

LANDING PATTERN SCREENING OF RECREATIONAL MALE AND FEMALE ATHLETES

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ABSTRACT

Landing Error Scoring System (LESS) is a useful, quick, reliable, valid and responsive instrument for determination of landing movement errors of male and female athletes. This study focused to investigate the landing pattern of recreational male and female athletes, using the Landing Error Scoring System. The study included 241 volunteer recreational athletes (101 females, 140 males). Jump-landings were recorded by two camcorders from sagittal and frontal planes. These records were replayed and scored by a trained rater on LESS score sheets. Total and frontal plane LESS score was significantly different between male and female athletes. Beside the total LESS score, each item may be evaluated separately; frontal plane evaluation results, in particular, can be a guiding factor in designing such jump-landing activity programs in female athletes.

Key words: jump-landing, ACL injury, screening movement errors

REKREATİF ERKEK VE KADIN ATLETLERİN YERE DÜŞÜŞ MODEL TESPİTİ

ÖZET

Erkek ve kadın atletlerin yere düşüş hareketinin değerlendirilmesinde Hatalı Yere Düşüş Puanlama Sistemi (LESS) kullanışlı, çabuk, güvenilir, geçerli ve duyarlı bir ölçüm aracıdır. Bu çalışmada, rekreatif erkek ve kadın atletlerin LESS ile hareket modelleri araştırılmıştır. Çalışmaya 241 (101 kadın, 140 erkek) gönüllü rekreatif atlet katılmıştır. Atletlerin yere düşüş, sagittal ve frontal düzlemden iki el kamerası ile kayıt altına alınmıştır. Bu kayıtlar, LESS konusunda eğitilmiş bir değerlendirici tarafından izlenerek puanlandırılmıştır. Erkek ve kadın atletler arasında yapılan karşılaştırmalarda toplam ve frontal düzlem LESS skorları anlamlı farklılıklar göstermiştir. Toplam LESS ile birlikte, her bir LESS maddesi ayrı olarak değerlendirilirse yere düşüş hata tespitinde daha faydalı bir araç olabilir. Bununla beraber, özellikle frontal düzlem değerlendirmeleri, kadın atletlerin sıçrama-düşüş aktivite programları tasarımında yol gösterici bir faktör olabilir.

Anahtar kelimeler: sıçrama-düşüş, ÖÇB yaralanmaları, hareket hataları tespiti

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INTRODUCTION

Landing maneuvers are a common physical activity inherent to many sports, and have been identified throughout the literature as a mechanism for non-contact anterior cruciate ligament (ACL) injury (Arendt, Agel, & Dick, 1999). The majority of ACL injuries are observed through non-contact mechanisms (Yu, Kirkendall, & Garrett, 2002), and Colby, Francisco, Yu, Kirkendall, Finch, and Garrett (2000) reported that these situations could potentially occur near foot strike, when the quadriceps is eccentrically contracting to resist knee flexion. It is therefore suggested that the mechanism of non-contact injury to the ACL involves both internal and external forces generated by the leg muscles of players (Colby, et al., 2000). The latter can be exemplified as the ground reaction force during landing. Landing studies mostly focused on biomechanical and neuromuscular variables, especially interms of gender bias, in an effort to characterize the role of different factors in injury (Colby, et al., 2000; Zhang, Bates, & Dufek, 2000; Cowling & Steele, 2001; Self & Paine, 2001; Chappell, Yu, Kirkendall, & Garrett, 2002; Lephart, Ferris, Riemann, Myers, & Fu, 2002; Decker, Torry, Wyland, Sterett, & Richard Steadman, 2003; Salci, Kentel, Heycan, Akin, & Korkusuz, 2004). The higher incidence of ACL injuries among females has been well documented. Several studies reported that females injure their ACL two to eight times more frequently than their male counterparts, with the risk of injury increasing with participation in basketball, soccer and volleyball (Clarke & Buckley, 1980; Ferretti, Papandrea, Conteduca, & Mariani, 1992; Zelisko, Noble, & Porter, 1982). Arent & Dick (1995), Messina, Farney, and DeLee (1999), and Hewett (2000) reported similar findings, that non-

contact ACL injury rates are 3 to 4 times greater for female athletes.

