Agreement Between Visual Assessment and 2-Dimensional Analysis During Jump Landing Among Healthy Female Athletes

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Context: Altered movement patterns, including increased frontal-plane knee movement and decreased sagittal-plane hip and knee movement, have been associated with several knee disorders. Nevertheless, the ability of clinicians to visually detect such altered movement patterns during high-speed athletic tasks is relatively unknown.

Objective: To explore the association between visual assessment and 2-dimensional (2D) analysis of frontal-plane knee movement and sagittal-plane hip and knee movement during a jump-landing task among healthy female athletes.

Design: Cross-sectional study.

Setting: Gymnasiums of participating volleyball teams.

Patients or Other Participants: A total of 39 healthy female volleyball players (age = 21.0 ± 5.2 years, height = 172.0 ± 8.6 cm, mass = 64.2 ± 7.2 kg) from Divisions I and II of the Israeli Volleyball Association.

Main Outcome Measures(s): Frontal-plane knee movement and sagittal-plane hip and knee movement during jump landing were visually rated as good, moderate, or poor based on previously established criteria. Frontal-plane knee excursion and sagittal-plane hip and knee excursions were measured using free motion-analysis software and compared among athletes with different visual ratings of the corresponding movements.

Results: Participants with different visual ratings of frontal-plane knee movement displayed differences in 2D frontal-plane knee excursion (P < .01), whereas participants with different visual ratings of sagittal-plane hip and knee movement displayed differences in 2D sagittal-plane hip and knee excursions (P < .01).

Conclusions: Visual ratings of frontal-plane knee movement and sagittal-plane hip and knee movement were associated with differences in the corresponding 2D hip and knee excursions. Visual rating of these movements may serve as an initial screening tool for detecting altered movement patterns during jump landings.

Key Words: movement pattern, movement analysis, validity

Volleyball involves repetitive jumping and landing that likely exerts a considerable strain on the lower extremity and, in particular, the knee. Accordingly, patellofemoral pain and patellar tendinopathy are commonly experienced by volleyball players,1–3 and whereas not as common, anterior cruciate ligament (ACL) tears may still occur during volleyball.4 A frequent impairment associated with the aforementioned conditions is an altered lower extremity movement pattern typically characterized by decreased sagittal-plane hip and knee movement or increased frontal-plane movement.5–11 Interestingly, women seemed to exhibit these altered movement patterns more often than men,12–14 which is a possible reason for the greater incidence of noncontact ACL tears and patellofemoral pain among women.6,15,16

One paradoxical limitation of the literature regarding lower extremity movement patterns is the strong reliance on 3-dimensional (3D) movement analysis. Whereas this type of analysis is very accurate and reliable, it is not readily available in most settings. Consequently, the information gained from such analyses may be difficult to apply in the clinical setting. Alternatively, clinicians, athletic trainers, and coaches must develop visual observation skills that will enable them to identify faulty and potentially injurious movement patterns. Applying such skills may result in a more timely prescription of preventive measures and a decreased rate of injuries.

Relatively few authors, however, have specifically assessed the agreement between visual observation and more quantitative measures of movement during jumping and landing. Whatman et al17 used a dichotomous rating of knee alignment based on the relative position of the patella over the ipsilateral second toe and found no association with 3D frontal-plane knee alignment. Similarly, Ekegren et al18 reported that a dichotomous rating of frontal-plane knee alignment was not sensitive enough to detect a truly risky knee-valgus alignment as determined by 3D motion analysis. However, Stensrud et al19 showed that poor visually rated frontal-plane knee alignment was associated with greater medial knee excursion using a 2-dimensional
(2D) analysis, whereas Nilstad et al\textsuperscript{20} found that greater visually rated medial knee alignment during jump landing was associated with a greater 3D knee-abduction angle.\textsuperscript{20}

In addition to their inconsistent findings, a common limitation of these studies is the sole reliance on frontal-plane knee alignment in determining the quality of movement or the risk of injury. Whereas increased knee valgus has been associated with the risk of ACL rupture,\textsuperscript{8} investigators have also related decreased sagittal-plane hip and knee movement with ACL rupture,\textsuperscript{8} patellofemoral pain,\textsuperscript{6} and patellar tendinopathy.\textsuperscript{5,7,9} Consequently, relying solely on frontal-plane knee alignment during jumping and landing may underestimate the level of risk associated with these functional tasks.

