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# Increases in Jump-and-Reach Height Through an External Focus of Attention

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## **ABSTRACT**

The present study examined whether the previously observed benefits of an external focus of attention (i.e., focusing on the movement effect), relative to an internal focus (i.e., focusing on one's body movements) and control conditions, would generalize to tasks requiring maximum force production, such as jumping. In two experiments, participants performed a vertical jump-and-reach task. A Vertec™ measurement device was used to determine jump-and-reach height. Participants performed under three conditions in a within-participant design: External focus (i.e., focus on the rungs of the Vertec that were to be touched), internal focus (i.e., focus on the finger, with which the rungs were to be touched), and control conditions (i.e., focus on jumping as high as possible). Experiment 1 showed that participants' jump-and-reach height was greatest with an external focus. Those results were replicated in Experiment 2. In addition, it was observed that the vertical displacement of the center of mass was greater under the external focus condition, compared to the other two conditions. This suggests that participants jumped higher by producing greater forces when they adopted an external focus. These findings indicate that the previously shown benefits of an external attentional focus generalize to tasks requiring maximal force production.

**Key words:** Attentional Focus, Jumping, Motor Performance

## **INTRODUCTION**

In the past few years, there has been converging evidence that an individual's focus of attention has a significant influence on motor performance and learning. Specifically, it has been shown that directing a performer's attention to the effects that his or her movements have on the environment, such as an implement or apparatus (i.e., inducing an "external" focus), is more beneficial than attention directed at the movements themselves (i.e., an "internal

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focus") [1, 2, 3, 4]. For example, in learning to balance on a balance platform (stabilometer), instructing participants to focus on keeping *markers* attached to the platform horizontal (external focus) has been found to be more effective for balancing than asking them to focus on keeping their *feet* horizontal (internal focus) [1, 5]. (It should be noted that in those studies the effects of attentional focus were not confounded by visual information, as participants were instructed not to look at the marker or their feet, but simply to concentrate on them.) Other studies have shown external focus advantages for sport skills such as hitting a golf ball [6, 7], shooting a basketball [8, 9], kicking a football [10] or soccer ball [11, 12], hitting a tennis ball [13] or serving a volleyball [11]. Furthermore, studies using participants with Parkinson's disease [14] or cerebrovascular accident [15] have also demonstrated benefits of inducing an external focus. An important aspect of these findings is that external focus benefits have been found not only relative to internal focus conditions, but also relative to control conditions with no specific focus instructions [1, 14, 16-18]. That is, inducing an external focus typically results in more effective performance than both internal focus and control conditions, which do not differ from each other, presumably because individuals tend to focus on their movements when left to their own devices. This suggests that the effectiveness of training can be *enhanced* through an external focus.

The advantages of adopting an external focus have been explained with a greater automaticity in movement control associated with this type of focus. While focusing on one's movements when performing a motor skill results in a relatively conscious type of control, thus constraining the motor system, directing attention to the movement effect is assumed to promote a more automatic mode of control ("constrained action hypothesis"; [2, 5, 19]). Several lines of evidence provide support for this notion. For example, in the study by Wulf et al. [2], participants balancing on a stabilometer with an external focus not only showed more effective balance performance but also faster probe reaction times, compared to participants with an internal focus. Faster probe reaction times are seen as an indication of reduced attentional demands of the primary (balance) task, or greater automaticity [20]. Furthermore, postural adjustments in balance tasks generally show higher frequency characteristics when individuals adopt an external relative to internal focus, which is also viewed as an indication for the greater utilization of fast, reflexive, and automatic control processes [2, 3, 5].