Biomechanical analysis provides the most valuable and reliable information in determining the effects of landing on ACL injuries, however, such studies require expensive laboratory facilities with limited participants. Padua et al. (2009) reported on a newly developed visual screening method, termed "Landing Error Scoring System" (LESS). This method has a greater applicability and facilitates the inclusion of larger sample sizes in ACL injury studies. However, there are few studies that utilize this clinical assessment tool with athletes involved in multiple levels of sport participation.

Therefore, the purpose of this study was to investigate the landing pattern of recreational male and female athletes using the LESS, which has been shown to be a valid and reliable qualitative screening method. It was hypothesized that male and female recreational athletes would demonstrate differences in qualitative screening of landing maneuvers.

MATERIALS and METHODS

Participants

The study included 241 volunteer recreational athletes between the ages of 18 and 22 years. Of these, 140 subjects (mean age 20.35 ± 1.14 years; body mass 77.88 ± 6.09 kg; height 1.78 ± 0.06 m) were healthy males and 101 subjects (mean age 20.02 ± 1.06 years; body mass 64.66 ± 4.91 kg; height 1.68 ± 0.04 m) were healthy females. A recreational athlete was defined as participating in any sport events one to three times per week, without following a designed training regimen. Participants were excluded from participation for previous lower extremity surgery; any lower extremity injury sustained within the previous six months; and participation in a lower extremity strength-training program or jump-

training program. All of the participants completed testing session. The aim and nature of the study was explained to volunteer and they all signed an informed consent document prior to study.

Measures & Procedures

All testing procedures were performed in the exercise physiology laboratory. Participants performed 3 two-footed landings from a 30-cm height box. Following a verbal start command, participants landed on the floor, evenly balanced on both feet, without lowering their body prior to leaving the platform. After landing, the participant immediately jumped as high as possible. Each subject had the opportunity to perform three practice trials. During practice and test trials, the descriptions of the Padua et al. were followed for the correct task, which was characterized by clearing the box with both feet, jumping forward and ending the task in a fluid motion (Padua et al., 2009). For all sessions, no feedback was given to the participants regarding their lower limb motion. Video recordings of all landing maneuvers were obtained using two camcorders (Sharp Viewcam VL-Z5U, SHARP Corporation, Osaka, Japan). Cameras were positioned (camera 1 to sagittal- & camera 2 to frontal plane) on tripods positioned 4 m from the side of the landing platform, at an elevation of 120 cm. Subsequently, the recordings were stored in a computer, where LESS scores were determined by trained two observers. Scoring was performed according to pre-defined errors, which related to specific landing-movement characteristics. The LESS scoring system comprised 17 items (sagittal plane items 1,2,3,4,12,13,14,16 and frontal plane items 5,6,7,8,9,10,11,15) (Padua et al., 2009). Higher scores indicate a greater number of landing maneuver errors, whereas lower scores indicate better landing performances.

The LESS scores were categorized into 4 levels: excellent (LESS score, ≤ 4), good (LESS score, >4 to ≤ 5), moderate (LESS score, >5 to ≤ 6) and poor (LESS score >6) (Padua et al., 2009).

Statistical Analyses

All variables had descriptive statistics run using the Statistical Package for Social Sciences was used as statistical program. Independent t-tests were used to compare gender differences between means for total LESS scores, sagittal- and frontal plane LESS scores. Intraclass correlation coefficient (ICC) and standard error of measure (SEM) were calculated to evaluate the reliability of measures. To evaluate intrarater agreement (ICC 2,1), the same rater reassessed the LESS data for 25 randomly selected subjects (13 men, 12 women) out of the 241 subject pool. The second grading session was scheduled 2 weeks later, to reduce potential recall bias. Interrater agreement (ICC 2,k) was determined by assessment of a second rater. A group of 25 randomly selected subjects from the whole sample were rescored by a free (second) rater. Chi-square analysis was used to compare LESS score levels between male and female recreational athletes. The level of significance was set at $p < 0.05$ for all tests.