The Landing Error Scoring System (LESS) is a video-based rating system that includes assessment of sagittal-plane hip and knee movement.\textsuperscript{21} Whereas the LESS has been validated by comparison with 3D motion analysis, its use necessitates pausing the video several times to rate the performance,\textsuperscript{21} which makes it more time consuming than real-time movement analysis. A real-time version of the LESS has been described\textsuperscript{22} but has not been validated against a more quantitative motion-analysis system.

A recently described visual rating scale for movement quality during jump landing specifically includes the rating of sagittal-plane hip and knee movement.\textsuperscript{23} The entire scale, as well as each of its items, had adequate interrater reliability\textsuperscript{23}; however, the association between ratings made according to this scale and more quantitative measures of movement has not been determined. Therefore, the purpose of our study was to further explore the association between the visual rating of movement quality during jump landing and 2D movement analysis. More specifically, we aimed to determine whether different levels of visually rated frontal-plane knee and sagittal-plane hip and knee movements were associated with differences in 2D frontal-plane knee and 2D sagittal-plane hip and knee excursions, respectively, during jump landings among healthy female volleyball players.

**METHODS**

**Participants**

Female volleyball teams from Divisions I and II of the Israeli Volleyball Association were contacted and informed of the study. Thirty-nine female volleyball players (age = 21.0 ± 5.2 years, height = 172.0 ± 8.6 cm, mass = 64.2 ± 7.2 kg) participated in the study. Seventeen athletes played in Division I, and 22 athletes played in Division II. The average number of years of play was 9.1 ± 4.8 years, and the average number of practice and game sessions per week was 5.7 ± 2.3. Teams from both divisions typically played once each week throughout the season and practiced 3 to 5 more times each week. In addition to scheduled team practices, many players from both divisions worked out individually in the gymnasium. To be included in the study, participants had to be at least 16 years of age. Potential participants were excluded if they reported any lower extremity or lumbar spine symptoms on the day of data collection or had sustained a lower extremity injury resulting in missed practice or game participation for more than 1 week over the 6 months before data collection.

All participants or their parents or guardians provided written informed consent, and the study was approved by the Ethics Committee of Ariel University.

**Examiners**

Before data collection, all examiners met for a total of 3 hours to review all measurement procedures and conduct pilot testing of 7 healthy volunteers.

Two physical therapists (A.R., Z.K.) with 16 and 28 years of experience, respectively, performed all ratings and measurements for this study. A physical therapy student (not an author) performed an additional set of 2D frontal-plane knee- and sagittal-plane hip- and knee-excursion measurements to establish the interrater reliability of these measures. This student was nearing the end of her senior year, having already completed all didactic and clinical education in the field of musculoskeletal physical therapy.

**Procedures**

We collected demographic information and information regarding volleyball experience, characteristics of play, and any past volleyball-related injuries that resulted in missed practice or game participation during the 2 years before the study. Next, we made video recordings of a jump-landing task conducted in the gymnasiums of the participating teams immediately before a scheduled team practice. These video recordings were later used for the visual and 2D analyses of movement. Given that the examiners performing both analyses also conducted the video recordings, they could have incidentally been exposed to the performance of some participants during these video-recording sessions, although they were strictly focused on obtaining the video recordings during these sessions. Therefore, a “washout” period was deemed necessary before performing the visual and 2D analyses so any recall bias would be minimized. Consequently, the visual rating of movement quality was performed 3 months after data collection. Because both examiners (A.R., Z.K.) performed the visual ratings to establish interrater reliability and 1 examiner (A.R.) later performed the 2D analysis, another 3-month washout period was deemed necessary between the visual and 2D analyses.

**Tests and Measures**

**Jump-Landing Test.** The jump landing was performed from a 30-cm box placed at a distance equaling half of the participant’s height from a 1-× 1-m landing area marked with tape. Participants were instructed to drop off the box and on the landing area and then immediately jump straight up as high as possible. We imposed no restrictions on upper extremity position or movement during the test and gave no instructions regarding the landing technique. Participants performed 5 repetitions to familiarize themselves with the procedure. The test itself consisted of 3 additional trials. Participants performed the test while wearing shorts that fully exposed their knees and their own athletic shoes.

The jump-landing test was videotaped using 2 camcorders (model GC-PX100; JVC Corp, Yokohama, Japan) at a frame rate of 50 frames per second. One camcorder was positioned 3.4 m in front of the landing area and captured the performance from the frontal plane, and the other was
positioned 3.4 m to the right side of the landing area and captured the performance from the sagittal plane. Each camcorder was placed on a tripod so that its lens was 1.2 m from the floor.

