



The effects of instructional cues on performance and mechanics during a gross motor movement

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ABSTRACT

Externally focused instructions specific to performance have shown to improve body mechanics (Gokeler et al., 2015; Welling, Benjaminse, Gokeler, & Otten, 2016). However, the effect of using an external focus instruction may have been more profound if the content of the instruction had been relevant to mechanics. Therefore, the present study examined the effects of externally focused instructions specific to performance and externally focused instructions specific to body mechanics on mechanics and performance. Twenty-four adults ($n = 12$ males; $n = 12$ females) performed a series of drop jumps following external focus cues that were specific to performance and landing mechanics. Participants completed a drop jump followed by a maximal effort vertical jump. The initial contact, maximal angle, and range of motion at the knee in the sagittal and frontal plane motion were measured for mechanics and the height of the second vertical jump was measured for performance. The results suggest external focus instructions specific to performance are beneficial for performance, but not for improving landing mechanics. This suggests that external focus instructions must be specific to the contents of the instruction.

1. Introduction

Attentional focus strategies in motor behavior have been investigated in a variety of paradigms such as explicit and implicit (Green & Flowers, 1991; Lam, Maxwell, & Masters, 2009; Masters, 1992), associate and dissociate (Morgan & Pollock, 1977), skill-focused and extraneous (Beilock, Carr, MacMahon, & Starkes, 2002; Beilock, Wierenga, & Carr, 2002; Gray, 2004), broad and narrow attention (Nideffer, 1976), and external and internal focus (Wulf, Höß, & Prinz, 1998). Wulf et al. (1998) have shown that using an external focus of attention is more beneficial for performance (directing performer's attention to the effects of the movement on the environment) relative to internal focus (directing performer's attention to the body movements). When these benefits were explored further and narrowed to specific motor skills, the findings have been widely replicated in numerous skills such as: dart throwing (Lohse, Sherwood, & Healy, 2014; Marchant, Clough, & Crawshaw, 2007), golf (Christina & Alpenfels, 2014; Wulf, Lauterbach, & Toole, 1999), volleyball serves (Wulf, Mcconnel, Gärtner, & Schwarz, 2002, Exp. 1), basketball shooting (Zachry, Wulf, Mercer, & Bezodis, 2005), standing long jump (Ducharme, Wu, Lim, Porter, & Geraldo, 2016; Porter, Anton, Wikoff, & Ostrowski, 2013; Porter, Ostrowski, Nolan, & Wu, 2010), vertical jump (Wulf & Dufek, 2009; Wulf, Zachry, Granados, & Dufek, 2007), agility (Porter, Nolan, Ostrowski, & Wulf, 2010), and balance (McNevin, Shea, & Wulf, 2003; Wulf et al., 1998; Wulf, McNevin, & Shea, 2001; Wulf, Shea, & Park, 2001).

The beneficial effects of using an external focus has been explained by the constrained action hypothesis (McNevin et al., 2003; Wulf, McNevin, et al., 2001; Wulf, Shea, et al., 2001), proposing that the conscious control of one's body acts as a constraint on motor

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coordination, while attention directed to the results of the movement promotes automated processing. This has been supported by studies using electromyography (EMG), showing lesser neuromuscular activation in an external focus condition (i.e., less control necessary for enhanced performance) (Marchant & Greig, 2017) with poorer performance when internal focus is adopted relative to external focus (Lohse, Sherwood, & Healy, 2010; Marchant, Greig, & Scott, 2009; Wulf, Dufek, Lozano, & Pettigrew, 2010; Zachry et al., 2005). Studies in movement coordination have also demonstrated automaticity, with an external focus showing greater mean power frequency (MPF) relative to internal focus for balance, which is indicative of well-learned coordination (McNevin et al., 2003; Wulf, McNevin, et al., 2001).

