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The Effect of External Focus Versus Internal Focus Instruction on Jump-Landing Biomechanics in Healthy Females

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Context: There are different ways to deliver external focus (EF) and internal focus (IF) instruction. Understanding each modality better will help to develop more effective interventions to reduce injury risk.

Objectives: To investigate the difference in landing biomechanics between participants who received EF and IF instruction and control participants. A secondary aim was to evaluate participant perceptions of focus of attention.

Design: Randomized controlled trial.

Setting: Laboratory.

Patients or Other Participants: Forty-one healthy women (EF: n = 14, 23.0 ± 2.9 years, 1.69 ± 0.07 m, 64.0 ± 6.8 kg; IF: n = 15, 22.9 ± 3.2 years, 1.66 ± 0.08 m, 66.2 ± 12.4 kg; control: n = 12, 21.1 ± 2.9 years, 1.67 ± 0.11 m, 74.3 ± 15.1 kg).

Main Outcome Measure(s): Participants scoring greater than or equal to 5 on the Landing Error Scoring System were allocated into the EF, IF, or control group. Knee and hip flexion and abduction were collected pre- and postintervention during 5 drop vertical jumps. For the intervention, each group was provided separate instructions. In between the intervention jumps, participants answered, "What strategy were you focusing on when completing the previous jump-landing trials?" Postintervention minus preintervention change scores were calculated, and separate 1-way analysis of variance assessments were performed to determine differences in the dependent variables.

Results: Individuals in the EF group had a greater change in hip and knee flexion angles than individuals in the control group. There was no significant difference between the EF and IF groups for any variables. There were no significant differences in frontal plane variables. In the EF group, 71.4% aligned with the instructions given; in the IF group, 80% aligned; and in the control group, 50% aligned.

Conclusions: External focus instruction may not produce immediate changes in movement compared with IF instruction. Hip and knee flexion were greater in the EF group than in the control group but was not better than that in the IF group. Clinicians should provide instructions to patients, but the mode of instruction may not be as critical to see positive biomechanical changes. Patients may not always focus on the instruction being given; therefore, the relationship between instruction and patient experience should be further explored.

Key Words: feedback, lower extremity biomechanics, injury prevention

Key Points

- The external focus of attention group had increased knee and hip flexion after landing compared with the control group.
- External focus of attention may not be superior to internal focus of attention in improving jump-landing biomechanics.
- Patients participating in jump-landing interventions may not always focus on the instruction given; further research should explore the patient's perceived focus of attention.

It is widely known that anterior cruciate ligament (ACL) injury is common in females.[1–3] Exercise intervention programs have become popular to attempt to decrease the rate of ACL injuries.[4] Many interventions have focused on jump-landings because an improper jump-landing technique is a contributing factor to noncontact ACL injuries.[2] Different forms of feedback and/or instruction have been used in these interventions that have demonstrated favorable results in decreasing load by increasing knee and hip flexion or reducing ground reaction forces during jump-landing.[5–12] It has been reported that participation in ACL injury intervention programs can reduce the risk of noncontact ACL injury up to 70%.[13] However, ACL injury rates are still high in physically active populations, suggesting that something is missing between positive outcomes in the laboratory setting and clinical outcomes on the field or court.[1,14] To bridge this gap, interventions should consider the influence of focus of attention on motor learning and movement changes. Within the motor-learning domain, it is well accepted that *external focus* (EF) instruction may provide benefits over *internal focus* (IF) instruction when trying to target biomechanical risk factors that may increase ACL injury risk and increase movement efficiency.[15,16] An EF of attention is when a participant focuses attention outside of the body while completing a task, whereas IF of attention is when a participant focuses attention on the body while completing a task.[17] More recently, clinicians have been using EF over IF when developing intervention programs to improve jump-landing mechanics while still being able to accomplish performance-based goals.[18–20]

Several studies have included focus of attention as a part of interventions to improve jump-landing biomechanics; however, no studies have investigated biomechanical differences in a healthy population that exhibits landing mechanics that may place this population at an increased risk for ACL injury.[10,18,20–25] Interventions that have investigated similar EF and IF differences included different patient populations, such as patients with ACL reconstruction and soccer players during an on-the-field intervention, and have investigated different outcome variables, such as performance.[19,20,25] There are many different options for interventions using EF and IF that may be effective in changing jump-landing biomechanics, which may place someone at increased risk for ACL injury. The way certain interventions are organized (ie, instructions used and how they are given) is important to explore because participants may have a more favorable response to the way certain interventions are delivered. Researching a variety of ways to deliver EF and IF will help clinicians and researchers better understand each of these modalities and will provide clinicians and patients more autonomy in the choices of interventions, which could lead to better jump-landing and injury risk outcomes.