Electromyographic (EMG) activity has also been shown to be reduced when participants adopt an external focus [9, 21, 22]. In a study by Vance et al. [22], participants performing a biceps curl task were either instructed to focus on the movements of the curl bar (external focus) or of their arms (internal focus). In the external focus condition, integrated EMG activity was significantly reduced relative to the internal focus condition. As the movement outcome (weight lifted) was identical under both conditions, this suggests movement efficiency was enhanced by the external focus. Interestingly, an external focus reduced integrated EMG activity not only in the biceps muscles (i.e., the agonists), but also in the triceps muscles (i.e., the antagonists). Recently, Marchant et al. [21] extended the Vance et al. [22] findings by showing that instructing participants to focus on the curl bar resulted in significantly less EMG activity than both instructions to focus on their arms, or no focus instructions (control condition). Thus, the external focus instructions reduced muscular activity even compared to the "natural" control condition. Finally, Zachry et al. [9] found reduced EMG activity for the biceps and triceps muscles during basketball free throw shooting when participants adopted an external focus (basket) compared to an internal focus (wrist motion). As free-throw accuracy was also enhanced under the external focus condition, Zachry et al. [9] argued that an external focus of attention might not only enhance

movement efficiency, but might also reduce "noise" in the motor system that hampers fine movement control and makes the outcome of the movement less reliable.

Given that an external focus of attention has been demonstrated to enhance movement effectiveness and efficiency, one might expect to find external focus advantages not only for tasks that require movement accuracy, such as hitting a target [6, 11, 13] or balancing [1, 14, 23, 24], but also for tasks that require the production of maximal forces. This would be the case for tasks in which an object (e.g., shot, discus, hammer) or one's own body (e.g., high jump, long jump, basketball jump shot) has to be propelled. In those cases, the timing and direction of the generated forces need to be optimal in order to maximally accelerate the object or body. For example, the height of a maximum vertical jump depends – aside from the individual's absolute strength – on the coordination of the forces generated by the legs and arms. Inaccuracies in the timing of these forces, unnecessary co-contractions, or "noise" in the motor system would result in less-than-maximal jump height. If focusing on the movement effect reduces those detrimental effects, one might expect the coordination of forces to be optimized with an external as compared to an internal focus (i.e., when the individual is given internal focus instructions, and perhaps also when not given instructions). The purpose of the present study was therefore to examine whether an external focus would enhance performance in a jump-and-reach task, compared to internal focus or no focus instructions. If this were the case, it would complement and extend the findings of previous studies, which have almost exclusively shown benefits of external focus for tasks requiring movement accuracy.

In two experiments, participants performed a jump-and-reach task under all three conditions in a within-participant design. The advantage of this design is that problems related to between-participant differences (e.g., height, strength, or skill level) are reduced. Under external focus conditions participants were instructed to focus on an object to be touched, whereas under internal focus conditions they were asked to focus on the finger, with which the object was to be touched. Thus, the instructions were very similar in terms of the actual locus of attention. Yet, in one case attention was directed at the intended movement outcome, or effect, whereas in the other case it was directed at the part of the body, with which this effect was to be achieved. In the control condition, participants were simply instructed to jump as high as possible. While in the first experiment our main interest was in determining jump-and-reach height, in Experiment 2 we went one step further and also looked at center of mass (COM) vertical displacement as a function of attentional focus.

## **EXPERIMENT 1**

This experiment was the first investigation into whether attentional focus instructions would have an effect on performance of a dynamic task that required maximal force production, namely, a jump-and-reach task. Most active, healthy young adults presumably already have this skill in their repertoire of motor skills. It would therefore seem almost counterintuitive that jump-and-reach height could be affected by attentional focus instructions. Yet, if an external focus has the capacity to optimize the coordination of forces, and reduce "noise" in the motor system [9], instructions to adopt an external focus might result in increased jump-and-reach height. Thus, in the present experiment we compared jump-and-reach height when performers were instructed to adopt an external focus, an internal focus, or were not given attentional focus instructions.

## METHOD

### PARTICIPANTS

Ten healthy, physically active kinesiology university students (1 male, 9 females; age: 23.0 years,  $SD = 5.81$ ) participated in this study. Informed consent was obtained from all participants. They were not aware of the specific purpose of the study.

### *Apparatus, Task, and Procedure*

A Vertec™ instrument was used to record maximal vertical jump-and-reach height. It consisted of plastic rungs (each with a spacing of 0.5 in. or 1.3 cm) at different heights that the participant reached for during the jumps. The Vertec was positioned to the participant's right side, with the lowest rung set at eight feet (244 cm), so that it extended out over the participant's head. Participants were shown how to perform a maximal vertical counter-movement jump. They were instructed to jump straight up and touch the highest rung on the Vertec they could reach with the tips of the fingers of their left hand. Participants were allowed to practice until they felt comfortable with the equipment and technique.