Although the benefits of using an external focus are robust, the primary goal of the tasks in the above-mentioned studies was to improve performance. For motor skills that require object manipulations, the content of the external focus instruction would be “focus on flight of the dart” (Lohse et al., 2014). For motor skills that do not require object manipulation, the instruction would be “focus on jumping as close to the cone as possible” (Ducharme et al., 2016). In some situations, however, the goal of the skill is to correct movement mechanics, and in these specific scenario’s external focus instructions should be specific to mechanics. When motor skills require object manipulation, directing attention to the effect of the object’s movements would change the body mechanics (e.g., motion of the clubhead in Christina and Alpenfels (2014)). However, when the motor skill does not require object manipulation and is specific to teaching mechanics (e.g., safe landing mechanics), there is no external cue to direct performers’ attention to. Thus, providing an external focus instruction specific to body mechanics without referring to body parts becomes challenging when the goal is to correct the mechanics. Only a limited number of studies have examined the effect of external focus instructions specific to body mechanics (Abdollahipour, Wulf, Psotta, & Palomo Nieto, 2015; Gokeler et al., 2015; Lawrence, Gottwald, Hardy, & Khan, 2011; Welling, Benjaminse, Gokeler, & Otten, 2016). Therefore, further investigations and modifications regarding external focus instructions with a goal to correct mechanics in motor skills that do not require object manipulation are required.

For motor skills in which the goal of the skill is to correct movement, rather than performance, previous research has demonstrated that using externally focused instructions improves safe landing mechanics (Gokeler et al., 2015; Welling et al., 2016). However, the instructions that they provided were specific to performance, even though the goal of the skill was to correct movement. It is possible that the benefits of external focus would be more profound if the instructional cues were specific to mechanics. Therefore, the purpose of this study was to compare externally focused instructions specific to performance with an external focus instruction specific to mechanics. We hypothesize external focus instructions specific to performance (external focus-performance) will be superior to baseline (i.e., “do your best” with no external focus instructions) and external focus instructions specific to mechanics (external focus-mechanics). We also hypothesize that an external focus-mechanics will improve mechanics more than external focus-performance and baseline would. We chose not to include an internal focus condition based on previous literature showing the superior effects of an external focus of attention using tasks that examine jump performance (Ducharme et al., 2016; Gokeler et al., 2014; Porter et al., 2010; Welling et al., 2016; Wulf & Dufek, 2009; Wulf et al., 2007).

2. Methods

2.1. Participants

Twenty-four university students, 12 males ($M = 22.42$ yrs, $SD = 3.55$ $M_{body\ mass} = 78.64$ kg, $SD = 15.49$ $M_{height} = 178.46$ cm, $SD = 9.15$) and 12 females ($M = 20.42$ yrs, $SD = 0.90$ $M = 66.58$ kg, $SD = 12.29$ $M = 165.17$ cm, $SD = 4.80$) were recruited for this study. Exclusion criteria included injuries or pain in the lower extremity, history of surgery 6 months prior to participation. Upon the approval of the university’s Ethical Committee, all participants completed an informed consent.

2.2. Apparatus and task

The present study used a previously validated modified drop jump task (Padua et al., 2009). Participants stood on a 30 cm box and jumped forward to a landing area. Immediately following the landing, participants attempted a second vertical jump. The distance from the step to the landing area was adjusted to 50% of individual’s height. A Vertec (Sports Imports, OH) was placed to the left of the landing area to measure the second vertical jump performance. Two cameras were placed in front and to the right of the landing area, collecting at 1080×720 pixel and 60 fps, to quantify landing mechanics. Landing mechanics were measured on the first landing from the box with the following protocols in Kinovea (Fig. 1). The second author determined the bony landmarks by palpation and marked the greater trochanter, lateral epicondyle of the femur, and lateral malleoli with pieces of tapes (2×2 cm). Following data collection, a research assistant used a Kinovea software and drew extended lines that pass through the greater trochanter and lateral epicondyle markers and lateral epicondyle and lateral malleolus markers (Fig. 1). Then, the marginal points of the two lines were marked. This mark was defined as the knee axis. The angle between the two lines around the knee axis served as knee flexion angles in the sagittal plane. Valgus angle was measured by drawing lines that pass through the mid-point of the ankle, mid patella (i.e., red tapes), and mid-point of the upper legs. The marginal points of the two lines were marked and used to determine the knee axis of the frontal plane. For knee flexions, greater angle represents greater knee flexion. For knee valgus movements, zero degree represents neutral position, negative degrees represent valgus, and positive degrees represent knee varus movements.

