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Section I – Kinesiology

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Influence of Attentional Manipulation on Jumping Performance: A Systematic Review and Meta-Analysis

by
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Enhancing jumping ability can lead to substantial benefits in sports performance and physical activity. Previous studies indicate that directing an individual's attention externally before the jump is an effective way to improve jumping performance, especially when the standing long jump (SLJ) and vertical jumps (VJs) are performed. To scrutinize reported findings, we systematically reviewed studies that compared the effects of attentional manipulations on jumping performance in adults. Four electronic databases (MEDLINE, Scopus, SPORTSDiscus, and Web of Science) were searched for original research publications. A priori defined inclusion criteria were: (a) participants were healthy adults with a mean age > 18 years, (b) an external (EF) or an internal focus (IF) of attention instruction was used, (c) the study compared an external focus intervention with an internal focus intervention or an external focus with a control (no attentional; CON) intervention or an internal focus intervention with a control intervention, (d) jumping performance was tested, and (e) an immediate effect of focus of attention intervention was evaluated. Of the 380 papers identified, 14 studies were used in 3 part meta-analyses (EF vs. IF, EF vs. CON, and IF vs. CON) that involved 24 comparisons in total. The findings of this analysis revealed that the EF condition displayed superior jumping performance relatively to the IF ($p < 0.05$) and CON ($p < 0.05$) conditions. There were no significant ($p > 0.05$) differences between the IF and CON conditions. These findings suggest that EF instructions should be incorporated into testing procedures when jumping performance is assessed.

Key words: *jump testing, external focus of attention, internal focus of attention, standing long jump, vertical jump, instructions.*

Introduction

The utilization of reliable and valid tests and measurements are essential in the evaluation of the effectiveness that physical training has on athletic performance. Moreover, performance testing is commonly used to identify athletic potential and assess the physical abilities of athletes, students, clients and patients. Additionally, using tests in training or physical education programmes allows coaches and teachers to set individual goals for athletes or students. Tests are used by strength and conditioning professionals to detect areas of immediate change that are needed in the exercise regimen so athletes are better able to reach their long term performance goals. Measurements of physical performance are not only used by practitioners, but they are also employed by researchers to investigate and observe the effectiveness of implemented training programs (Baechle and Earle, 2008).

The standing long jump (SLJ) and vertical jump (VJ) are popular field tests adopted by personal trainers, strength and conditioning coaches and physical education teachers to evaluate jumping performance. Jumping ability is an important indicator of overall physical health and is critical for athletes in many sports

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(González-Badillo and Marques, 2010). For example, the ability to out-jump an opponent provides a clear advantage in sports such as basketball, volleyball, soccer and football, just to name a few. Both the SLJ and VJ are also popular in sports training because they are easy to adopt and produce highly valid and reliable measures (Balsalobre-Fernández et al., 2015; Porter et al., 2013).

A large body of evidence in motor behavior research has shown the benefits and disadvantages of attentional focus interventions for the testing of physical abilities. Studies have demonstrated providing instructions that direct an individuals' attention externally to the effect their movement has on the environment (e.g. focusing on a distant cone or a hanging ball) resulted in superior motor performance compared to instructions that promote an internal focus of attention towards the movement of the body (Makaruk and Porter, 2014; Wulf, 2013). An external focus of attention had an immediate positive effect on horizontal jumps (Porter et al., 2010c), vertical jumps (Wulf and Dufek, 2009), throwing a shot (Makaruk et al., 2013) and sprinting (Porter and Sims, 2013). The constrained action hypothesis (Wulf et al., 2001) is often used to explain why an external focus of attention enhances motor performance as well as why focusing attention internally can have a depressing effect on motor behavior. This hypothesis suggests that an external focus leads to effective control of movements by utilizing unconscious and automatic control processes. In contrast, an internal focus promotes conscious control of movements and disrupts automatic control processes. Interestingly, some studies also showed that when individuals receive no attentional focus instructions (when assigned to a control condition) that do not prompt a specific focus of attention, the effects of their performance are similar to trials under an internal focus (Ducharme et al., 2016). It has been demonstrated that sports practitioners commonly use instructions that direct attention internally or use no attentional focus instructions during training and testing sessions (Porter et al., 2010a, Van der Graaff et al., 2018), despite the empirical evidence showing that providing external focus directing instructions are superior relatively to internal focus cues.