Although studies have indicated that EF instruction is superior to IF instruction, research has shown that IF instruction is more commonly used by physiotherapists rehabilitating patients who have had a stroke or experienced an upper extremity motor deficit.[17,26] Internal focus instruction may be more commonly used in patients with stroke or motor deficits because the modality could be a more direct way to relay information to the patient, and this could be the case in sports medicine as well. Altering attentional strategies could be counterproductive to individuals when they have already established a preferred type of instruction; therefore, it is important to determine participants' perceptions of the instruction that they are given.[27] We do not know if participants who receive EF instruction perceive that they are either externally or internally focused or if they are applying the type of instruction that they were given. Due to the commonality of IF instruction, participants in the EF or control group may report focusing on internal cues even though they were not given that type of instruction. Collecting information on participants' perceptions is vital to a deeper understanding of how focus of attention modalities work.

The primary aim of this study was to investigate the difference in landing biomechanics between participants who received EF instruction and IF instruction and a control group that only received instruction on task completion. We hypothesized that participants who received EF instruction would demonstrate increased hip and knee flexion and decreased knee abduction angles following the instruction compared with those receiving IF instruction and the control group. The secondary exploratory aim of this study was to evaluate whether participants self-reported that they focused on the instruction they were given. We hypothesized that the EF group would report focusing on the external cues given, the IF group would report focusing on the internal cues given, and the control group would report focusing on the instruction given.

METHODS

This was a randomized controlled trial conducted in a laboratory setting. Participants attended a single testing session where pretest, jump-landing intervention, and posttest measures were collected.

Table 1. Participant Demographics[a]

Group	n	Age, y	Height, m	Weight, kg
External focus	14	23.0 ± 2.9	1.69 ± 0.07	64.0 ± 6.8
Internal focus	15	22.9 ± 3.2	1.66 ± 0.08	66.2 ± 12.4
Control	12	21.1 ± 2.9	1.67 ± 0.11	74.3 ± 15.1

[a] There were no statistically significant differences between groups in the demographics.

Participants

Forty-one healthy women with no history of ACL injury, lower extremity fracture, or surgery volunteered to participate in this study (Table 1). Sample size was estimated using means and SDs for knee flexion angles from a previous study with a similar design.[7] Participants self-reported they were free of injury for 6 months before testing, had no current pain, and were recreationally active at least 3 times per week for 30 minutes each time. This study was approved by the university Institutional Review Board.

Participants first read and signed the informed consent to participate and were then prescreened with the Landing Error Scoring System (LESS) live.[28] To be included in the study, participants had to demonstrate *poor* landing biomechanics as determined by a score of greater than or equal to 5 on the LESS. Higher LESS scores would ensure that participants had the potential to change their landing mechanics as a result of the intervention. Included participants then completed the Godin exercise questionnaire and previous injury history questionnaire.

Preintervention Data Collection

Biomechanical measures for all participants were collected pre- and postintervention within the same day. To perform a static calibration of the 10-camera motion-analysis system (Motion Analysis Corporation), 49 reflective markers were placed on the following anatomical landmarks: sternum, cervical spine, right scapula (offset marker), bilateral acromioclavicular joints, anterior superior iliac spines, posterior superior iliac spines, iliac crests, greater trochanters, thigh cluster (4 markers), medial knee, lateral knee, shank cluster (4 markers), medial and lateral malleolus, heel cluster (4 markers), and first and fifth metatarsal heads. Sixteen markers were removed following the static calibration, and 33 markers remained for the jump-landing data collection.

Baseline kinematic data were collected preintervention while the participants performed 5 drop vertical jumps from a 30-cm-high box placed half the participant's height away from the target landing area. Participants were instructed to jump to the landing area, land with both feet, and immediately rebound for maximum height.[29] Participants were allowed 3 practice trials to familiarize themselves with the task, and 5 successful trials were recorded. After baseline trials were collected, the researcher opened a numbered envelope to randomly allocate participants into 1 of 3 groups: EF, IF, or control. Participants were blinded to group allocation. The researcher who provided the instruction to the participants could not be blinded to group allocation.