Using Kinovea, the following lower limb kinematics were measured: knee flexion angle at the initial contact (knee IC), peak knee flexion angle (knee Max), knee valgus angle at the initial contact (Valgus IC), and peak knee valgus angle (Valgus Max). IC was operationally defined as the frame that the entire feet came in contact with the floor (Padua et al., 2009). Valgus angle was defined as the displacement of the knee joints in the frontal plane (Fig. 1). Prior to the collection, reliability was tested (i.e., intra-class

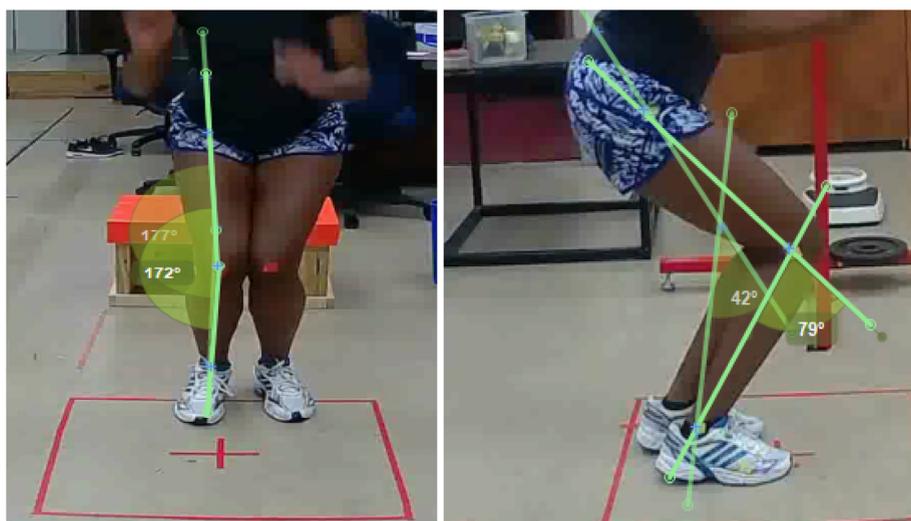


Fig. 1. Picture (Left) shows how knee valgus angle at Initial Contact and maximal angle were determined. Angles were subtracted by 180, thus zero degree shows neutral position, positive degrees indicates varus, and negative degrees indicates valgus movements. Picture (Right) shows how knee flexion angles were determined.

correlation (ICC) and standard error of measurement (SEM). A research assistant blinded to the conditions measured a sample of ten pilot subjects on two different occasions with the 48-h interval between the sessions. The results of the reliability test were $ICC_{3,1} = 0.94$, $SEM = 2.32$ for Valgus IC, $ICC_{3,1} = 0.97$, $SEM = 4.12$ for valgus Max, $ICC_{3,1} = 0.84$, $SEM = 3.84$ for Knee IC; and $ICC_{3,1} = 0.95$, $SEM = 3.98$ for knee Max. The reliability of knee ROM and Valgus ROM was not reported since it is the difference between the IC and Max angles.

2.3. Procedure

Participants completed a 5-min stationary cycling warm-up followed by a 5-min dynamic warm up of 10 lunges, 10 body weight squats, and 10 hops with brief rests in between exercise. Following the warm up, participants received general instructions about the drop jump. Specifically, participants were asked (1) to jump and land with both feet; (2) to minimize vertical displacement on the first jump (i.e., jump forward rather than up); (3) to attempt a second vertical jump immediately after landing from the drop jump; and (4) to reach with both hands to the highest Vertec rung during the second jump. Prior to data collection, two pieces of red tape were attached to the mid-patella, two pieces of green tape were attached to the tips of the shoes, and yellow tapes were attached to the fifth metatarsal, lateral malleolus, lateral epicondyle of tibia, and greater trochanter. Additionally, all participants practiced the standardized jump for 4 trials to become familiarize with the task and understand the protocols. Following this procedure, participants completed 3 baseline trials and were asked to “jump forward and jump as high as you can”. Participants then completed 3 trials counterbalanced across participants using external focus-performance and 3 trials with external focus-mechanics. For the external focus-performance condition, participants were reminded, “when jumping vertically, focus on the rungs on the Vertec, reaching as high as you can” (Wulf & Dufek, 2009). For the external focus-mechanics condition, participants were told, “when landing from the box, focus on pushing the red tape forward (to improve knee flexion angle), and pointing the green tape forward (to promote a neutral knee alignment).” If a jump failed to meet the above-mentioned four general instructions, another jump was recorded.