It is well established in the scientific community that small changes in the content of verbal instructions can significantly change movement outcomes. Strength and conditioning professionals should be mindful of the content in the instructions they provide. To further understand how deeply the focus of attention manipulation is related to motor performance outcomes, the aim of this study was to determine the effects of attentional strategies leading to improvements in jumping performance. Specifically, the primary aim of this meta-analysis was to compare the immediate effects of providing external, internal and no attentional focusing instructions on horizontal and vertical jumps.

Methods

Search strategy

A literature search was conducted using the following databases: MEDLINE, Scopus, SPORTSDiscus, and Web of Science. The following Boolean search syntax was used: (focus of attention OR attentional focus OR attentional foci OR external focus OR internal focus OR external foci OR internal foci OR attentional strateg*) *for title, abstract, and keyword search field* AND (jump* OR jump* performance OR jump* task OR jump* ability OR jump* parameters OR jump* assessment OR jump* testing OR jump* evaluation OR jump* height OR jump* distance OR horizontal jump* OR vertical jump* OR countermovement jump* OR CMJ OR standing long jump OR long jump OR triple jump OR plyometric*) *for full texts*. The search was limited to peer-reviewed investigations that were published in the English language.

Eligibility criteria

To be eligible for inclusion in this review, the study had to meet each of the following criteria: (a) participants were healthy adults with a mean age > 18 years, (b) an external or an internal focus of attention instruction was used, (c) the study compared an external focus intervention with an internal focus intervention or an external focus with a control (no attentional focus) intervention or an internal focus intervention with a control intervention, (d) jumping performance was tested, (e) an immediate effect of the focus of attention intervention was measured. The study was excluded if: (a) it was a non-randomized or a review study, (b) it was reported as an abstract only, (c) it did not include sufficient data for a

meta-analysis, (d) or the authors did not reply to our request for these data, (e) it used a motor learning protocol.

Study Selection and Data Extraction

All publications identified in the literature search were exported to bibliographic software (Endonote X9, Clarivate Analytics, USA), and duplicate references were removed. After excluding papers based on title and abstract screening, the full texts of the remaining publications were examined. The selection and extracting process was performed independently by the first and second authors of this review. Disagreements were resolved by discussion. Reviewers were not blinded to authors or journals. The following information was collected from the included studies: characteristics of participants, type and content of instruction, task and apparatus, results (means and measures of dispersion) and study design. When a study reported two or more variants of the same type of instructions, the practical application for strength and conditioning (Makaruk and Porter, 2014) was considered essential for inclusion.

Statistical Analysis

Each meta-analysis was computed using Review Manager Software (RevMan, Version 5.3. Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration, 2014) according to the random-effects model with inverse variance weighting. Attentional intervention effects expressed as standardized mean difference (SMD) with 95% confidence intervals (CIs) were quantified as trivial (<0.2), small (0.2-0.5), moderate (0.51-0.8), large (>0.8). The level of significance for overall effect was set at $p < 0.05$. Heterogeneity was assessed using the χ^2 test and I^2 statistics, with an $I^2 < 25\%$ indicating low heterogeneity (Higgins et al., 2003).

Results

Our initial literature search yielded 380 studies (Figure 1). After screening the titles and abstracts, 274 publications were eliminated from the initial pool. A total of 47 full-text papers were assessed. Fifteen studies out of 47 met eligibility criteria. One of the 15 studies used a motor learning protocol (between-subject design) and was eliminated from the sample. This screening resulted in 14 studies being used in the meta-analysis (Figure 1). Since the control conditions were not counterbalanced in 5 studies, only the internal and external conditions from those 5 studies were included in the meta-analysis.

Characteristics of the included studies are presented in Tables 1a and 1b. The total number of participants was 360 (226 men and 134 women). Seventy-four participants were athletes or skilled jumpers and 286 were recreationally trained or untrained volunteers. The age of participants ranged between 18 and 30 years. All attentional (external and internal foci) and no attentional focus (control) instructions were provided verbally. Four studies used a counter movement jump (CMJ), one used a drop jump (DJ), and 10 studies used the standing long jump (SLJ) to evaluate jumping performance.