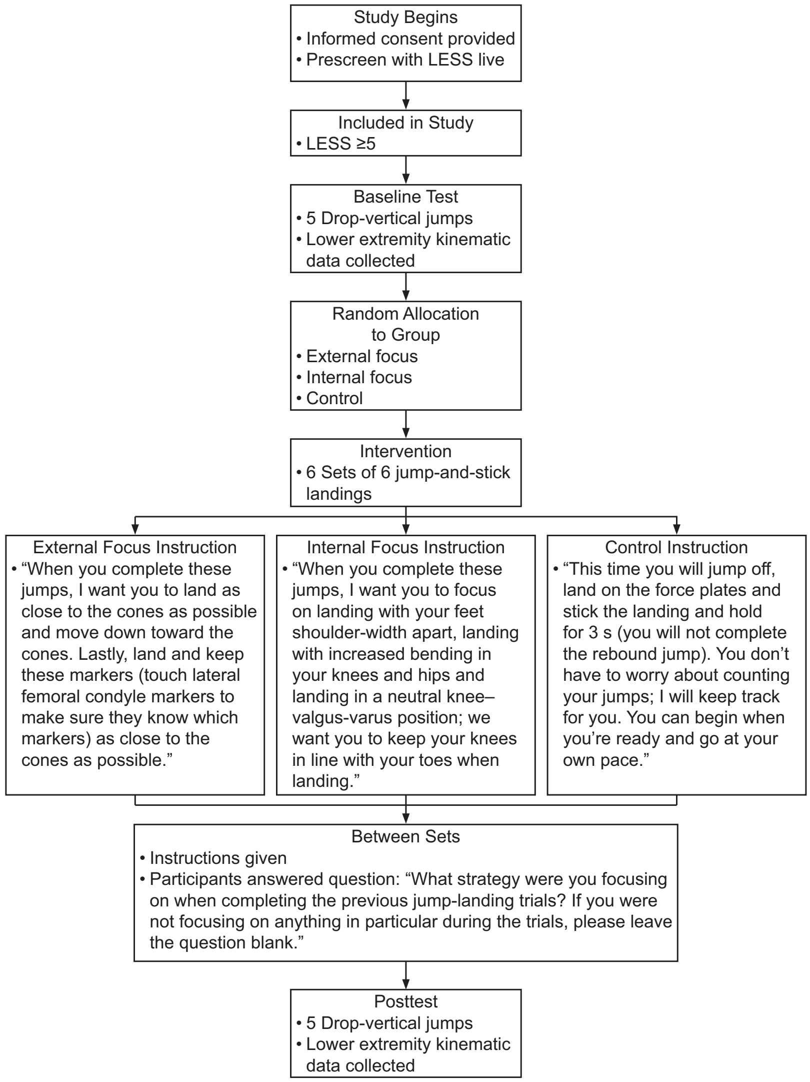

Figure. The study protocol and instructions given. Abbreviation: LESS, Landing Error Scoring System.

Intervention Protocol

For the intervention jump-landings, participants were asked to perform a "jump and stick" landing, which was different from the baseline drop vertical jump task.[6] Participants were instructed to perform 6 sets of 6 jump and stick landings off the same 30-cm box, land on the target landing area, stick the landing, and hold for 3 seconds. There was no rebound jump for the jump and stick task. Each group was provided separate instructions, which are detailed in the Figure. In between each set of 6 jump and stick landings, participants in each group were asked to write their answer to a single open-ended question, "What strategy were you focusing on when completing the previous jump-landing trials? If you were not focusing on anything in particular during the trials, please leave the question blank." The researcher asked the participants to complete the question as honestly as possible and indicated that there was no incorrect response. The only additional information given by the researcher was to leave the question blank if they did not think that they were focusing on anything. Between each set of jumps, participants were also reminded of the initial instructions given to them at the beginning of the intervention based on their allocated group.

Postintervention Data Collection

Participants were posttested in the same manner as the baseline test. The study flow is detailed in the Figure.