2.4. Analysis

2.4.1. Landing mechanics

Based on previous literature that has examined gender differences in the landing kinematics (Decker, Torry, Wyland, Sterett, & Richard Steadman, 2003), the analysis for the present study was conducted with separate 2 (Gender) \times 3 (Condition) ANOVA with repeated measures on the second factor was conducted for knee flexion at IC, knee Max, knee ROM, Valgus at IC, Valgus Max, and Valgus ROM. If a main effect was found on the condition factor, *post hoc* analysis was conducted for pairwise comparison among the three conditions with Bonferroni correction of Type I error. For all the analyses, alpha was set *a priori* at 0.05.

2.4.2. Performance

Similarly, substantial gender effects in maximal strength and power have been reported (Mayhew & Salm, 1990; Stephens, Lawson, DeVoe, & Reiser, 2007). Therefore, for the performance of the second vertical jump, a 2 (Gender) \times 3 (Condition) ANOVA with repeated measures on the second factor was conducted. The same *post hoc* analysis with Bonferroni correction of Type I error was conducted if there was a significant result on the condition factor. For all the analyses, alpha was set *a priori* at 0.05 and effect

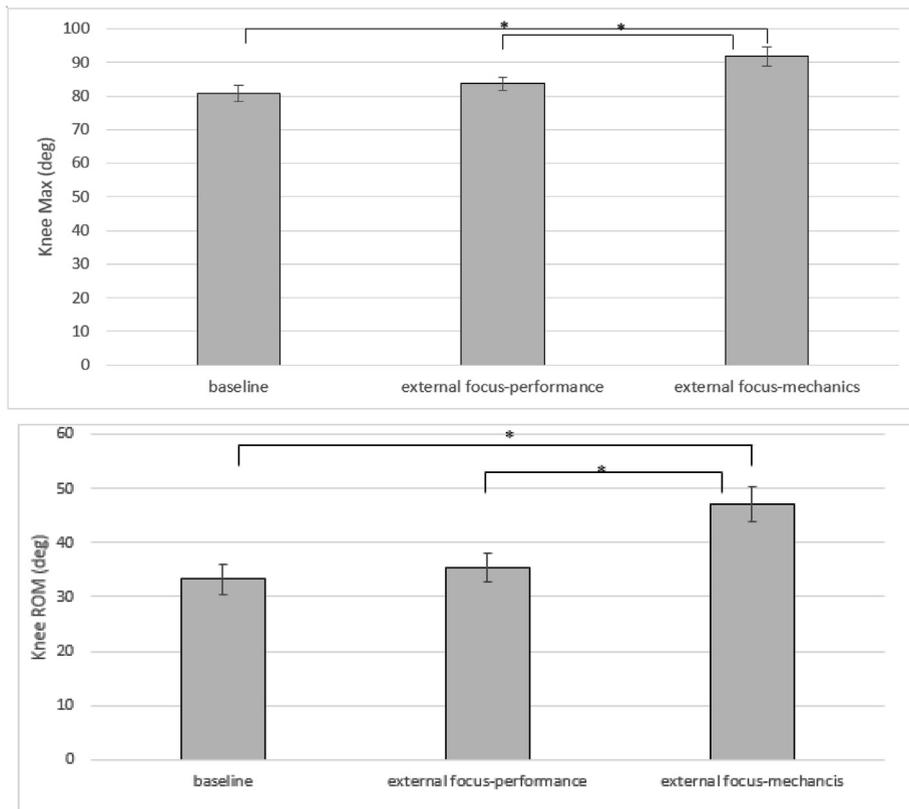


Fig. 2. Knee maximum flexion angle (top) and knee ROM (bottom) at the landing. Asterisks show significant differences between conditions: External focus-mechanics instruction led to greater peak knee flexion relative to the baseline and External focus-performance instruction. There was no difference between baseline and External focus-performance. Asterisks represents $p < .05$.

size (η^2) were reported with SPSS (IBM, version 25).