The first meta-analysis comparing the effects of directing attention internally verses externally showed an overall significant beneficial effect of directing attention externally on jumping performance when compared to directing attention internally (SMD = 0.33, 95% CI 0.14 to 0.51, Z = 3.50, $p < 0.001$). The results of the comparison of the internal and external conditions are displayed in Figure 2. One study demonstrated a large intervention effect (SMD > 0.8), 2 studies showed a moderate effect, 4 studies small, and 6 studies demonstrated trivial effects. The second meta-analysis comparing an external focus of attention to trials completed under a control condition revealed that an external focus resulted in superior jumping performance compared to attempts completed under a control condition (SMD = 0.35, 95% CI 0.11 to 0.58, Z = 2.92, $p < 0.001$) (Figure 3). Two studies showed the effect was moderate, while one study showed a small effect and three studies reported trivial effects. The third meta-analysis did not find any significant differences between the internal focus and control conditions (SMD = 0.07, 95% CI -0.20 to 0.35, Z = 0.52, $p > 0.05$, Figure 4). All four studies showed a trivial effect of the intervention. In one study that was included in the qualitative analysis, but excluded from the quantitative analysis, the authors found that participants using an external focus instruction jumped significantly ($p < 0.01$) farther than participants instructed to focus their attention internally (Porter et al., 2010c).

There was no statistically significant heterogeneity (the variation in study outcomes between studies) in any of the three meta-analyses

(I^2 ranged between 0 and 7%, $p > 0.05$). This finding suggests that the results reported across the experiments included in our analysis were statistically consistent.