Data Analysis

Three-dimensional kinematic data were filtered using a fourth-order Butterworth filter with a cutoff frequency of 12 Hz. The segment coordinate systems for the lab follow the right-hand convention. The *x* axis aligned with the medial-lateral direction, the *y* axis aligned in the anterior-posterior direction, and the *z* axis aligned in the vertical direction. Kinematic data were collected at a sampling rate of 200 Hz and filtered with a low-pass Butterworth filter at a cutoff frequency of 12 Hz. Visual 3D software (C-Motion, Inc) was used to calculate 3-dimensional joint angles. We extracted the following variables at the point of peak knee flexion during the jump-landing task: knee and hip flexion (positive rotations) and knee and hip abduction (positive rotations); these variables were chosen because they have been previously associated with increased ACL injury risk.[2] The dependent variables of interest were averaged over the 3 middle trials, and change scores (postintervention minus preintervention) were calculated and used for statistical analysis.

Each written question response was transcribed verbatim electronically for ease of use. The written responses that coordinated with the 3 trials used for kinematic analysis were extracted. Using Template Analysis, we explored the first 10 participants allocated to various groups independently before beginning the preliminary coding process.[30,31] An a priori code named *alignment*, defined as the relationship between the instruction the participants received and what the participants perceived to be focused on during the intervention, was developed based on those 10 participants and was applied to the rest of the participants' responses. A participant was considered *aligned* when they reported that their perception of focus was on 1 or more of the instructions received in the intervention in at least 2 of the 3 jump-landings. A participant was considered *unaligned* when the participant reported that their perception of focus was on a different type of instruction or on something other than the instructions given in the intervention. Preliminary coding supported the use of our a priori theme alignment. The codes aligned and unaligned were then applied to the remaining data. Two researchers independently coded the responses, which were then discussed, and agreement was met regarding the final categories. Once all participant responses were reviewed, frequencies of aligned and unaligned by instruction group were recorded and expressed as percentages. To explore these data further, within the unaligned group, we determined the number of participants who focused on a different instruction type. For example, those who were unaligned with the instruction in the control group were reviewed to determine if they were focused on the instructions given for the EF or IF groups. The Figure details the instructions given.

Statistical Analysis

A 1-way analysis of variance (ANOVA) was used to assess differences among groups in demographic and biomechanics variables at baseline. Next, separate 1-way ANOVAs were used to assess differences in hip flexion and knee abduction change scores among groups. The a priori α level was set at $P \leq .05$ for significance of the omnibus 1-way ANOVA. If a significant difference was found, planned contrasts to compare each individual instruction group with the control group and with each other were performed to identify group differences. To account for multiple comparisons in the contrast tests, the P value was adjusted to $P \leq .016$ with Bonferroni correction.

The assumption of equal variances was not met for the hip abduction and knee flexion variables; therefore, the Welch test was used to assess differences for these variables. The a priori α levels were set at $P \leq .05$ for the omnibus test and $P \leq .016$ for the Bonferroni corrected planned contrasts. All statistical analyses were performed with SPSS version 25.0 software (SPSS, Inc).

RESULTS

The groups were similar in age ($P = .218$), height ($P = .629$), weight ($P = .080$), and Godin score ($P = .322$). There were no significant differences among groups for any of the dependent variables or biomechanical variables at baseline ($P > .05$). Forty-two potential participants were screened with the LESS to determine if they met the study qualifications. One potential participant scored less than 5 on the LESS and was therefore dismissed from the study.

The ANOVA comparing the hip flexion angle change score among groups was statistically significant ($F_{2,38} = 3.55$, $P = .039$). The EF group displayed significantly more hip flexion than the control group ($T_{2,38} = -2.58$, $P = .014$), whereas there was no difference in hip flexion between the IF and EF groups ($T_{2,38} = 0.675$, $P = .504$) or between the IF and control groups ($T_{2,38} = 1.972$, $P = .056$; Table 2). The ANOVA comparing the knee abduction angle change score among groups was not statistically significant ($F_{2,38} = 1.542$, $P = .227$).

The Welch test comparing the knee flexion angle change score among groups was statistically significant ($F_{2,24.3} = 4.55$, $P = .021$). The EF group displayed significantly more knee flexion than the control group ($T_{2,22.23} = 2.677$, $P = .014$), whereas there was no difference in knee flexion between the IF and EF groups ($T_{2,23.87} = 0.103$, $P = .919$) or between the IF and control groups ($T_{2,19.19} = -2.052$, $P = .054$). The Welch test comparing the hip abduction angle among groups was not statistically significant ($F_{2,38} = 2.191$, $P = .135$; Table 2).