**Visual Rating of Quality of Movement.** Frontal-plane knee movement and sagittal-plane hip and knee movements were rated as good, moderate, or poor based on the prevailing movement patterns in 2 or more of the 3 jump-landing repetitions (Table 1). Ratings were based on slight modifications of previously established criteria (Table 1, Figures 1 through 4). These criteria were included in a 6-item rating scale for quality of movement during jump landing and were judged to possess the most direct association with knee injury based on the literature. In addition, these criteria have demonstrated a substantial level of interrater reliability for frontal-plane knee movement ($\kappa = 0.76$; 95% confidence interval [CI] = 0.62, 0.90) and sagittal-plane hip and knee movement ($\kappa = 0.69$; 95% CI = 0.52, 0.87). Briefly, frontal-plane movement was rated based on the amount of medial knee movement from initial foot contact to the most medial knee position during landing, and sagittal-plane movement was rated based on the amount and smoothness of hip and knee flexion during landing. Whereas the sagittal-plane rating criterion was previously based on maximal hip- and knee-flexion angles during landing (ie, >90° or <90°), we believed excursion rather than a specific joint angle could be more accurately assessed during real-time visual observation. Given the high speed of the jump-landing task, we also believed that using qualitative (ie, large, moderate, minimal) rather than quantitative rating criteria would facilitate a more accurate assessment.

All ratings were conducted separately by the 2 physical therapists to re-establish their interrater reliability as performed in this study. To minimize bias, the ratings used for data analysis were all made by the physical therapist not subsequently involved in the 2D motion analysis (Z.K.). Each examiner was allowed to watch the frontal- and sagittal-plane videos once at full speed; no slow motion or pausing was allowed. Examiners were allowed to pause the

| Table 1. Criteria for Visually Rating Frontal-Plane Knee and Sagittal-Plane Hip and Knee Movement During Jump Landing |
| --- |
| **Criterion** | **Definition** | **Score** | **Comments** |
| Frontal-plane knee movement | Knees stay over or lateral to feet (Figure 1)  
Knees move medial to feet but do not make contact  
Knees make contact (Figure 2) | Good (0)  
Moderate (1)  
Poor (2) | On the first test repetition, stance width during initial contact was judged as narrow (<shoulder width) or normal (>shoulder width).  
A poor score was assigned when stance width was normal and the knees made contact during any 1 of the test repetitions. A poor score was also assigned when stance width was narrow and the knees made contact during at least 2 test repetitions (if the knees made contact only once when stance width was narrow, a moderate score was assigned).  
The score was based on the judgment of ≥2 test repetitions.  
A good score was assigned when landing appeared soft and a large amount of hip and knee flexion was clearly observed. The following descriptors were used to characterize a good score: “jackknife like,” “bouncy,” “like a coil,” and “hip and knee folding.” A poor score was assigned when landing appeared stiff and very little hip or knee flexion was observed. The following descriptors were used to characterize a poor score: “nonyielding,” “hard,” and “not using the legs.” Finally, the examiners were instructed to assign a moderate score to all cases in which it was not possible to clearly assign a good or poor score.  
When the total score was 2 and consisted of moderate ratings on both frontal- and sagittal-plane criteria, the participant was assigned to the good/moderate group; however, if the score included a poor rating on either criterion, the participant was assigned to the poor group. |
| Sagittal-plane hip and knee movement | Large hip- and knee-flexion displacement (Figure 3)  
Moderate hip- and knee-flexion displacement  
Minimal (almost no) hip-flexion or knee-flexion displacement (Figure 4) | Good (0)  
Moderate (1)  
Poor (2) |  |
| Total score | Combined scores of the frontal-plane knee and sagittal-plane hip and knee criteria | Good/moderate (0–2)  
Poor (2–4) |  |
videos between jump-landing repetitions to document their ratings.

