Section A-Research paper
ISSN 2063-5346

Association Between Y-Balance Test Performance and Knee Strength

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DOI: 10.48047/ecb/2023.12.si4.1678

Abstract

BACKGROUND: Y-Balance test (YBT) one of the most commonly used dynamic test that was found to be able to predict non-contact injuries. However, there is a lack of understanding of the association between knee muscle strength and YBT.

OBJECTIVES: To investigate the association between isometric knee strength and YBT performance in male and female athletic students.

METHODS: Thirty-six healthy athletic students (17 women, 19 men), aged 22±2 years, voluntarily participated in this study. Peak knee flexor and extensor torques were measured using the Biodex Isokinetic System 4 Pro. The YBT scores in the anterior, posteromedial, and posterolateral directions were measured. The normalized knee flexor/extensor peak torque and YBT scores were used in the analysis. Pearson's correlation was used to investigate the association between knee flexor/extensor peak torque and the YBT scores in the three reach directions.

RESULTS: There was a significant positive association between YBT performance and knee flexor strength in all three reach directions (anterior r=.388, p=.019; posteromedial r=.37, p=.024; and posterolateral r=.42, p=.011) but not knee extensor strength (p>.05).

CONCLUSIONS: YBT performance correlated with knee flexor but not with knee extensor strength. This information may aid clinicians and researchers in developing injury prevention programs.

Keywords: Y-balance test, knee joint, hamstring muscle, quadriceps muscle, and isometric strength

Introduction

The Y-balance test (YBT) is a dynamic balance test used to assess an individual's ability to maintain the center of mass of one limb while performing a movement [1, 2]. It is one of the most commonly used balance tests, with good reliability for testing dynamic balance in athletes [3]. This test was developed as a shorter version of the star excursion balance test (SEBT). In a healthy population, the YBT and SEBT both have excellent intra- and inter-rater reliability [4]. A recent systematic review stated that the YBT is a reliable test for analyzing dynamic neuromuscular control [5]. In addition, the performance of the YBT was found to be associated with injury occurrence and is commonly used to detect injury risk [6, 10]. Herrington et al. [6] found that individuals with anterior cruciate ligament deficiency had lower SEBT scores in most directions than healthy individuals. Another study found that high school athletes with lower SEBT scores in the anterior direction had a greater risk of developing lower extremity injury than athletes with greater SEBT scores in football [7]. In addition, Plisky et al. [8] found that SEBT can help identify high school basketball players with a greater risk of developing lower extremity injury. Moreover, players who scored lower on the SEBT were 2.5 times more likely to develop an injury. Furthermore, previous research found that athletes with an asymmetry of ≥ 4 cm in the anterior reach direction in YBT have a high risk of developing a non-contact injury and are 4 times more likely to miss days of practice owing to non-contact injuries [9, 10]. Although there is a strong link between injury occurrence and YBT score, there is lack of knowledge regarding the factors influencing this score.

Performance of the YBT involves the ability to maintain balance during a single-leg stance while moving the contralateral leg; this requires stability and strength. However, the role of knee muscle strength in YBT performance is poorly understood. In other words, the relationship between knee flexor/extensor strength and YBT score remains controversial. Previous research has found a significant positive correlation between isometric strength of the knee muscles and YBT scores [11- 13]. Some researchers have found a positive association between YBT scores and knee flexor strength in middle-aged to older women aged 40–80 years and children aged 12–

15 years [11]. In young elite male soccer players, Chtara et al. [14] found a significant positive association between isometric knee extensor muscle strength and YBT performance in all three reach directions but only in the posterolateral reach direction with isometric knee flexor strength. Moreover, knee extensor strength predicted approximately 40% of the performance of the YBT in the anterior direction. However, the results of these studies are inconsistent, and they fail to reflect the association between the performance of YBT and knee strength at an age where individuals are active (20–26 years) and have a high incidence of non-contact injury. Therefore, this population may benefit significantly from an injury prevention program [15, 17].

Although maintaining the center of gravity during a single-leg stance requires muscle strength, there is lack of knowledge regarding the muscles that affect YBT performance. Moreover, no study has yet investigated the relationship between knee strength and YBT performance in a population that includes both male and female athletes. Investigating this correlation is important because of the possible implications for improving YBT performance. This may help improve injury screening and develop an effective injury prevention program that potentially helps reduce the risk of injury. Therefore, this study aimed to investigate the association between knee muscle strength and YBT performance in healthy individuals. We hypothesized that there would be a significant positive correlation between knee strength and YBT performance.