Within the EF group, 71.4% of the written responses were aligned and 28.4% were unaligned with the EF instruction given by the researcher; in the IF group, 80% were aligned and 20% were unaligned with the IF instruction given by the researcher; and in the control group, 50% were aligned and 50% were unaligned with the control instruction given by the researcher. Fifty percent of those considered unaligned in the EF group reported focusing on an IF cue. Sixty-six percent of those considered unaligned in the IF group reported focusing on an IF cue that was not given by the researcher. Fifty percent of those considered unaligned in the control group reported focusing on an IF cue. The remaining participant responses deemed unaligned in the control group reported that they were focused on the completion of the task or something not relevant to their jump-landings at all or left the response blank, indicating that they did not perceive to be focused on anything.

DISCUSSION

Anterior cruciate ligament injuries are common in the physically active population.[1–3] Interventions have been deployed to try and reduce injury risk, specifically in the female population.[2,4] Motor learning research has investigated EF and IF of attention when providing instruction during interventions. External focus has been suggested to be superior to IF of attention.[17] Benjaminse et al found the transfer of increased hip and knee flexion following video instruction and EF compared with IF, and Dalvandpour et al found EF to be superior in changing hip and knee flexion biomechanics during ACL prevention exercises.[18,20] Our study aimed to investigate the difference in landing biomechanics between participants who received EF instruction and IF instruction and a control group who only received instruction on task completion. We expected the participants in the EF group to present with greater changes in landing biomechanics than participants in the IF group or the control group. Although there were no significant differences in the change in knee or hip kinematics between EF and IF, we did find a significant difference in the change in hip and knee flexion between the EF and control groups, whereas the IF group did not demonstrate a significant difference compared with the control group. We did not see any significant changes

Table 2. Pre, Post, and Change Kinematic Means and Standard Deviations

Group	Hip Flexion Angle, °			Knee Flexion Angle, °			Hip Abduction Angle, °			Knee Abduction Angle, °		
	Pre	Post	Change	Pre	Post	Change	Pre	Post	Change	Pre	Post	Change
External focus	60.9 ± 11.5	68.8 ± 12.2	7.9 ± 6.7[a]	92.7 ± 11.1	104.2 ± 10.3	11.5 ± 8.2[a]	1.7 ± 6.7	3.2 ± 6.6	−4.8 ± 5.8	1.1 ± 6.6	5.5 ± 7.8	4.5 ± 3.3
Internal focus	56.9 ± 14.1	63.1 ± 13.1	6.1 ± 6.6	85.8 ± 12.1	97.7 ± 16.2	11.9 ± 12.9	0.6 ± 5.8	0.6 ± 5.4	−1.2 ± 2.7	0.1 ± 7.6	5.8 ± 9.0	5.6 ± 5.4
Control	51.6 ± 20.6	52.5 ± 20.3	0.9 ± 7.4	87.6 ± 10.4	92.0 ± 13.5	4.4 ± 5.2	0.9 ± 6.9	1.3 ± 7.5	−2.1 ± 3.8	−0.8 ± 7.8	1.8 ± 9.4	2.6 ± 4.5

[a] Significantly different from the control.

in the frontal plane hip and knee variables for either of the intervention groups compared with the control group.

The instructions given to the EF group included landing as close to the cones as possible, moving down toward the cones, and keeping the marker placed on the lateral side of the knee as close to the cones as possible. All these instructions encouraged participants to focus on something outside of their body. The instructions given to the IF group included landing with the feet shoulder width apart, landing with increased bending of the knees and hips, landing in a neutral knee valgus/varus position, and keeping the knees in line with the toes when landing. All of these instructions encouraged participants to focus inside of their body. An important point to note is that the preintervention and postintervention jump-landing was a rebound jump-landing task, and the intervention jump-landing was a jump and stick task. The reason this was done was to allow the participants more time to focus on the instruction given during the intervention jump landings. Following the intervention during the rebound jump-landing task, participants in both the EF and IF groups increased hip and knee flexion, demonstrating that the intervention created the desired improvements in sagittal plane variables; however, the EF group was the only group that was significantly different than the control group. Changes in frontal plane variables were smaller and nonsignificant, suggesting that this intervention did not create the desired improvements in frontal plane variables even though participants were provided instruction directly related to changing frontal plane variables. It should be noted that the room for change in frontal plane variables may be less than the room for change in sagittal plane variables.[32]