RESULTS

Intraclass correlation coefficient (ICC 2,k) was 0.80 and standard error of measure (SEM) was 1.38 for interrater reliability. Intrarater reliability (ICC 2,1) was 0.89 and SEM was 1.27. Interrater and intrarater reliability indicated that they had a good reliability, respectively. The total LESS scores of males (5.27 ± 2.97) and females (6.46 ± 3.30) were significantly different ($p < 0.05$) (Table 1). No significant gender difference was found between sagittal plane scores ($p > 0.05$), but frontal plane evaluation was significantly different

between male and female participants (Table 1).

According to the chi-square analysis (Table 2) there were statistically significant outcomes regarding LESS score levels ($\chi^2_3 = 13.2, p < 0.004, \phi = 0.23$). In terms of gender, 36.4% of males scored as excellent in landing as compared to 20.8 % of females. In addition, females were more likely to scored as poor (55.4 %) in their landings as compared to males (32.9 %). Furthermore, females were scores as good 9.9 % and moderate 13.9 % as

compared to males 10.7 % and 20 % respectively. Based on the column percentages, cells on the excellent and poor LESS scores considerably significant results because they show the largest differences: 15.6 % on excellent row (36.4 % and 20.8 %) and 22.5 % on poor row (55.4 % and 32.9 %). Using standardized residuals, only the cell on the poor row (z score = 2.0, higher than the critical value of 1.96) is the significant contributor to the chi-square relationship between gender and LESS scores.

Table 1. Comparison of over all, frontal and sagittal LESS assessments for both gender.

| Variable | Female | | Male | | t | df | p | Cohen's d |
|---------------|--------|-----|------|-----|------|-----|-------|-----------|
| | M | SD | M | SD | | | | |
| Total LESS | 6.4 | 3.3 | 5.2 | 2.9 | 2.93 | 239 | .004* | 0.39 |
| Frontal LESS | 0.9 | 0.7 | 0.4 | 0.5 | 5.74 | 239 | .000* | 0.85 |
| Sagittal LESS | 4.5 | 2.5 | 4.0 | 2.4 | 1.57 | 239 | ns | 0.21 |

* $p < 0.05$.

Table 2. Percentage distribution of total LESS scores for both gender and analysis of the resulting standardized residuals.

| Variable | Excellent | | | Good | | | Moderate | | | Poor | | | χ^2 | df | p | ϕ |
|----------|-----------|------|------|------|------|----|----------|------|-----|------|------|------------------|----------|----|-------|--------|
| | n | % | SR | n | % | SR | n | % | SR | n | % | SR | | | | |
| Male | 51 | 36.4 | 1.4 | 15 | 10.7 | .1 | 28 | 20 | .7 | 46 | 32.9 | -1.7 | 13.2 | 3 | .004* | 0.23 |
| Female | 21 | 20.8 | -1.7 | 10 | 9.9 | -1 | 14 | 13.9 | -.9 | 56 | 55.4 | 2.0 ^a | | | | |

* $p < 0.05$.

df = 3; 0 cells (0.0%) have expected frequencies less than 5.

^a Significant at 0.05 (Standardized residuals (SR) > +1.96 or < -1.96.)

DISCUSSION

ACL is one of the most commonly injured ligaments in the knee joint. Despite the extensive literature on ACL injuries, there are few studies on a quick, effective and standardized instrument for detecting individuals who may be at greater risk of ACL injury. Therefore, the aim of the present study was to screen landing patterns in recreational male and female athletes using the landing error scoring system (LESS). Observations in the present study indicated that, total LESS scores and frontal plane evaluation scores showed significant differences between genders. The chi-square analysis was also demonstrated

statistically significant outcomes regarding LESS score levels (Table 2).

Several investigators identified gender-differences in LESS scores, including where female participants scored worse than their male counterparts (Beutler, de la Motte, Marshall, Padua, & Boden, 2009; Padua et al., 2009). Current study was also revealed significant gender differences in evaluating LESS scores so female athletes had higher LESS scores than male athletes. This poorer landing technique could be interpreted as female athletes landed with less lower extremity flexions especially knee and hip joints. These movement error patterns are

thought to be related with lower extremity injuries.

