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Original Research—CME

Single Leg Squat Test and Its Relationship to Dynamic Knee Valgus and Injury Risk Screening

Viviane Ugalde, MD, Chuck Brockman, PT, Zach Bailowitz, Christine D. Pollard, PhD, PT

Abstract

Background: Lower extremity injuries are common in athletes. Valid tests to assess for risk of injury that are easily performed during a preparticipation sports physical examination are lacking. Two-dimensional (2D) analysis of the drop-jump test can identify athletes at risk, but it is too expensive and cumbersome to use in this setting.
Objective: To identify if those who perform a "positive"(abnormal postures) single leg squat (SLS) test also exhibit greater "dynamic valgus" on the 2D drop-jump test. Our secondary purpose was to assess whether group differences in gender, age, or body mass index are evident between those who exhibit a positive SLS test result versus a negative SLS test result. Also, we wanted to determine any gender differences with the 2D drop-jump test.
Design: A cross-sectional study.
Setting: Private practice, preparticipation sports physical examinations.
Participants: A total of 142 middle school and high school athletes.
Methods: Participants performed a SLS test and a drop-jump test during their preparticipation sports physical examination. Individuals were partitioned into groups based on the outcome of their SLS test (positive SLS group versus negative SLS group). Independent sample *t*-tests were used to evaluate SLS group differences in the drop-jump test, age, and body mass index, and the χ^2 test was used to evaluate SLS group differences in gender ($P \leq .05$).
Main Outcome Measurements: The SLS test and drop-jump test.
Results: Seventy-three of the 142 athletes (51%) had a positive SLS test result, whereas 69 athletes (49%) had a negative SLS test result. Individuals in the positive SLS group had a significantly lower knee-hip ratio), indicative of greater dynamic knee valgus, than did those in the negative SLS group ($P = .02$). Individual characteristics between SLS groups including gender, age, and body mass index were similar.
Conclusion: The SLS test is a reasonable tool to use in preparticipation sports physical examinations to assess for dynamic knee valgus and the potential risk of lower extremity injury.

Introduction

Lower extremity injury in sports is common in high school athletes, ranging from 29%-89% of all injuries sustained in 1 year [1]. The incidence of lower extremity injury in high school athletes was 1.33 per 1000 athletic exposures, which represents 807,222 nationally per year [2]. Some lower extremity injuries, such as anterior cruciate knee ligament (ACL) injuries, result in significant time loss from sport and an increased risk of osteoarthritis later in life [3]. Girls' soccer has the highest incidence of ACL injury in the 14-18-years-old age group, at 14.08 per 100,000 athletic exposures, with football the second highest incidence, at 13.8 per 100,000 athletic exposures [4]. Interest in sport injury prevention has been expanding in the past 10-15 years, particularly in light of injury prevention programs that have been shown to reduce injury rates of the ACL and other lower extremity injuries [5-10]. Implementation of these injury prevention programs can be challenging and are not readily available. An alternative to generalized injury prevention training for all athletes would be to prescreen athletes and stratify individual risk of injury. This type of prescreening may allow targeted prevention techniques for individual athletes [11].

Clinical biomechanical tests proposed to identify at-risk athletes for lower extremity injuries include the single leg squat (SLS) test [12,13], drop-jump test