Methods

Participants

Thirty-six healthy athletic students (17 women and 19 men, 22±2 years, 66.3±17 kg, 1.66± .11 m) were recruited. Participants who were healthy with no musculoskeletal or neuromuscular injuries in the last 6 months, had no history of lower limb surgeries, were between 20 and 26 years of age, and participated in sports regularly, at least three times a week. Each participant signed an informed consent form approved by Taibah University. This study was approved by the Ethics Committee of Scientific Research at College of Medical Rehabilitation Sciences at Taibah University (approval number: CMR-PT-2022-07) according to the guidelines of Declaration of Helsinki for medical research involving human subjects.

Y-balance testing

The YBT was performed according to previously published protocols [18]. The participants were asked to stand on one leg and try to reach as far as possible with the opposite leg in three different directions (anterior, posteromedial, and posterolateral) and return to the starting position while maintaining their balance. Before the actual trials began, the participants were asked to perform six trials in each direction for familiarization, after which three trials in each reach direction were performed. The maximum reach distance in centimeters in the three trials for each reach direction (i.e., anterior, posteromedial, and posterolateral) was used for analysis. All values were normalized to leg length by dividing the reach distance by leg length (cm) and multiplying by 100. Leg length was measured using a tape measure as the distance between the anterior superior iliac spine and medial malleolus in the supine position. The normalized composite reach distance was calculated as the sum of the maximum reach distances in each direction, divided by three times the leg length, and multiplied by 100.

Strength testing

Isometric knee extensor and knee flexor torques were obtained using Biodex Isokinetic System 4 Pro (Biodex Medical Systems, 20 Ramsey Road, Shirley, New, USA). The participants were positioned according to the manufacturer's guidelines, to prevent additional movement and to isolate the knee extensors and flexors. The axis of rotation of the dynamometer was determined to be at the level of the lateral epicondyle of the tested leg. The lever arm of the machine was positioned 2 cm above the lateral malleolus. The participants were asked to perform two familiarization trials before the test. Subsequently, they performed a set of five maximum contractions of 5-s knee extension and five maximum contractions of 5-s knee flexion, with 7-s rest between them to prevent fatigue. The tests were repeated with the other leg. To ensure maximal effort, players were verbally and visually encouraged throughout the test. The peak torque and average peak torque of the knee flexors and extensors were obtained from each test for statistical analysis.

Statistical analysis

Pearson's correlation analyses were performed to investigate the relationship between YBT performance and knee strength variables. The Y-Balance variables included the three reach directions (i.e., anterior, posteromedial, and posterolateral) and the composite score. Knee

strength variables included isometric knee flexor and extensor peak torques. The strength of the correlations was determined as follows for the absolute value of the correlation coefficient (r): strong correlation ($.5 \leq r \leq 1$), moderate correlation ($.3 \leq r < .5$), and weak correlation ($r < .3$). All statistical analyses were performed using SPSS version 24 software (SPSS Inc., Chicago, IL, USA). Data were tested for normality using Shapiro-Wilk test. The significance level was set at $\alpha = .05$.

Table 1: Y-Balance scores and dominant leg isometric knee strength (mean ± SD)

Test	Mean
Y-Balance (%leg length)	
Anterior	74.7 ± 11
Posterolateral	97.8 ± 15
Posteromedial	96.8 ± 12
Composite	99.5 ± 14
Isometric knee strength (Nm/kg)	
Knee extensor	2.8 ± .6
Knee flexor	1.2 ± .2

Results

Table 1 illustrates the mean and standard deviation of normalized knee flexor and extensor to the body mass, and normalized Y-Balance scores of the dominant legs. Knee flexion significantly correlated with anterior (r=.388, p=.019), posteromedial (r=.37, p=.024), and posterolateral (r=.42, p=.011) (Table 2). However, there was no significant correlation between isometric knee flexion strength and composite score (p=22). In addition, there was no significant correlation of knee extensor strength with anterior (p=36), posteromedial (p=.23), posterolateral (p=.16), and with the composite score (p=.75).