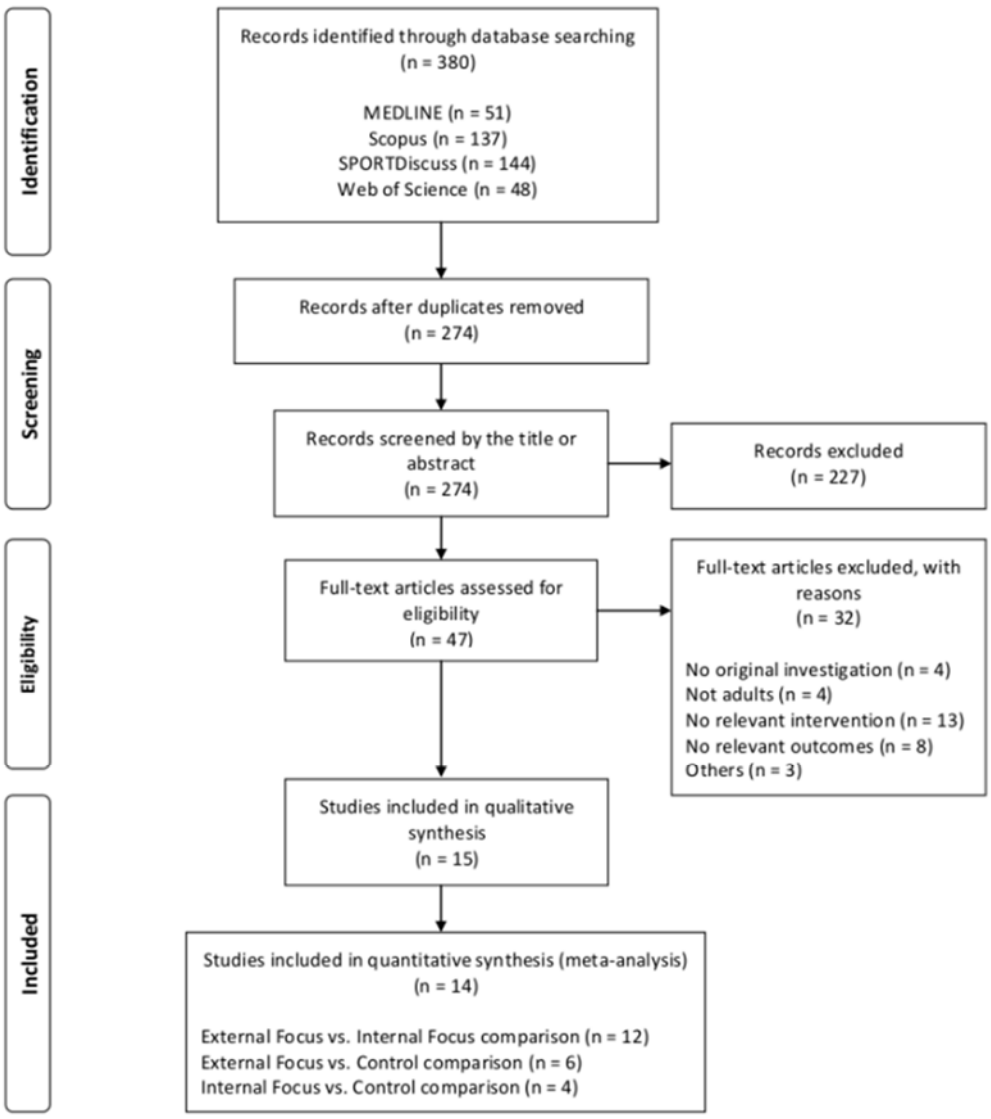

Figure 1

Flow chart of the study identification and selection process.

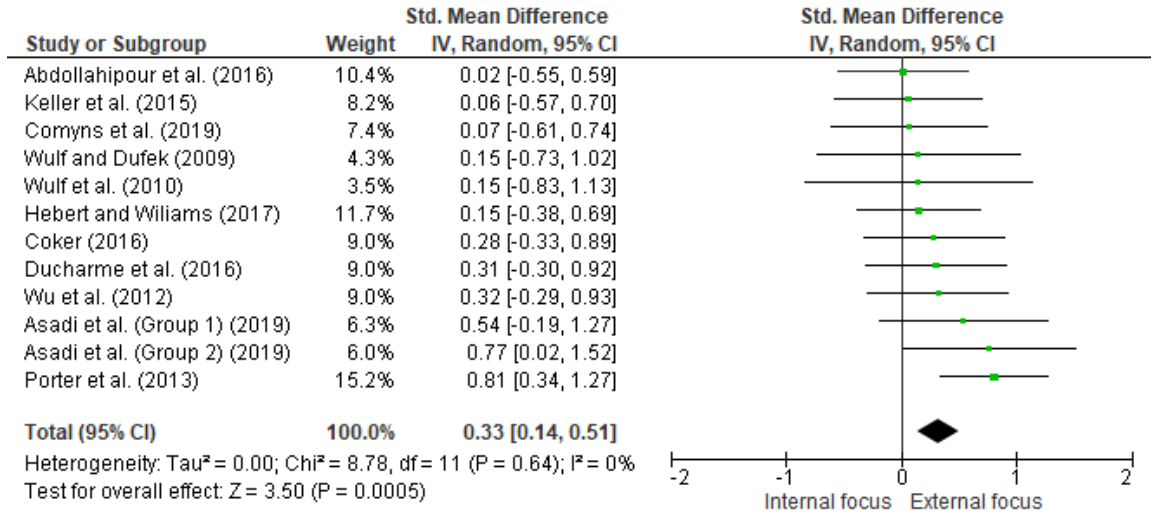

Figure 2

First meta-analysis comparing the effects of an external focus to an internal focus of attention on jumping performance expressed as standardized mean differences. CI = confidence limits.

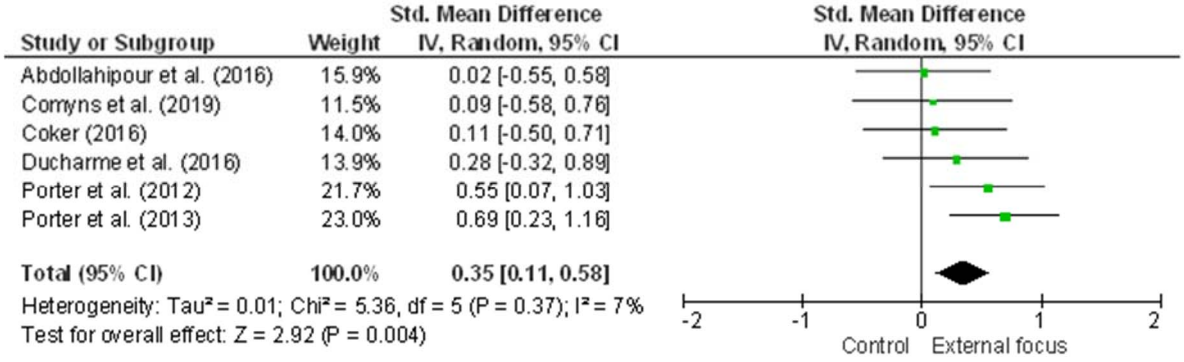

Figure 3

Second meta-analysis comparing the effects of an external focus of attention to a control condition on jumping performance expressed as standardized mean differences. CI = confidence limits.