3. Results

3.1. Landing mechanics: knee flexion angle at initial contact

For the knee IC, there was no effect for condition ($F_{2,44} = 2.12, p > 0.12, \eta^2 = 0.09$), gender ($F_{1,22} = 0.21, p > 0.64, \eta^2 < 0.01$) or interaction ($F_{2,44} = 0.85, p > 0.43, \eta^2 = 0.04$).

3.2. Landing mechanics: knee maximal flexion angle

For the knee Max, there was a main effect for condition ($F_{2,44} = 24.08, p < .01, \eta^2 = 0.52$), but no difference was found for gender ($F_{1,22} = 2.23, p > 0.14, \eta^2 = 0.09$) and interaction ($F_{2,44} = 1.99, p > 0.14, \eta^2 = 0.08$). *Post hoc* analysis revealed that the knee Max angle was greater in the external focus-mechanics condition than the baseline, $p < .001$, and the external focus-

Table 1

Knee max and ROM angles in degree (SD) between conditions.

	Knee Max			Knee ROM		
	Base	EXF-P	EXF-M	Base	EXF-P	EXF-M
Males	83.13 (14.17)	85.86 (10.81)	96.96 (14.68)	34.24 (17.42)	36.38 (14.38)	52.63 (16.27)
Females	78.38 (9.29)	81.43 (8.27)	86.67 (11.12)	32.31 (10.15)	34.52 (12.36)	41.50 (12.87)
Total*	80.75 (11.97)	83.64 (9.68)	91.83 (13.78)	33.27 (13.98)	35.44 (13.14)	47.06 (15.43)

Note. EXF-P = External focus-performance, EXF-M = External focus-mechanics, Base = Baseline measures. EXF-M showed significantly greater angles in both Knee Max angle and ROM relative to EXF-P and Base.

* Data used for Fig. 2 are the results of Total (average of both genders) since no gender or interaction was found to be significant.

Table 2
Valgus angles in degree (SD) between conditions by gender.

	Valgus IC			Valgus max			Valgus ROM		
	Base	EXF-P	EXF-M	Base	EXF-P	EXF-M	Base	EXF-P	EXF-M
Males	2.86 (11.82)	3.49 (9.99)	7.81 (7.80)	7.82 (16.43)	10.17 (16.66)	10.64 (22.47)	4.96 (9.38)	6.68 (3.66)	2.83 (16.44)
Females	0.43 (5.44)	0.56 (5.37)	2.08 (6.36)	-7.83 (13.60)	-10.53 (10.85)	-7.44 (22.47)	-8.26 (13.95)	-11.08 (9.95)	-9.53 (11.43)

Note. EXF-P = External focus-performance, EXF-M = External focus-mechanics, Base = Baseline measures. Positive values mean varus and negative values mean valgus angle. Neutral (zero degree) means the upper and lower leg aligned straight. Significant difference was found only in Valgus IC. However, a *post hoc* failed to detect significance that overcame adjusted $p = .05$.

performance condition, $p < .001$, where no difference was found to be significant between external focus-performance and baseline conditions, $p > .17$. Fig. 2 shows the difference between conditions in knee maximal flexion angle. Table 1 shows the means and standard deviations of the knee IC, Max, and ROM in males and females. For the knee ROM (i.e., knee Max – knee IC), a main effect was found for condition ($F_{2,44} = 20.07$, $p < .01$, $\eta^2 = 0.48$) with no significance for gender ($F_{1,22} = 0.95$, $p > 0.33$, $\eta^2 = 0.04$) or interaction ($F_{2,44} = 2.59$, $p > 0.08$, $\eta^2 = 0.11$). *Post hoc* revealed that the knee ROM was greater in the external focus-mechanics condition than the external focus-performance condition, $p < .001$, and the baseline, $p < .001$, where no difference was found between baseline and external focus-performance conditions, $p = 1.00$ (Fig. 2).