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[13-17], landing error scoring system [18], star excursion balance test [19], and the functional movement screen (FMS) [20,21]. The drop-jump test and the landing error scoring system use two-dimensional (2D) or three-dimensional (3D) video analysis, and the star excursion balance test and FMS require multiple tasks, which make them impractical for implementation at large group preparticipation examinations or in physician offices. The SLS test is a simple test that can easily be used in these settings. The SLS test identifies core strength [22] and generally relates to landing, running, and cutting tasks [13,23-25]. Strensrud et al [13] reported a good correlation between subjective assessment of an SLS test and 2D frontal plane video analysis with elite handball players; however, this has not been examined in middle school and high school athletes [13]. The primary purpose of this study was to examine the relationship between performance on a simple yet defined SLS test and a 2D drop-jump test in middle school and high school athletes. In particular, our aim was to identify if those who have a "positive" SLS test result (which suggests poor lower extremity mechanics) also exhibit greater "dynamic valgus" on the 2D drop-jump test. Our secondary purpose was to assess whether group differences in gender, age, or body mass index (BMI) are evident between those who exhibit a positive SLS test result versus those with a negative SLS test result. Finally, we aimed to determine if there was a gender difference in dynamic valgus by using the 2D drop-jump test in this population of athletes who attended preparticipation physical examinations.

Methods

Participants

Participants consisted of 142 athletes (92 girls and 50 boys; mean (standard deviation) age, 13.8 $\pm$ 1.8 years) who were recruited at preparticipation sports physical examinations from 4 physical examination sessions over a 2-year period (Table 1). Athletes with previous lower extremity injuries were excluded from participating in the study. The participants were composed of middle school and high school athletes who were participating in cross country, track, soccer, football, wrestling, volleyball, Nordic and alpine ski racing, lacrosse, and basketball. All the athletes signed assent forms and their parents signed consent forms before participation.

Table 1
Participant characteristics

	No. Girls	No. Boys	Group Mean Age, y	Group Mean BMI, kg/m^2
Positive SLS group	48	25	13.6	20.3
Negative SLS group	44	25	13.8	20.8

BMI = body mass index; SLS = single leg squat.

The St Charles Medical Center Institutional Review Board approved the study.

Procedures

The participants were evaluated while performing an SLS test and a 2D drop-jump test. Evaluators were licensed physical therapists, orthotists, or certified athletic trainers who had undergone training in the testing methods. Each of these tests was performed on the same day (ie, the day of their preparticipation sports physical examination). Data were obtained in a blinded fashion for the SLS test and the 2D drop-jump test results, in that participants completed the SLS test at the SLS testing session and the 2D drop-jump test at the 2D drop-jump test station, which was located in a different room.

SLS Test

This test was conducted similarly to the SLS test described by Sciascia and Kibler [12]. The barefooted athletes were asked to place their hands on their hips and stand on one limb and flex the opposing limb to 90°. They then were instructed to perform an SLS to 30° of knee flexion and then return to a fully extended knee position (Figure 1). Visual inspection was used to estimate whether the participants squatted to 30°. If not, then the rater would give verbal cues to either increase or decrease the amount of knee flexion in subsequent squats. The participants performed the SLS test 3 times in a row on each leg. The investigator noted any abnormal responses, which consisted of arms flailing, the Trendelenburg sign, or collapse of the supporting knee into valgus, which indicated an abnormal response [12]. We defined a positive SLS test result as more than two-thirds of abnormal responses on either leg of the 6 total trials (3 SLS trials on each leg). Each participant was given either a positive or a negative score on the SLS test. A positive SLS test result may be suggestive of poor lower extremity mechanics, reduced core strength, or hip abductor weakness.

2D Drop-Jump Test

This test was conducted as described by Noyes et al [16]. A Sony DCR-HC52 Mini DV Handycam Camcorder (Sony Electronics Inc, San Diego, CA) was connected to a Dell Latitude E6400 laptop (Dell Inc, Round Rock, TX) equipped with Dartfish ProSuite 4.5.2.0 video software (Dartfish Software, Alpharetta, GA). The camcorder then was placed on a DYNEX Digital Series 60" Universal Tripod (Dynex Products, Richfield, MN). The tripod, which stood at 102.24 cm in height, was placed 365.76 cm in front of a box of 32.0 cm in height and 34.0 cm in width.

The participants were barefoot during the drop-jump test. Orange Styrofoam (Dow Chemical Co, Midland, MI) spheres were placed by a physical therapist onto each

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