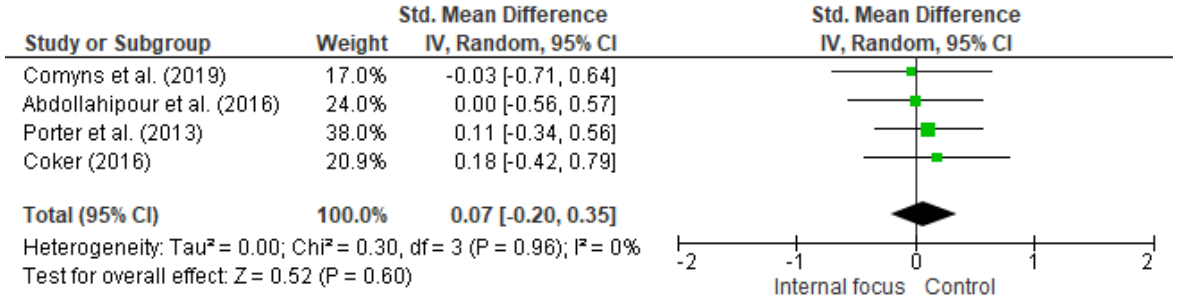

Figure 4

Third meta-analysis comparing the effects of an internal focus of attention to a control condition on jumping performance expressed as standardized mean differences. CI = confidence limits.

Table 1a

Studies included in the analysis

Study	Participants, gender (n), age (mean ± SD in years)	Group and content of instructions	Task and results (mean ± SD in cm)	Study design
Abdollahipour et al. (2016)	University students: men (n=8) and women (n=16), age=25.0±3.3	EF: "concentrate on the ceiling" IF: "concentrate on your fingers" C: no focus instructions	VJ (jump height): EF=30.93±41.01* IF=30.09±42.43* C=30.23±42.77*	WS; the order of conditions was counterbalanced
Asadi et al. (2019) (Group 1)	Undergraduate male students, low-skilled jumpers (n=15), mean age=23±4	EF: "try to jump to the red cone" IF: "focus on extending your knees as rapidly as possible" C: "jump to the best of your ability" SC (self-control): "focus on the measurement lines on the jump mat and pick a line in front of them"	SLJ (jump distance): EF=208.86±21.61* IF=196.26±23.94* C=204.17±21.63 SC=210.51±21.77	WS; the order of attentional conditions was counterbalanced
Asadi et al. (2019) (Group 2)	Undergraduate male students, skilled jumpers (n=15), mean age=23±4	EF: "try to jump to the red cone" IF: "focus on extending your knees as rapidly as possible" C: "jump to the best of your ability" SC (self-control): "focus on the measurement lines on the jump mat and pick a line in front of them"	SLJ (jump distance): EF=247.24±14.67* IF=235.48±15.04* C=238.53±12.76 SC=245.06±12.21	WS; the order of attentional conditions was counterbalanced
Becker et al. (2018)	University students who without the experience of the SLJ, men (n=11) and women (n=18), age=18-30	EF: "focus on jumping as close to the cone as you can" IF: "focus on extending your legs as quickly as you can"	SLJ (jump distance): EF=177.55±38.65* IF=169.50±39.96*	WS; the order of attentional conditions was counterbalanced
Coker (2016)	Hockey female players (n=21); age = 19.3±1.5	EF-f (far): focus on jumping as close as possible to a cone (at a distance of 3 m) EF-a (attainable): focus on jumping as far as possible past a cone placed (at the maximum distance achieved on a given player last SLJ) IF: focus on extending the knees as rapidly as possible C: "perform the SLJ as you normally would when tested"	SLJ (jump distance): EF-f=159.62±18.3* EF-a=163.93±18.15 IF=154.71±15.78* C=157.71±16.32*	WS; randomized, counterbalanced
Comyns et al. (2019)	Recreationally trained collegiate males (n=17), age=24.4±4.9	EF: "imagine the ground is a hot surface, get off the ground as quickly as possible … focus on jumping to the roof" [partial quotation] IF: "explosively extend your ankles, knees, and hips as rapidly as possible to jump high" C: "perform the jump to the best of your ability"	DJ (jump height): EF=27.9±6.4* IF=27.5±5.3* C=27.3±6.4*	WS; randomized, counterbalanced
Ducharme et al. (2016)	Untrained university students: men (n=10) and women (n=11), age=21.3±1.7	EF: "think about jumping as close to the green target as possible" IF: "think about extending your knees as rapidly as possible" C: "jump as far as you can"	SLJ (jump distance): EF=172.3±48.4* IF=156.5±52.3* C=158.2±48.9	WS; the order of attentional conditions was counterbalanced