3.3. Landing mechanics: knee valgus angle at initial contact

For the Valgus IC, a main for condition ($F_{2,44} = 3.43$, $p > .03$, $\eta^2 = 0.14$) was found. There was no difference for gender ($F_{1,22} = 1.60$, $p > 0.21$, $\eta^2 = 0.07$) or interaction ($F_{2,44} = 0.83$, $p > 0.43$, $\eta^2 = 0.04$). For the condition factor, however, after adjusting for Type I error in *post hoc*, no difference was found. Although with large effect size, there was no difference between baseline, external focus-performance, external focus-mechanics. Table 2 summarizes the results of the Valgus IC, Valgus Max, and Valgus ROM.

3.4. Landing mechanics: maximal knee valgus angle

No difference was found for condition ($F_{2,44} = 0.23$, $p > .74$, $\eta^2 = 0.01$) or interaction ($F_{2,44} = 0.49$, $p > 0.61$, $\eta^2 = 0.02$), but there was a main effect for gender ($F_{2,22} = 9.98$, $p < .001$, $\eta^2 = 0.31$). Males showed varus motions relative to the neutral position while females showed valgus motions, indicating differential knee movement pattern was detected between genders with no influence by attentional focus manipulations (Table 2). For the valgus ROM, there was no difference for condition ($F_{2,44} = 0.32$, $p > .72$, $\eta^2 = 0.02$) or interaction ($F_{2,44} = 0.93$, $p > 0.40$, $\eta^2 = 0.04$). However, there was a difference for gender ($F_{1,22} = 10.527$, $p < .05$, $\eta^2 = 0.32$), showing females had greater valgus ROM than males. However, the lack of interaction indicates this difference was not caused by the attentional focus manipulations.

3.5. Performance

Main effect was found for gender ($F_{1,22} = 23.13$, $p < .01$, $\eta^2 = 0.51$) and condition ($F_{2,44} = 19.29$, $p < .01$, $\eta^2 = 0.51$), but no interaction was found to be significant ($F_{2,44} = 2.31$, $p > 0.10$, $\eta^2 = 0.10$). First, gender difference was significant as expected that males jumped higher than females, $p < .01$ (Table 3). For condition, *post hoc* revealed external focus-performance was significantly greater than baseline, $p < .001$, and external focus-mechanics, $p < .01$, where no difference was seen between the external focus-mechanics and baseline, $p > 0.39$ (Fig. 3).

4. Discussion

The present study investigated the effects of an external focus instructions specific to performance and mechanics for a drop jump. Examining both landing quality and performance, we hypothesized that external focus-performance would be more beneficial for performance relative to external focus-mechanics. In addition, we hypothesized that external focus-mechanics will be more effective

Table 3
Jump height performance in cm (SD) of the second vertical jump.

	Base	EXF-P	EXF-M
Males	54.56 (10.60)	58.19 (10.12)	55.43 (7.41)
Females	38.10 (8.20)	39.51 (8.44)	37.00 (8.31)
Total	46.33 (12.51)	48.85 (13.19)	45.22 (11.39)

Note. EXF-P = External focus-performance, EXF-M = External focus-mechanics, Base = Baseline measures. Significant difference was found for gender and condition with no interaction for gender by condition.

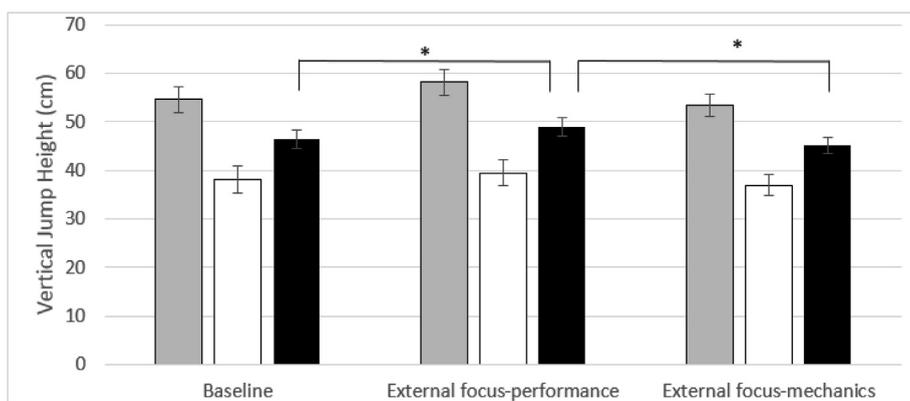


Fig. 3. Vertical jump height of the second jump with SE by gender. Males (gray) jumper higher than females (white). (black bars) External focus-performance showed significantly higher jump performance than the baseline and External focus-mechanics (shown in the asterisk). No difference was evident between Baseline to External focus-mechanics. There was no gender interaction. Asterisks represents $p < .05$.