**Two-Dimensional Motion Analysis.** Measurements of 2D frontal-plane knee excursion and sagittal-plane hip and knee excursions were performed using free motion-analysis software (version 0.8.15; Association Kinovea, Paris, France). For frontal-plane knee excursion, the distance-measuring function of the software was used after the scale was calibrated based on the width of the jump-landing step (57.5 cm). Next, the distance in centimeters between what the examiner perceived to be the lateral aspect of each knee (ie, interknee distance) was measured on the frame corresponding to initial foot contact of either foot (ie, interknee distance[initial contact]; Figure 5A) and again on the frame corresponding to the minimal distance between the knees (ie, interknee distance[minimal]; Figure 5B). The following formula was used to express the normalized frontal-plane knee excursion:

\[
\frac{(\text{Interknee Distance}_{\text{initial contact}} - \text{Interknee Distance}_{\text{minimal}})}{\text{Interknee Distance}_{\text{initial contact}}} \times 100
\]

The normalized frontal-plane knee excursion was calculated for each of the 3 jump-landing repetitions, and the average was used for data analysis.

For sagittal-plane hip and knee excursions, the angle-measuring function of the software was used. First, hip- and knee-flexion angles on the frame corresponding to initial foot contact of either foot were measured. Second, hip- and knee-flexion angles were measured on the frame corresponding to maximal knee flexion. Sagittal-plane hip and knee excursions were then calculated by subtracting the hip
and knee angles measured on initial contact from those measured during maximal knee flexion. The knee-angle measurement was taken by placing the point of the angle over what the examiner perceived to be the location of the lateral femoral epicondyle. The location of the lateral epicondyle was estimated using available visual landmarks, such as the width of the lateral aspect of the distal thigh, the lateral aspect of the patella, the fibular head, and the outline of the iliotibial band. After the location of the lateral epicondyle was determined, the proximal arm was extended over the lateral midline of the thigh toward the perceived location of the greater trochanter, and the distal arm was extended along the lateral midline of the leg toward the perceived location of the lateral malleolus (Figure 6). The location of the greater trochanter was estimated using the width of the lateral aspect of the proximal thigh and the contour of the gluteus maximus, and the location of the lateral malleolus was estimated using the width of the lateral aspect of the distal leg and the contour of the upper part of the shoe. The hip-angle measurement was taken by placing the point of the angle over what the examiner perceived to be the location of the greater trochanter; the proximal arm was extended along the trunk toward the perceived location of the base of the neck, and the distal arm was extended along the lateral midline of the thigh toward the perceived location of the lateral epicondyle (Figure 6). All measurements were repeated for each of the 3 jump-landing repetitions, and the average was used for data analysis.

To establish the interrater reliability of the 2D measurements, a physical therapy student separately repeated the frontal- and sagittal-plane measurements of all participants.

**Statistical Analysis**

Descriptive statistics were used to summarize the data with measures of central tendency and dispersion for the continuous variables and frequency counts for the categorical variables. Percentage agreement and weighted $\kappa$ coefficients with 95% CIs were used as estimates of interrater reliability of the visual ratings, whereas the intraclass correlation coefficient (ICC) was used to express the interrater reliability of the 2D measurements.

For the primary purpose of the study, 2D frontal-plane knee excursions were compared among participants with differing visual ratings of frontal-plane knee movement.
using the Kruskal-Wallis $H$ test. When we observed a difference, we conducted separate pairwise comparisons using Mann-Whitney $U$ tests with a Bonferroni-adjusted $P$ value of $\leq 0.017 \ (0.05/3)$. Similarly, 2D sagittal-plane hip and knee excursions were compared among participants with different visually rated sagittal-plane hip and knee movements using a Kruskal-Wallis $H$ test, with pairwise comparisons using Mann-Whitney $U$ tests as needed. A nonparametric analysis was selected due to the relatively small and uneven sizes of the subgroups created by the visual ratings (Table 2). All analyses were conducted using SPSS (version 21; IBM Corp, Armonk, NY) with the $\alpha$ level set a priori at 0.05.

**RESULTS**

Percentage agreement and weighted $\kappa$ (95% CI) for the interrater reliability of visually rated frontal-plane knee movement were 82.1% and 0.74 (0.57, 0.92), respectively, and of visually rated sagittal-plane hip and knee movement were 79.5% and 0.68 (0.48, 0.88), respectively. The ICC (95% CI) for interrater reliability of the 2D frontal-plane knee excursion, sagittal-plane hip excursion, and sagittal-plane knee excursion were 0.93 (0.87, 0.96), 0.97 (0.95, 0.99), and 0.97 (0.95, 0.99), respectively.