**-used in meta-analysis, VJ-vertical jump, DJ-drop jump, SLJ-standing long jump, WS-within-subjects design*

Table 1b

Studies included in the analysis.

Study	Participants, gender (n), age (mean ± SD in years)	Group and content of instructions	Task and results (mean ± SD in cm)	Study design
Hebert and Williams (2017)	Recreationally-active college student: men (n=13) and women (n=14)	EF: "focus your attention on jumping over a line on the floor you think you can reach on your best jump" IF: "focus your attention on pushing as hard as possible with your legs, and swinging your arms in a big motion" KF (kinesthetic focus): "focus your attention on feeling explosive, and think the word 'Go' as you jump"	SLJ (jump distance): EF=114.99±47.90* IF=107.47±48.20* KF=113.34±45.60	WS; counterbalanced
Keller et al. (2015)	Physically active university students: men (n=11) and women (n=8), age=27.5±4.2	EF: "focus your attention on jumping as close to the ball as you possibly can" IF: "focus your attention on extending your legs as rapidly as possible" AF (augmented feedback): "maximise the number on the screen indicating your jump height"	CMJ (jump height): EF=31.21±6.67* IF=30.77±6.87* AF=32.04±7.11	WS; randomized, counterbalanced
Porter et al. (2013)	Collegiate male athletes (n=38), age=20.7±2.2	EF-n (near): "focus on jumping as far past the start line as possible" EF-f (far): "focus on jumping as close to the cone as possible" IF: "focus on extending your knees as rapidly as possible" C: "perform the standing long jump as you normally would"	SLJ (jump distance): EF-n=216.2±24.8 EF-f=224.2±22.5* IF=204.4±26.0* C=207.2±25.9*	WS; counterbalanced
Porter et al. (2012)	Recreationally trained males (n=35), age=22.3±2.5	EF-n (near): "jump as far past the start line as possible" EF-f (far): "when you jump, focus on jumping as close to the cone as possible" C: "jump to the best of your ability"	SLJ (jump distance): EF-n=207 ± 30.5 EF-f=212.7±28.9* C=195.9±31.3*	WS; counterbalanced
Porter et al. (2010c)	Moderately skilled jumpers: men (n = 36), women (n = 24), age=21-22	EF: "focus your attention on jumping as far past the start line as possible'' IF: "focus your attention on extending your knees as rapidly as possible"	SLJ (jump distance): EF=187.37±42.66 IF=177.33±40.97	BS
Wu et al. (2009)	Untrained recreationally active subjects: men (n = 10), women (n = 11), age=21.3±1.7	EF: "think about jumping as close to the green target as possible" IF: "think about extending your knees as rapidly as possible" C: "jump as far as you can"	SLJ (jump distance): EF=153.6±38.6* IF=139.5 ± 46.7* C=133.8±35.7	WS; attentional conditions were counterbalanced
Wulf and Dufek (2009)	Physically active university students: men (n=4), women (n=6), age=20-30	EF: concentrate on the rungs of the Vertec, reaching as high as possible IF: concentrate on the tips of their fingers, reaching as high as possible during the jumps	VJ (jump height): EF=31.9±10.2* IF=30.4±9.6*	WS; conditions were counterbalanced
Wulf et al. (2010)	Physically active university students: men (n=3), women (n=5), age=22.6±2.5	EF: concentrate on the rungs IF: concentrate on the tips of their fingers	VJ (jump height): EF=32.4± 8.60* IF=31.0±8.99*	WS; conditions were counterbalanced

*-used in meta-analysis, VJ-vertical jump, DJ-drop jump, SLJ-standing long jump, WS-within-subjects design, BS-between subjects design

Studies included in the analysis.