Each participant performed 5 trials under each of the following conditions: Control, internal focus, and external focus. For the control condition, no attentional focus instructions were given. Under internal focus conditions, participants were instructed to concentrate on the tips of their fingers, reaching as high as possible during the jumps, whereas under external focus conditions, they were instructed to concentrate on the rungs of the Vertec, reaching as high as possible. The control condition was performed first, while the order of the internal and external focus conditions was counterbalanced across participants.

### DEPENDENT VARIABLES AND DATA ANALYSIS

The highest rung touched and displaced was recorded for each trial. Jump-and-reach height, as defined by the position of the highest rung displaced, was converted into cm and analyzed in a 3 (attentional focus: control, internal, external)  $\times$  5 (trial) analysis of variance (ANOVA) with repeated-measures on both factors. Mauchly's test was used to check the assumption of sphericity. It revealed that the assumption was not violated, and that there was no need to adjust the degrees of freedom.

## RESULTS

### JUMP-AND-REACH HEIGHT

Participants reached higher when they adopted an external focus (6.08 cm) compared to an internal focus (5.23 cm), or were not given focus instructions (control) (5.21 cm) (see Figure 1). The main effect of attentional focus was significant, with  $F(2, 18) = 7.84, p < .01$ . Post-hoc tests (LSD) indicated that the external focus condition was significantly different from both the internal focus and control conditions ( $p$ 's  $< .01$ ). There was also a main effect of trial,  $F(4, 36) = 3.52, p < .05$ . The first jump in each condition tended to be lower than the remaining 4 jumps. Post-hoc tests indicated that the first jump (4.99 cm) differed significantly from the third jump (5.69 cm) ( $p < .05$ ). The interaction of attentional focus and trial was not significant,  $F(8, 72) = .996, p > .05$ .

## DISCUSSION

The results showed that a change in the focus of attention significantly affected maximum jump-and-reach height: Focusing on the object to be touched (external focus) resulted in greater height than did focusing on the finger (internal focus), with which the object was to be touched. Furthermore, adopting an internal focus provided no advantage (or disadvantage)

relative to the control condition. Thus, instructing participants to adopt an external focus increased jump-and-reach height above and beyond what participants achieved under "normal" conditions. While these results are in agreement with those of previous studies [1, 14, 16, 21], they are the first to show this effect for a task that requires the production of maximum forces.

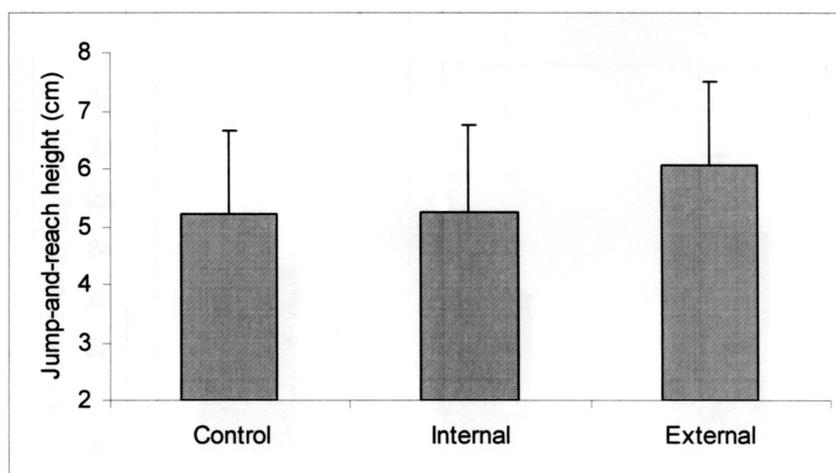


Figure 1. Jump-and-R Reach Height Under Control, Internal Focus, and External Focus Conditions in Experiment 1. The lowest rung was set at 8 feet, or 244 cm, for all participants.