Based on LESS score percentages, excellent and poor LESS scores demonstrated considerably significant results because they showed the largest differences: 15.6 % on excellent row (36.4 % and 20.8 %) males and females respectively, and 22.5 % on poor row (55.4 % and 32.9 %) females and males respectively. The present results are quite similar to those of Padua et al. (2009) who reported that difference as 16 % on excellent row (30 % of male and 14 % of female) participants were scored as "Excellent". However, compared to the present findings, Padua et al. (2009) reported relatively low proportions of "Poor" scores (23 % and 36 % for males and females, respectively). The reason for this difference is not clear but the level of athletes would be a factor. Identifying this difference in different populations may be beneficial to help support the use of the LESS in varying populations.

The present results also indicated that frontal plane LESS scores differed significantly between genders (Table 1). When examined in detail, the items comprising total frontal plane LESS scores (Knee valgus angle and lateral trunk flexion angle at initial contact, stance width (wide & narrow), foot position (toe in & out), symmetric initial foot contact and knee valgus displacement) were lower in male participants than their female counterparts. Knee valgus angle is thought to be an important factor in non-contact ACL injuries, putting females at greater risk of ACL injury (Olsen, Myklebust, Engebretsen, & Bahr, 2004; Boden, Dean, Feagin, & Garrett, 2000). Several authors reported that females showed greater knee valgus than males (Malinzak, Colby, Kirkendall, Yu, & Garrett, 2001; Kernozek, Torry, Van Hoof, Cowley, & Tanner, 2005; Pappas, Hagins, Sheikhzadeh, Nordin, & Rose,

2007). Additionally, initial foot-contact symmetry and foot position are thought to be associated with ACL injuries. Moreover, Kernozek et al. (2005) reported that, during landing maneuvers, the majority of the differences in biomechanical variables between male and female recreational athletes were evident in the frontal plane. Additionally, the sagittal plane comparison was not different between genders. Huston, Vibert, Ashton-Miller, & Wojtys (2001) reported that landing from less than 40 cm height had no discriminating effect on differences in knee flexion angles between males and females. Further studies may be needed to fully clarify the effect of different landing platform heights in LESS evaluations.

Actually, ACL loading is specific to each plane of movement (sagittal, frontal and transverse) and there are multiple loading patterns and mechanics that occur that can lead to injury. However, search for a quick, useful and responsive instrument for identifying individuals at high risk of injury can result in lack of plane evaluations.

The findings of present study showed good interrater and intrarater reliability, respectively. Similar observation was previously reported by Padua et al. (2009) and Onate, Cortes, Welch & Van Lunen (2010). Additionally, they claimed that LESS is a reliable assessment tool for identifying landing movement errors. On the contrary, to the best of our knowledge, only one previous prospective study examined the relationship between the ACL injuries and the LESS, and the authors concluded that LESS did not be able to predict ACL injury in their group of participants (Smith et al., 2012). The ACL injury predictivity of LESS should not be limited with such a valuable single research, be extended with collaborative prospective further studies. Applicability, reproduction and especially validation of

prior studies is necessary for the conformation of such clinical researches.

CONCLUSIONS

Significant gender-differences were found in LESS score evaluations, particularly the proportions of male and female participants achieving "Excellent" and "Poor" jump-landing scorings which demonstrated the largest proportional differences. Finally, the use of a movement analysis laboratory is optimal for identifying quantitative lower-extremity injury factors or identifying individuals at greater risk of lower

extremity injury. However, if there is a large number of subjects with limited time, alternative valid and reliable screening tools are needed to identify injury factors. LESS is a useful, quick, reliable, valid and responsive instrument for determination of landing movement errors of male and female athletes. In addition to the total LESS score, each item may be evaluated separately, especially in female athletes frontal plane evaluations, and can be a guiding factor in designing such jump-landing activity programs.

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