Table 2: Correlations between Y-Balance scores and dominant leg isometric knee strength

Test	r	P value	Strength of correlation
Anterior			
Knee extensor	.15	.36	Not significant
Knee flexor	.388	.019*	Moderate correlation
Posteromedial			
Knee extensor	.202	.23	Not significant
Knee flexor	.37	.024*	Moderate correlation
Posterolateral			
Knee extensor	.23	.16	Not significant

Knee flexor	.42	.011*	Moderate correlation
Composite			
Knee extensor	.053	.75	Not significant
Knee flexor	.188	.22	Not significant

Note: *p<.05

Discussion

This study investigated the association between YBT performance and isometric knee muscle strength. Our hypothesis was partially supported by the main finding that there is a significant positive moderate correlation of all three reach directions of YBT (i.e., anterior, posterolateral, and posteromedial) with knee flexor strength but not with knee extensor strength. The results of this study are important as they help understand the role of knee muscle strength in YBT performance. This may help clinicians improve screening and injury prevention programs, potentially reducing the risk of injury.

In the current study, a moderately positive association was found between isometric knee flexor strength and YBT performance in the anterior, posteromedial, and posterolateral directions. The hamstring muscles may contribute to pelvic stability during the YBT as well as stabilization of the stance limb against the knee flexion moment created by gravity. The results of the current study indicate that YBT performance may improve as hamstring muscle strength increases. Similarly, Alhusaini et al. [13] investigated the association between isometric knee strength in male schoolchildren with an average age of 14 years. A positive correlation was found between isometric knee flexor strength and YBT performance. In the previous study, the composite score positively correlated with knee flexor strength, whereas in the current study, there was no correlation between the aforementioned variables. A possible explanation for this difference is that the present study population was older and included both men and women [5]. Likewise, Lee et al. [11, 12] found a positive association between YBT performance and knee flexor strength in middle-aged and older women. In contrast, Chtara et al. [14] examined the relationship between YBT performance and isometric knee strength in elite male soccer players. They reported that knee extensor strength, but not knee flexor strength, was positively associated with YBT performance. In the current study, no association was found between knee extensor strength and YBT performance. These controversial results could be due to differences in skill level, age, and sex, which prior research has indicated may affect the results [5]. In our study, we

recruited healthy recreational athletes, whereas Chtara et al. [14] recruited elite male athletes. In addition, our study is more generalized, as we recruited both male and female athletes with an average age of 22 years.

Even though the results of the current study showed that there is a positive moderate relationship between YBT performance and knee flexor strength, there may be other variables that contribute to stability during YBT, such as hip muscle strength and plantar flexor muscle strength [11, 19, 20]. However, the findings of this study will be helpful to clinicians. Our study and previous studies have suggested that muscle strengthening should be included in rehabilitation to improve the performance of YBT. Therefore, improving the performance of the YBT may reduce the risk of injury.

This study has some limitations. First, we examined only healthy individuals. Therefore, these results may not reflect the population of individuals with injuries. Future research should investigate the association between knee muscle strength and YBT performance in individuals with injuries. In addition, the current study design (i.e., cross-sectional) did not allow for a cause-and-effect relationship between knee flexor strength and YBT performance. Therefore, future research should investigate the effects of knee flexor strengthening on YBT performance. Moreover, the inclusion of electromyography may add more information about the role of knee muscle activation during YBT, which would help support our findings. Further studies with larger sample sizes of male and female participants are needed to better understand the association between YBT and knee muscle strength.

Conclusion:

Our study revealed a significant positive moderate association between knee flexor strength and YBT performance in all three directions. However, there was no correlation between knee extensor strength and YBT performance. These findings might be helpful to clinicians, as it indicates that they should include strengthening of the knee flexor muscle to improve YBT performance. In addition, the findings of this study will help researchers develop an injury prevention program, which may help reduce the risk of injury.

Acknowledgement

The author would like to thank Editage (www.editage.com) for language editing and reviewing this manuscript.

Ethical Considerations:

All participants in this study signed an informed consent form approved by Taibah University. The study was also approved by the Ethics Committee of Scientific Research at the College of Medical Rehabilitation Sciences at Taibah University (approval number: CMR-PT-2022-07). This approval was granted in accordance with the guidelines of the Declaration of Helsinki for medical research involving human subjects.

Conflict of interest:

The author has no conflicts of interest to report.

Funding

The author reports no funding.

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