However, based on the present results, it does not seem justified to conclude that participants actually *jumped* higher when they adopted an external focus. That is, they might not necessarily have produced greater forces (or forces that were coordinated more effectively) that resulted in greater jump-and-reach heights. An alternative explanation is that participants produced different actions in the air. For example, they might have produced a greater extension in one or more joints that enabled them to reach higher. To rule out this possibility, it was necessary to determine the displacement of the center of mass (COM) during the jumps. If greater maximum COM displacement were observed under the external focus condition, compared to the other two conditions, this would indicate that individuals actually jumped higher. The main purpose of Experiment 2 was therefore to determine whether the external focus, in fact, acted to produce greater jump-and-reach height by determining the vertical COM displacement.

In addition, we wanted to address a shortcoming of the first experiment. In that experiment, the control condition was performed first, that is, before the other two conditions, as we wanted to avoid possible influences of attentional focus instructions on the control condition. However, this leaves open the possibility that performance in the external or internal focus conditions was affected (positively) by practice effects, or (negatively) by effects of fatigue, relative to the control condition. Therefore, in the second experiment, we counterbalanced the order of the three conditions.

## EXPERIMENT 2

Experiment 1 provided preliminary evidence that jump-and-reach height can be enhanced by adopting an external focus. The main purpose of the present experiment was to determine the underlying reason for this effect. A possible, but perhaps less interesting, explanation would be that focusing on the rungs caused participants to produce more effective actions in the air, such as greater extension in the shoulder, elbow, or wrist joints, which enabled them to reach higher. A more interesting finding would be that individuals generate more force when they focus on the desired movement effect. In this case, greater COM displacements should be seen under external relative to internal focus and control conditions. Such a finding would provide additional evidence that a focus on the desired movement effect optimizes motor control. Therefore, we replicated the first experiment, but also measured vertical ground reaction forces to determine COM displacement, with the order of attentional focus conditions counterbalanced.

## METHOD

### PARTICIPANTS

Twelve university students (5 males, 7 females; age: 23.6 years,  $SD = 1.16$ ), who had not participated in Experiment 1, volunteered to participate in this experiment. They were not informed of the specific purpose of the study. All participants signed an informed consent form before testing commenced.

### APPARATUS, TASK, AND PROCEDURE

The same Vertec measurement device that was used in Experiment 1 was used in the present experiment. In contrast to Experiment 1, however, the lowest rung was not set at a constant height, but was adjusted to each participant's height such that the lowest rung was at a height that the participant could reach with his or her fingertips when standing upright with the arm extended. This procedure allowed us to better accommodate differences in participants' heights. To measure vertical ground reaction forces (vGRF) and determine COM displacement, kinetic data were collected using a force platform (Kistler, Model # 8600B, 40 x 60 cm) at 1080 Hz. At the start of a trial, the participant was instructed to step onto the force platform with both feet and stand still. After approximately 1 second, the participant was given the "go" signal and jumped on that prompt. The testing environment was oriented such that participants also landed with both feet on the force platform.

Otherwise, the procedure was similar to that used in the first experiment. All participants performed 5 trials under all three conditions: External focus (i.e., focus on the rungs of the Vertec), internal focus (i.e., focus on the finger tips), and control (i.e., no focus instruction). In contrast to Experiment 1, the order of conditions was counterbalanced so that each condition was performed first, second, or last an equal number of time. Specifically, one third of the participants (i.e., 4) performed in one of the following orders: Control-internal-external, internal-external-control, and external-control-internal [25, 26].

### DEPENDENT VARIABLES AND DATA ANALYSIS

As in Experiment 1, maximum jump-and-reach height was determined by the highest rung that the participant was able to touch. In order to determine COM displacement, vertical acceleration of the COM was first computed following Newton's second law of motion (force = mass x acceleration) and embracing the accepted assumption that the resulting vGRF vector measured by the force platform is a reflection of the inertial characteristics of the system (i.e., movement of the participant's COM). The vertical acceleration values were

double integrated, resulting in a measure of the vertical position of the system COM. The maximum change in position for each participant-trial was identified as well as the vertical position of the COM in the pre-jump (standing) orientation. The difference between these two measures resulted in the change in vertical position (displacement) of the COM during the jump. Jump-and-reach height and COM displacement were analyzed in a 3 (attentional focus) x 5 (trials) ANOVA with repeated measures on both factors. Mauchly's test indicated that the sphericity assumption was not violated in any case.