The 2D frontal-plane knee excursion and sagittal-plane hip and knee excursions among participants with different visually rated frontal-plane knee movement and sagittal-plane hip and knee movements (Mean ± SD)

| Knee and Hip Excursions | Visually Rated Frontal-Plane Knee Movement | Visually Rated Sagittal-Plane Hip and Knee Movements |
|-------------------------|------------------------------------------|----------------------------------------------------|
|                         | Good (n = 8)                              | Moderate (n = 24)                                  | Poor (n = 7) | $\chi^2$ Value | $P$ Value |
| 2-Dimensional frontal-plane knee excursion, % | 4.3 ± 11.0$^a$ | 16.9 ± 6.8 | 25.2 ± 7.8 | 13.00 | .001$^c$ |
|                         | Good (n = 7)                              | Moderate (n = 23)                                  | Poor (n = 9) | $\chi^2$ Value | $P$ Value |
| 2-Dimensional sagittal-plane hip excursion, ° | 49.6 ± 10.9$^a$ | 35.4 ± 10.5$^b$ | 11.3 ± 15.6 | 18.41 | <.001$^c$ |
| 2-Dimensional sagittal-plane knee excursion, ° | 75.3 ± 4.1$^a$ | 64.0 ± 9.4$^b$ | 48.8 ± 14.5 | 17.10 | <.001$^c$ |

$^a$ Different from moderate and poor ratings ($P < .05$).

$^b$ Indicates difference ($P < .05$).

$^c$ Different from poor rating ($P < .05$).
plane hip and knee movements, respectively, are summarized in Table 2. The analysis for 2D frontal-plane knee excursion revealed differences ($\chi^2 = 13.00$, $P = .001$). Pairwise comparisons indicated that participants with a good visual rating displayed less 2D frontal-plane knee excursion than participants with either a moderate ($U = 32.0$, $P = .005$) or poor ($U = 2.0$, $P = .003$) rating. Whereas participants with a moderate visual rating also displayed less 2D frontal-plane knee excursion than participants with a poor rating, this difference did not reach statistical significance ($U = 42.0$, $P = .047$).

The analysis for 2D sagittal-plane hip ($\chi^2 = 18.41$, $P < .001$) and knee ($\chi^2 = 17.10$, $P < .001$) excursions also revealed differences. Pairwise comparisons indicated that participants with a good visual rating displayed greater 2D sagittal-plane hip and knee excursions than participants with a moderate (hip: $U = 25.5$, $P = .007$; knee: $U = 18.0$, $P = .002$) or a poor (hip: $U = 2.0$, $P = .002$; knee: $U = 3.0$, $P = .003$) rating. In addition, participants with a moderate visual rating displayed greater 2D sagittal-plane hip ($U = 23.0$, $P = .001$) and knee ($U = 35.5$, $P = .004$) excursions than participants with a poor visual rating.

**DISCUSSION**

Visual ratings and 2D measurements of frontal-plane knee and sagittal-plane hip and knee movements during jump landing demonstrated substantial and excellent interrater reliability, respectively. The visual ratings were also associated with differences in the corresponding 2D measures, which is encouraging given the diminished agreement between visual ratings and quantitative measures of movement during high-speed functional tasks, such as the one used in this study.

Our findings are supported by those of authors whose visual ratings of frontal-plane knee alignment were associated with 2D and 3D measures of knee alignment during jump landing. Stensrud et al. associated visual rating of frontal-plane pelvis and knee alignment with the frontal-plane knee-projection angle, whereas Nilstad et al. reported that visual rating of frontal-plane knee alignment correlated with 3D knee abduction during jump landing. Similar to our investigation, both sets of researchers used a 3-point scale to rate frontal-plane knee alignment. In contrast, investigators using a dichotomous visual rating of knee alignment did not attain acceptable levels of agreement with 3D measures of knee alignment. It may be that the variability associated with frontal-plane knee movement during jump landing can be better expressed using a 3-point than a 2-point rating scale, as the latter may force the assignment of a good or poor score to borderline cases.

A relevant question in the context of our findings is “How well do 2D measures of knee alignment correlate with 3D measures of knee alignment?” Mizner et al. reported that a knee-to-ankle width ratio (distance between the knees divided by the distance between the ankles) represented 3D frontal-plane knee alignment better than the frontal-plane projection angle, accounting for 35% of its variance. Post hoc analysis of our data revealed the 2D measure of frontal-plane knee excursion that we used to be highly correlated with the knee-to-ankle separation ratio as described by Mizner et al. ($r = 0.73$, $P < .001$). Furthermore, this knee-to-ankle separation ratio was different among participants with different visual ratings of frontal-plane knee movement ($\chi^2 = 11.75$, $P = .003$). These findings suggest that the 2D measure of frontal-plane knee excursion we used may serve as a proxy for 3D knee movement, but a direct comparison between this method and 3D knee alignment is warranted.

