The Relationship between Lower Extremity Musculature Strength, Q-angle, and Single-Leg Balance

Adam K. Russell, Megan C. Zerr, Todd G. Rinehart, Brandon M. Norris, Nicole K. Perkuhn
Faculty: Bryan J. Lehecka

Department of Physical Therapy, College of Health Professions

Abstract. The purpose of this study was to examine the relationship between quadriceps angle of the lower leg, hip strength (measured by dynamometry), and balance (measured by Star Excursion Balance testing). Studies have shown that lower extremity alignment has an effect on both muscle strength and balance. However, there is a lack of research on how quadriceps angle, hip strength, and balance relate to one another. Data from 31 healthy participants between 20 and 30 years old was analyzed. Results suggest that hip flexion and hip abduction strength in males is correlated with larger quadriceps angles. Hip flexion strength was also correlated to Star Excursion performance in females. This may have important implications for lower extremity injury screening and rehabilitation interventions.

1. Introduction

For years, the domain of balance training was in physical therapy and the rehabilitation industry. In the past decade, healthcare professions have realized the significance of balance for injury prevention. Emery et al found only 3/100 healthy adolescents who performed a home-based balance training program reported sport- related injuries versus 17/100 in the control group [1]. Addressing factors that may affect balance such as strength and lower extremity (LE) alignment in exercise and rehabilitation programs may be an essential component of injury prevention. Therefore, the purpose of this study was to examine the interaction between LE muscle strength, Q-angle, and dynamic single leg balance (SLB).

2. Experiment

Thirty-one healthy subjects (mean age = 24 + 1.83) participated in the study. Volunteers were free of LE musculoskeletal or neuromuscular injury in the past six months, and pregnant women were also excluded. Subjects completed a health history questionnaire prior to participation in order to confirm all inclusion/exclusion criteria were met. Participants performed a two-minute warm-up on a stationary bicycle, proceeded through bilateral measurement of Q-angle and leg length, Star Excursion Balance Testing (SEBT), and hip abduction (HABD), flexion (HFLEX), extension (HEXT), external rotation (HER), and knee extension (KEXT) strength testing.

Q-angle is the angle formed by one line drawn from the anterior superior iliac spine to the patellar midpoint, and another line from the patellar midpoint to the tibial tubercle [2]. This is a common measurement of LE alignment used by physical therapists that has been related to several pathologies such as knee extensor dysfunction and patellofemoral pain [2].

The SEBT is a screening tool to assess dynamic balance and postural control, consisting of single-limb squats using the non-stance limb to reach maximally along designated lines on the ground in eight directions [3]. This test is a valid dynamic test for predicting the risk of LE injury, identifying dynamic balance deficits in patients with LE conditions, and responsiveness to training programs in both healthy participants and participants with LE injuries [4]. These studies have recommended that only three directions (anterior (STAR-A), posterolateral (STAR-PL), and posteromedial (STAR-PM)) need to be tested due to the high correlation between an individual's reaching distance in one direction, and his or her reaching distance in the other seven directions [5]. Therefore, a modified SEBT was used in this study in which only these three directions were measured. Participants stood on one LE (stance foot), with their great toe in the center of the grid. Next, they reached in the three designated directions using the reach leg, while maintaining a single leg stance (SLS).

Hip and knee isometric strength was recorded bilaterally using a hand-held dynamometer (HHD) (Lafayette Instrument Company; Lafayette, IN.) and external fixation in the form of a belt as recommended by Thorburg et. al. [6]. The dynamometer was positioned between the tested body part and a belt that was fixated to the frame of the examination table or to the handle of a fixed door, depending on the hip or knee action. This allowed for an isometric contraction of the respective musculature. The test positions were chosen based on

procedures commonly applied in clinical settings [6]. The subject then exerted a three-second maximum voluntary isometric contraction (MVIC) against the dynamometer and the fixation belt. The individual test was administered three times to reduce a possible learning effect and establish mean strength.

3. Results

Significant correlations for hip and knee strength, Q-angle, and SEBT are presented in Tables 1 and 2 for males and females, respectively. In males (n=11), HABD and HFLEX were negatively correlated with Q-angle (r = -.605, p = .049), (r = -.649, p = .031), respectively. In females (n=20), HFLEX was positively correlated with performance on SEBT in the STAR-PL test direction (r = .542, p = .014). All other measures were found to be not significantly correlated.

Table: 1
Relationships (Pearson Coefficients) Between Variables in Males

	HABD	HFLEX
Q-Angle	-0.605 P = .049	-0.649 P = .031

Table: 2
Relationships (Pearson Coefficients) Between Variables in Females

	HFLEX
Q-Angle	-0.542 P = .014

4. Discussion

Analysis of relationships found a negative correlation between Q-angle and HABD and HFLEX in males. Data showed that Q-angle represents 37% of the variance in HABD, and 42% of the variance in HFLEX. Previous research has also indicated a relationship between Q-angle and HFLEX [2]. However, there has been limited research on the relationship between Q-angle and HABD. Based on knowledge of the line of pull, and the relationship between LE alignment and muscle strength, both of these findings were expected. These data suggest that HFLEX and HABD strength in males with larger Q-angles may have an important role in LE injury screening and rehabilitation interventions. Hip flexion strength was also found to be significantly correlated to STAR-PL performance in females. In the current study, HFLEX represents 29% of the variance of the SEBT in that test direction. This finding suggests that eccentric HFLEX strength as used in STAR-PL may be an important focus in balance training in females. These limited findings between LE strength and SEBT performance suggests that other factors besides strength of the selected LE muscles have an influence on SEBT. One factor that has been previously suggested is core strength [5].

5. Conclusions

The findings of this study suggest there is a relationship between Q-angle and certain LE muscle strength in males, and that LE FLEX strength relates to at least one direction of the SEBT in females. Examination of gender differences in the relationship between Q-angle and LE strength alone is warranted. Further study is also needed to determine differences between male and female SEBT performance, and whether there is a correlation between all directions in both genders. These studies may help determine why HFLEX was positively correlated to SEBT performance in females only, and why Q-angle is negatively correlated to HABD and HFLEX in males only.

6. Acknowledgments

The authors would like to thank the Wichita State Department of Physical Therapy and its students for their participation in this study.

7. References

[1] Emery C, Cassidy J, Klassen T, Rosychuk R, Rowe B. Effectiveness of a home based balance-training program in reducing sports-related injuries among healthy adolescents: a cluster randomized controlled trial. *CMAJ*. 2005; 172: 749-754. [2] Byl T, Cole J, Livingston L. What determines the maginitude of Q-angle? A preliminary study of selected skeletal and muscular measures. *J Sport Rehabil*. 2000; 9:26-34.
[3] Reiman M, Manske R. Functional testing in human performance. 1st ed. Champaign, IL: Human Kinetics Inc.; 2009.
[4] Carter, R., Lubinsky, J., & Domholdt, E. Rehabilitation Research Principles and Applications. 4th ed. St. Louis, MO: Elsevier Saunders; 2011.
[5] Gordon AT, Ambegaonkar JP, Caswell SV. Relationships between core strength, hip external rotator muscle strength, and star excursion balance test performance in female lacrosse players. *Int J Sports Phys Ther*. 2013; 8: 97-104.
[6] Thorburg K, Petersen J, Magnusson S, Holmich P. Clinical assessment of hip strength using a hand-held dynamometer is reliable. *Med Sci Sports*. 2010; 20: 493-501.