## RESULTS

### JUMP-AND-REACH HEIGHT

Participants reached higher rungs when they adopted an external focus (24.5 cm) compared to an internal focus (23.2 cm), or no attentional focus instructions (23.7 cm) (see Figure 2). The main effect of attentional focus was significant, with  $F(2, 22) = 7.31, p < .01$ . Post-hoc tests (LSD) indicated that the external focus condition was significantly different from both the internal focus and control conditions ( $p$ 's  $< .05$ ). The main effect of trial,  $F(4, 44) = 1.13, p > .05$ , and the Attentional Focus x Trial interaction,  $F(8, 88) = 1.54, p > .05$ , were not significant.

### COM DISPLACEMENT

Participants' COM reached a greater maximum height when they were instructed to adopt an external focus (38.7 cm), as opposed to an internal focus (36.0 cm), or when they were not given focus instructions (36.4 cm) (see Figure 3). The Attentional Focus main effect was significant,  $F(2, 22) = 5.22, p < .05$ . Post-hoc tests confirmed that the external focus condition differed significantly from the two other conditions ( $p$ 's  $< .05$ ). The main effect of trial,  $F(4, 44) = 1.11, p > .05$ , and the interaction of attentional focus and trial,  $F(8, 88) = .871, p > .05$  were not significant.

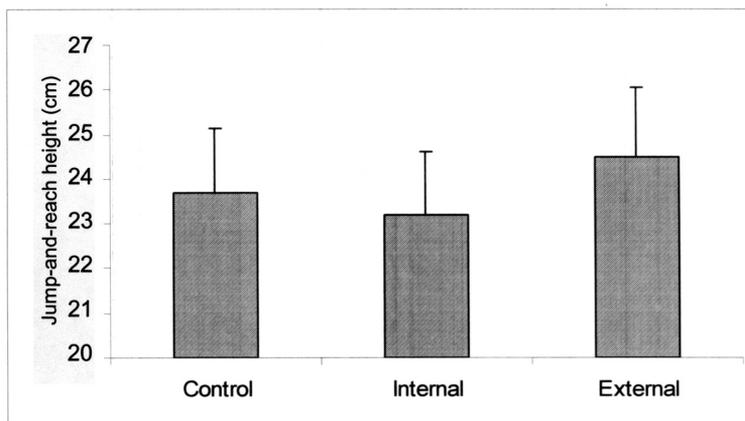


Figure 2. Jump-and-Reach Height Under Control, Internal Focus, and External Focus Conditions in Experiment 2. The lowest rung set at each participant's maximum standing reach height.

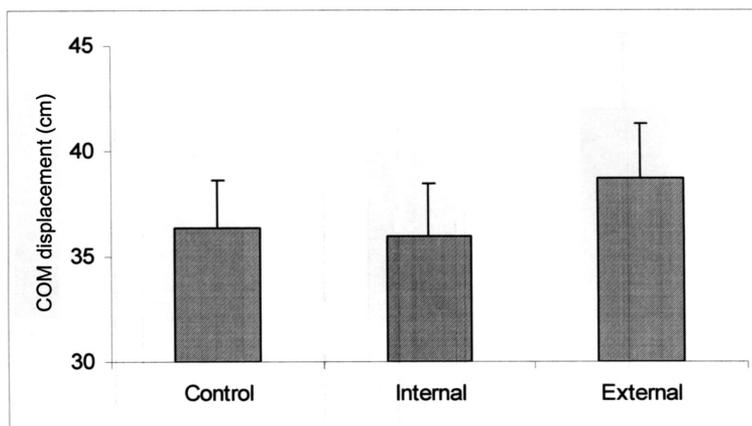


Figure 3. Center-of-Mass (COM) Vertical Displacement Under Control, Internal Focus, and External Focus Conditions in Experiment 2.