To our knowledge, we are the first to report on the association between a visual rating of sagittal-plane hip and knee movement and a quantitative measure of sagittal-plane movement during jump landing. Given that decreased knee flexion has been associated with several sport-related knee disorders, this may be of considerable importance to clinicians involved in injury prevention. The findings regarding sagittal-plane hip and knee movements display several similarities with findings on the LESS. According to the LESS, knee flexion of 45° or less from initial contact to maximal knee flexion is considered inadequate. Participants in our study with a poor visual rating of sagittal-plane movement displayed an average knee flexion very similar to this cutoff threshold (48.8°). Similarly, according to the LESS, hip flexion is considered inadequate when the thigh does not flex farther on the trunk from initial contact to maximal knee flexion. Participants in our study with a poor visual rating of sagittal-plane movement displayed very limited hip flexion (11.3°). Furthermore, individuals with an overall excellent or overall poor quality of movement according to the LESS displayed knee-flexion excursions that were fairly similar to those of participants with good or poor sagittal-plane movement in our study (LESS = 71.4° and 55.5°, respectively; our study = 75.3° and 48.8°, respectively). Finally, individuals with an overall excellent quality of movement based on the LESS displayed hip-flexion excursions that were fairly similar to those of participants in our study (LESS = 49.4°; our study = 49.6°); however, the hip excursion of those with a poor sagittal-plane rating in our study was somewhat lower than that of individuals with an overall poor quality of movement based on the LESS (our study = 11.3°; LESS = 26.5°). The latter may be due to the fact that overall movement quality according to the LESS is based on factors other than sagittal-plane hip movement. Nevertheless, the similarities between these assessment methods are particularly encouraging because our ratings were based on observing movement at its natural speed compared with repeatedly pausing a video for the LESS.

Interestingly, post hoc analysis of the 2D motion data revealed a negative correlation between frontal- and sagittal-plane knee excursions during jump landing ($r = -0.39$, $P = .01$). The nature of this correlation indicates that greater frontal-plane knee movement was associated with decreased sagittal-plane knee movement. This suggests that increased frontal-plane knee movement may have compensated for decreased sagittal-plane knee movement. Such a movement strategy has been described during other functional tasks and may lead to an increased risk of injury.

The main advantage of the visual rating system we used is its clinical applicability. This quick, noninstrumented tool has been reliably applied by experienced and novice clinicians and may also be used by athletic trainers and professional coaches. Whereas we acknowledge that visual assessment is unlikely to ever replace quantitative 2D or 3D
movement analyses, it is still likely to be the most commonly used method during daily clinical practice and may be the only feasible way to conduct on-field assessments. Given its reliability and association with 2D frontal- and sagittal-plane hip and knee excursions, we believe this method of visually assessing movement quality can serve as a preparticipation screening tool for identifying athletes who need more extensive injury-prevention measures.

Our study had several limitations. First, although our findings imply that the visual rating of movement quality can detect differences in hip and knee kinematics during jump landings, the clinical meaningfulness of these differences is yet to be determined. Comparison with the literature is limited due to a lack of studies on the association between 2D motion analysis and injury risk. Comparison with studies using 3D analyses suggests that the subgroup with poor sagittal-plane movement quality in our study still displayed a greater knee-flexion angle than individuals who sustained an ACL tear or developed patellofemoral pain. However, the relatively small sample in our study and the differences in motion-analysis methods limit the comparison. Second, the visual rating of movement quality was based on observation of video playback, which may be different from real-time assessment. Whereas each video was viewed at full speed and only once, these conditions do not fully mimic real-time visual assessment. Third, 2D kinematics were measured by an examiner who was not blinded to the visual ratings of participants, possibly introducing bias into these measurements. However, the relatively long washout period between the visual and 2D analyses, along with the excellent interrater reliability of the 2D analysis, should considerably decrease this concern.

CONCLUSIONS

Visual ratings of frontal-plane knee movement and sagittal-plane hip and knee movement during jump landing demonstrated substantial interrater reliability and was associated with 2D measures of the corresponding hip and knee excursions. These findings suggest that this type of analysis may serve as a screening tool for movement quality during jump landing.

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