for improving mechanics relative external focus-performance. The results of the landing quality showed that an external focus-mechanics is beneficial for improving landing mechanics relative to external focus-performance and baseline. These results support previous literature demonstrating the benefits of using externally focused instructions when the goal is to adapt body movements (Abdollahipour et al., 2015; Christina & Alpenfels, 2014; Wulf et al., 1999; Wulf, Chiviacowsky, Schiller, & Ávila, 2010). The limited literature specifically related to the quality of movement and attentional focus when the task does not require object manipulation may be attributed to the difficulty to direct an individual's attention externally for body-oriented movement (Abdollahipour et al., 2015; Gokeler et al., 2015; Lawrence et al., 2011; Welling et al., 2016). As a result, the contents of instructional cues provided in those literature (Abdollahipour et al., 2015) have been questioned for their relevance of the contents of the instructions to the goal of the task (Collins, Carson, & Toner, 2016). This limitation may have resulted in contradictory findings in that no external focus benefits were evident between external or internal focus in improving performance (de Melker Worms et al., 2017; Lawrence et al., 2011). The results from these studies suggest that providing external focus cues is difficult when the task requires no object to manipulate due to difficulty in distinction between external focus and internal focus.

Previous studies have shown that females exhibited less knee flexion and greater hip rotation, less time to peak angular displacement (Laphart, Ferris, Riemann, Myers, & Fu, 2002) and less knee angle at IC (Huston, Vibert, Ashton-Miller, & Wojtys, 2001) compared to their male counterparts which may be attributed to weaker hamstring strength (Myer et al., 2009), anatomical structure or other factors (Boden, Dean, Feagin, & Garrett, 2000; O'Malley, Rubinstein, & Postma, 2015; Shultz et al., 2015). Our results did not show gender differences for the kinematics of the sagittal and frontal plane. Our findings were similar to previous studies that have also shown no gender differences for the knee flexion angle at IC or Max (Ford, Myer, & Hewett, 2005) and no differences in valgus motions when attentional focus instructions were provided (Gokeler et al., 2015; Welling et al., 2016). One potential explanation is that biomechanical risk factors are accentuated in females who suffered from a non-contact ACL injury than healthy females (Myer et al., 2009). In addition, differences exist in the experimental designs for the present study compared to previous studies, drop landing (Laphart et al., 2002) different landing heights (Huston et al., 2001), foot placement (Kovacs et al., 1999). Although the task adopted in the present study has been shown to be reliable when identifying kinematic profiles (Padua et al., 2009; Welling et al., 2016), it is possible that the differences in the experimental designs resulted in different findings for gender differences. The results from our findings showed that attentional focus instructions equally affected the landing kinematics across genders.

External focus-mechanics was shown to decrease the flexion angle at IC, for males while increasing the knee Max (see Table 1). This further increased the knee ROM since greater differences were observed between IC and Max. Previous research has shown that knee ROM is one factor that estimates force absorption, although kinetic measures and time to peak flexion are required to thoroughly understand the mechanism of force absorption (Kulas, Schmitz, Shultz, & Watson, 2006). The results from our study show no differences at IC and significant differences in Max, suggesting that the change in the knee ROM is attributed to the change in the knee Max. We believe this result may be due to the content of the instruction adopted in the present study. The instruction (i.e., "when landing from the box, focus on pushing the red tape forward, and pointing the green tape forward" for the external focus-mechanics condition) did not specify the *timing* to push the tapes forward. Thus, providing the timing of these cues may be necessary to increase knee flexion angle at IC. Although we did not show any improvements at IC, a previous study suggested that an increased knee flexion may reduce the risk of injury (Hughes, 2014). Thus, the external focus-mechanics may be beneficial in increasing the flexion angle following the moment of landing.