## DISCUSSION

The results of this experiment replicate and extend those of Experiment 1. As in the first experiment, jump-and-reach height was increased with external, compared to internal focus or no focus instructions. Also, as in Experiment 1 and previous studies [1, 14, 16], internal focus and control conditions produced similar performances. With the order of conditions counterbalanced, this pattern of results provides additional evidence that focusing on the anticipated movement effect enhances performance, compared to internal focus or "normal" conditions. Importantly, the COM data showed a greater displacement from baseline (standing still) to maximum jump height when participants were instructed to adopt an external focus. This indicates that individuals *jumped* higher with an external focus (rather than simply exhibiting different kinematic patterns while airborne resulting in greater stretch). Mechanically speaking, the only way to raise the COM is by increasing the magnitude of external force exerted. From a performance perspective, one can deduce that participants either increased force production, or optimized coordination between and among the segments during the jump to produce a more continuous summation of segmental velocities. Possible underlying mechanisms for this performance advantage as well as practical implications of the results are addressed in the general discussion.

## GENERAL DISCUSSION

The results of the present experiments provide converging evidence that a change in the focus of attention can affect maximum jump-and-reach height: Focusing on an object to be touched (external focus) resulted in greater jump-and-reach height than focusing on the finger with which the object was to be touched (internal focus). Furthermore, adopting an internal focus provided no advantage, or disadvantage, relative to the control condition, whereas an external focus did. Thus, an external focus increased jump-and-reach height above and beyond what participants achieved under "normal" conditions.

It might seem surprising that directing participants' attention to the finger tip, or rung,

would affect whole-body movement execution. Yet, previous research [16, 18] has also indicated that focusing on the finger or hands (internal focus), as compared to an object to be touched or held (external focus), can have an impact on whole-body movements. In those studies, balance performance was influenced by the type of focus on the "touching" or "holding" task. Furthermore, attentional focus instructions have been found to affect EMG activity not only in those muscle groups to which attention was directed, but also in "unrelated" muscle groups [9, 22]. The present results are in line with those findings in demonstrating that the attentional focus on one part of the body can impact whole-body coordination.

While both experiments showed greater jump-and-reach height in the external focus condition, Experiment 2 demonstrated, in addition, that the increase in jump height was accompanied by a greater vertical displacement of the COM. This indicates that participants produced greater forces under that condition. While it might be surprising that a simple change in an individual's focus of attention can enhance force production, and thus jump-and-reach height, previous studies have shown that an external focus results in more efficient movement patterns [9, 21, 22]. In those studies, the same outcome (i.e., weight lifted in a given amount of time) was achieved with less muscular activity when an external focus, as opposed to an internal or no particular focus [21, 22]. Interestingly, muscular (EMG) activity was reduced not only for agonist muscle groups, but also for antagonist muscles [22]. This suggests that a focus on the movement effect might not only facilitate an effective recruitment of muscles fibers within a muscle ("intra-muscular coordination"), but also the effective coordination between agonist and antagonist muscle groups ("inter-muscular coordination") [27]. Future studies, using EMG or motion analysis, for example, may be able to shed more light onto the exact mechanisms that are responsible for the greater movement effectiveness of an external focus for tasks that require maximum force production, such as the one used in the present study.

## **IMPLICATIONS FOR COACHING**

Our findings may have implications for sports in which maximum jumps are required (e.g., high jump, long jump, pole vault) or are at least advantageous (e.g., basketball lay-up or jump shot, volleyball kill shots). For example, in high jump, focusing on the bar might result in greater jump height than focusing on the coordination of one's body movements, such as arching one's back. In pole vaulting, a focus on bending the pole might lead to more effective performance than a focus on the body movements required to bend the pole. Similarly, for a basketball lay-up or jump shot, it may be advantageous to simply focus on the rim of the basket as opposed to trying to jump as high as possible. If this can be confirmed by future research involving complex sport skills, a simple change in the wording of the instructions might have a significant impact on the learning and performance of those skills.

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