Although previous investigators did find superior changes in jump-landing mechanics when comparing the EF group with the IF group, we did not find a significant difference between EF and IF instructions, and the EF group was the only group that was significantly different from the control.[18,19] This suggests that either intervention may be helpful in changing jump-landing mechanics that may place someone at an increased risk for injury. When we compared the current investigation with others, the instructions provided in the current investigation were more specific than EF and IF instructions provided in other investigations.[18,19] We included instructions that corresponded to the desired improvements we wanted to see in jump-landing mechanics (ie, an EF of moving down toward the cones and an IF of increasing bending in the knees). A few reasons why we may not have seen differences in jump-landing mechanics between the 2 instruction groups is that an EF of attention does not necessarily provide a mechanism for how a person can make the appropriate changes to improve errors in technique.[33] Even though specific instructions related to focus of attention were given to the participants, as researchers, we are unable to control how one interprets and applies the instructions that they are given. There are also other factors that play into whether one changes their jump-landing mechanics, such as motivation, behavioral change, and attentional focus.

Because researchers are unable to control how individuals might interpret instructions given in the intervention, it is important to consider how focus of attention is perceived by the participants. For the exploratory aim of this study, we expected to find that participants reported focusing on the instructions given, whether that be external focused, internal focused, or instructions given on how to complete the task (control). Results of this investigation were not what we expected. In the EF group, 28.4% of the participants self-reported to be unaligned with the EF instructions given. Of those in the EF group that were unaligned, 50% reported focusing on internal instructions even though they were not provided any IF instruction. Within the IF group, there were participants who reported focusing on IF cues that were not given to them during the intervention instead of the IF cue that the researcher gave them. Fifty percent of those who received task-oriented instructions (control group) reported focusing on an IF cue not given to them. One possible reason for these findings is that participants may have been more familiar with IF instruction. Both EF and IF have been identified as common directional attentions that most people are comfortable shifting between psychologically.[34] When considering which instructional type to use, it might be beneficial and more impactful to use whatever the participant is comfortable with. In fact, it has been previously speculated that altering attentional strategies could be counterproductive to individuals when they have already established a preferred type of instruction.[27] Psychological tools to evaluate attentional focus types should be developed to determine which type of focus may be preferred for individual participants and patients. Tools of this type may be useful for athletes who could benefit from changing movement patterns. Perhaps individuals could take the survey to find out which type of attentional focus may best fit them, and interventions could be tailored in that way. It has been acknowledged that cognitive and psychological processes of the participant may impact motor learning and the alterations of movement and biomechanics.[35] Therefore, in our future work, we intend to further analyze the results of our exploratory survey. Specifically, we aim to examine how familiarity of instruction, self-reported perceptions of attentional focus, and ability to understand the task goal instruction can impact motor learning and/or biomechanics.

This study is not without limitations. We provided different types of instruction, which have not been previously validated; however, we developed the instructions during the pilot testing phase of the study and based the development on examples from previous studies as well as common clinical practice. It should be noted that we did not use a rigorous qualitative approach to the secondary exploratory aim of this project, which may have limited the sensitivity to finding trends in the data. Although we used a more quantitative approach to the examination of survey results for this study, we aim to further examine these results and hope that these exploratory data provide information for future researchers. The study design was a single test session. Although there were multiple sets to practice the jumps, it is possible that a strong movement effect could have occurred if the intervention was repeated over multiple days. Ultimately, we want to see the changes produced in the lab transfer to other athletic activities outside of the lab; thus, more research to test retention and transfer should be conducted.

When providing jump-landing instruction, EF instruction may not produce superior results to produce an immediate change in movement compared with IF instruction. However, both types of instruction were shown to improve hip and knee flexion during jump-landing compared with the control group's instruction. Therefore, clinicians should provide instructions to patients when poor jump-landing mechanics are present, but the mode of instruction (EF or IF) may not be as critical to see positive biomechanical changes. This study also found that patients may not always be focused on the instruction being given to them by researchers and clinicians, suggesting that the relationship between instruction and the patient's experience should be further explored.

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