Further, the present study supports previous research that has examined the effects of attentional focus and how improvements were not observed in the valgus motion (Gokeler et al., 2015; Welling et al., 2016). We anticipate that this may be due to the absence of feedback. Subtle differences in knee motions in the frontal plane may be difficult to be detected with intrinsic feedback (i.e., our own senses). As a result, providing feedback is as effective as external focus (Welling et al., 2016). Another potential is related to the instructional content. When considering the results of the baseline condition, male participants exhibited more varus knee movements (i.e., knee moving outward) while female participants moved valgus movements (Table 2). This indicates that the instruction

may have been better to be based on individuals' movement characteristics (e.g., push the tapes *outward* for females and push the tapes *slightly inward* for males). Therefore, the instruction used in the present study (i.e., push the tapes forward) about the valgus correction was not relevant to males but too subtle for females. Previous studies have suggested gender specific instruction/training to prevent non-contact ACL injuries (Benjaminse, Otten, Gokeler, Diercks, & Lemmink, 2015; Welling et al., 2016). Thus, it may be necessary for instructional methods to be based on the pre-disposed characteristics.

Results showed gender differences for jump performance. Performance results showed that males significantly jumped higher than females. This supports previous literature showing gender differences for maximum strength and power, with males typically being stronger than females (Mayhew & Salm, 1990; Stephens et al., 2007). The results from our study specific to instructional effects showed that vertical jump height was greater when the content was specific to performance relative to external focus-mechanics. Our findings support previous research examining power tasks, showing that an external focus-performance is superior to the condition when participants were asked to “do your best” (Ducharme et al., 2016; Porter et al., 2010; Wulf et al., 2007). In addition, the results from this study further support the constrained action hypothesis (McNevin et al., 2003; Wulf, McNevin, et al., 2001; Wulf, Shea, et al., 2001), demonstrating that an external focus-performance directs individuals' attention to the effects (i.e., jumping to the rung of the Vertec), which automates the motor coordination system and enhances performance.

One of the main findings of the present study is that an external focus-performance and external focus-mechanics were not equally effective to both performance and landing quality. Gokeler et al. (2015) examined a clinical population and Welling et al. (2016) examined healthy individuals; both found that using an external focus-performance improved landing mechanics. However, these external benefits were in relation to internal focus (Gokeler et al., 2014) or in the post-test in relation to the pretest rather than between conditions (Welling et al., 2016). These results implied versatility of external focus effects, but not whether an alternative external focus (i.e., external focus-mechanics) was even “more” effective. Results from this study showed external focus-mechanics was superior to the external focus-performance for landing mechanics, but not performance. Similarly, the performance of the second jump was superior in the external focus-performance than the external focus-mechanics. We believe the observed results are due to specificity of instructions. For example, Wulf, Mercer, McNevin, and Guadagnoli (2004) examined the two types of instruction in a balance task. Subjects held a bar during a balance task and were told to focus on the stability of the bar in one condition and to focus on the stability of the balance itself in another condition. The results showed both types of external foci improved the balance task. However, the instruction to the bar stability led to a greater stability on the bar relative to the instruction to the postural stability, while the instruction to the postural stability showed greater stability of the body balance relative to the instruction to the bar stability. Therefore, external focus instructions specific to mechanics will typically result in improvements to mechanics and external focus instructions for performance will result in improvements to performance.

In addition, the external focus instructions that were used in the present study did not hinder prior or post-movements regardless of the content. That is, there was no performance decrements when an external focus-mechanics instruction was used, although individuals' attention was directed to the first landing and no instruction was provided about the second jump. In the same manner, no attention was directed to landing mechanics during the external focus-performance condition. However, the external focus-performance instruction did not hinder mechanics. This could be related to attentional resources. Previous studies have shown that external focus consumes less attentional capacity (Kal, van der Kamp, & Houdijk, 2013; Wulf et al., 2001). Based on these studies, participants in the present study may not have consumed attentional resources by adopting an external focus instruction. As a result, they may have had more “room” to allocate attention to the landing mechanics during the external focus-performance conditions, and vice versa. Future studies may be directed to answer attentional capacity and multiple movements.

Conflict of interest

The authors have no financial or any other kind of conflicts in this manuscript.

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