.414	0.152	Moderate
Hip abduction	0.403	0.153	Moderate
Hip internal rotators	0.243	0.403	Weak
Hip external rotators	0.473	0.088	Moderate

\* Indicates Significant Correlation. Source: Authors.

**Table 3** - Correlations between posterolateral distance of y-balance and isometric hip strength.

	r	P-value*	Classification
Posterolateral			
Hip flexion	0.254	0.381	Weak
Hip extension	0.249	0.391	Weak
Hip adduction	0.254	0.381	Weak
Hip abduction	0.228	0.432	Weak
Hip internal rotators	0.423	.0132	Moderate
Hip external rotators	0.405	0.151	Moderate

\* Indicates Significant Correlation. Source: Authors.

For posteromedial reach distance, a weak association was noted for hip flexion, extension, abduction and internal rotation (Table 4 provided for observation). However, moderate association was noted for hip adduction and external rotation. For composite score of YBT-LQ, a weak association was noted for hip extension and internal rotation (Table 5 provided for observation). Moderate association was observed for hip flexion, adduction and abduction. On the hand, the only strong association was observed betweenhip external rotators strength and composite score of YBT-LQ.

**Table 4** - Correlations between posteromedial distance of y-balance and isometric hip strength.

	r	P-value*	Classification
Posteromedial			
Hip flexion	0.219	0.451	Weak
Hip extension	0.079	0.789	Weak
Hip adduction	0.357	0.210	Moderate
Hip abduction	0.254	0.382	Weak
Hip internal rotators	0.173	0.554	Weak
Hip external rotators	0.358	0.209	Moderate

\* Indicates Significant Correlation. Source: Authors.

**Table 5** - Correlations between composite score of y-balance and isometric hip strength.

	r	P-value*	Classification
<b>Composite</b>			
Hip flexion	0.358	0.209	Moderate
Hip extension	0.263	0.364	Weak
Hip adduction	0.320	0.264	Moderate
Hip abduction	0.414	0.141	Moderate
Hip internal rotators	0.222	0.446	Weak
Hip external rotators*	0.516	0.059	Strong

\* Indicates Significant Correlation. Source: Authors.

The purpose of this study was to identify the relationship between YBT-LQ score and hip isometric strength in recreationally resistance trained women. The main finding of the current study was the strong association observed between hip external rotators strength and composite score of YBT-LQ. A weak/moderate association was noted between hip flexion, extension, adduction, abduction and internal rotation isometric strength and YBT-LQ reach distances or composite score. These results were partially in agreement with the previous evidences observed in the scientific literature (Brech, et al., 2013; Chen & Chou, 2017; Culiver, et al., 2019; Linek, et al., 2017; McCann, et al., 2017).

Despite the lack of a significant difference, a strong association between hip external rotation strength and the composite score of YBT-LQ was found in the present study. On the other hand, Gordon et al (2013) examined the relationships between core strength examined through the bent knee lowering test, hip external rotation strength and lower extremity balance measured by the SEBT's composite score in a sample composed by 45 female lacrosse players. Hip external rotator strength was measured singularly via hand held dynamometry (reported in Newtons). Hip external rotation strength of both left and right lower extremity (independently) were moderately correlated with scores on one reach direction (left posteromedial) but not with combined SEBT scores. Overall hip strength and core strength were not correlated with SEBT's composite score.

Wilson et al (2018) also investigated the relationship between components of isometric hip strength and the YBT-LQ. The authors evaluated 40 males and 33 females who were physically active. The authors found significant positive correlations between YBT-LQ and hip abduction strength. They also found correlations between the YBT-LQ and hip extension and external rotation strengths. Linear regression analysis showed hip abduction to be the only significant predictor of Y- Balance performance. In this context, one of the factors which must be pointed out is the training level of the participants between studies. The level of hip strength measures presented a large difference between the current study and Wilson et al (2018) for hip abduction ( $15.4 \pm 3.2$  vs.  $20.2 \pm 5.1$  N), external rotation ( $11.1 \pm 2.1$  vs.  $6.7 \pm 2$  N) and hip extension ( $20.2 \pm 5.3$  vs.  $14.5 \pm 4.9$  N). In the present study, the participants has at least three years of regularly resistance training experience, different to Wilson et al (18) who evaluated participants classified as moderately active in recreational activities.

The relevance of the participants background can be noted in Lee et al (2014) study, which investigated the relationship between YBT-LQ distance and the lower-limb strength of adult women aged 45 to 80 years. Participants were tested for maximal muscle strength of the lower limbs (hip extensors, hip flexors, hip abductors, knee extensors, knee flexors, and ankle dorsiflexors) and YBT-LQ distances in the anterior, posteromedial, and posterolateral directions. The authors noted a weak correlation between lower-limb strength (hip extensors, hip abductors, and knee flexors) and dynamic postural control as measured by the YBT-LQ. In another study Lee et al (2015) investigated the ability of the YBT-LQ and lower limb strength to discriminate between females in two age groups, the relationship between YBT-LQ distance and the Berg Balance Scale (BBS), and the degree to which performance on YBT-LQ distance is related to lower limb strength in middle-aged and older females. The YBT-LQ distance in three directions and lower limb muscle strength for both lower limbs were

significantly lower in the older adults than in the middle-aged group. A moderate correlation but insignificant correlation was found between the YBT-LQ composite and the BBS scores. In the older females, YBT-LQ distance was significantly positively correlated with strength of the knee flexor and hip abductor. In the middle-aged group, YBT-LQ distance was significantly positively correlated with strength of the knee flexor and hip extensor. This collection of evidence shows controversial results.

It's important to highlight that the intervention was proposed using a modified version of the YBT-LQ using a fixed tape on the floor which can lead the individuals to different neuromuscular strategies in order to maintain their balance. For instance, Jagger et al (2020) aimed to investigate if reach distances were similar during different dynamic stability tests, a modified Star Excursion Balance Test, a modified version of the Y Balance Test and the Y Balance Test in a sample composed of young and healthy individuals of both sexes finding differences between in all the three directions proposed in our study suggesting caution when comparing different studies.

#### 4. Final Considerations

There are important limitations in this study. First, we only tested healthy females with resistance training background. The healthy participants in the study conducted by Lee et al (2015) had an average age of 65.73 years, while the moderate physically active participants in the study by Wilson et al (18) had an average age of 25.40 years in the healthy participants in this study. This suggests that the age of the participant could play a larger role than their injury status and explain the discrepancy seen between correlations amongst the studies. However, the use of healthy subjects decreased the possibility that lower extremity pathology such as patellofemoral pain, ankle instability, or other limitations would prevent maximal performance.

Furthermore, the present findings provide clinicians with useful information regarding the relative contribution of hip muscle strength to YBT-LQ performance when evaluating dynamic balance in resistance training field. Further studies are needed to determine the clinical utility of this test in different age groups or injury conditions. All things considered, the main finding of the current research was the strong association observed between hip external rotators strength and composite score of YBT-LQ. A weak or moderate association was noted between hip flexion, extension, adduction, abduction and internal rotation isometric strength and YBT-LQ reach distances or composite score.

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