Discussion

The results of this systematic review and meta-analyses showed that an external focus of attention was more beneficial for jumping performance compared to using an internal or no focus of attention. We found that providing instructions that directed attention externally resulted in greater jumping distance in the SLJ in addition to greater jumping height in the VJ and DJ compared to performing the same task with instructions that directed participants' attention internally or neutrally. However, it is important to note that the overall effect sizes for both comparisons (EF vs. IF, and EF vs. CON) were small. An additional conclusion from the meta-analysis suggests that instructing participants to focus their attention internally did not hinder jumping performance, because no significant difference was found between the internal and control conditions.

The general findings of our analysis are consistent with the predictions of the constrained action hypothesis (Wulf et al., 2001). That is, all included studies in the present systematic review demonstrated that directing attention externally towards the result of the movement on the environment yielded superior outcomes relative to focusing internally on the movement. Interestingly, on average, adopting an external focus of attention increased jump performance by 6.8% (11.62 cm) for the SLJ and 3.1% (0.92 cm) for vertical jumps. However, despite the consistency of this finding, results from previous studies suggest that coaches still promote an internal rather than an external focus of attention when instructing jumping skills (Allan, 2012; Porter et al., 2010a; Van der Graaff et al., 2018). They often shift athletes' attention to form related cues, for example "Begin with a powerful squat jump, driving for height and extending completely at the hips, knees, and ankles" (Hansen and Kennelly, 2017) or "Explosively jump forward and up, using both arms to assist, with a goal of achieving maximal horizontal distance" (Haff and Triplett, 2015).

Our findings also showed that instructing an external focus of attention had greater advantages during jumping tests compared to receiving no attentional focus instructions. Some authors suggest (Wulf, 2008) that no attentional focus instructions be adopted by skilled athletes when well-learned movements are executed, or when a task is performed automatically without overt mental effort. However, two experiments in the present review (Asadi et al., 2019; Porter et al., 2013) demonstrated that male skilled athletes who received external focusing instructions achieved better jumping performance (on average, by 13 cm in the SLJ) compared to jumps completed under a control condition which did not receive attentional directing cues. Interestingly, when female athletes were tested using external and no attentional focus instructions (Coker, 2016), there were significant differences in SLJ performance (EF = 159.62 and CON = 157.71 cm). Therefore, it is our conclusion that providing no attentional focus instructions such as "perform the jump to the best of your ability" during testing sessions will result in less than optimal jumping performance. It is clear that the generalizability of the focus of attention effect to highly skilled jumpers warrants further investigation.

Unfortunatly, books, assessment procedures and training manuals (e.g. Baumgartner et al., 2015; Lacy and Williams, 2018; Miller, 2014; Tomchuk, 2011) typically do not include information related to the content of specific instructions which should be provided prior to the administration of a test. Testing guidelines primarily focus on basic issues such as the purpose of the test, description of procedures, outcome measures, environmental factors (e.g. weather conditions or proper footwear) and interpretation of testing results. Meanwhile, the lack of standardized instructions may bring serious methodological and practical consequences such as low reliability of testing scores, non-objective assessment and weakened test validity. For example, in one study included in our review, using two different attentional instructions resulted in an immediate 20 cm difference in SLJ performance (Porter et al., 2013). Findings such as this suggest that subtle variations in the content of verbal instructions can greatly impact jumping performance. This is a particularly important consideration when multiple strength and conditioning coaches are involved in the evaluation of athletes on or across sport teams. Not using standardized instructions that prompt an external focus of attention can result in significant differences in jump testing results.

The results of the meta-analysis comparing the IF and CON conditions indicated that when

participants were provided no attentional focus instructions under a control condition they tended to perform similarly to trials completed following internal focusing instructions. Some have interpreted this finding to mean that if participants are not explicitly instructed to use an external focus of attention, they may default to using an internal focus of attention (Land et al., 2013). However, other investigations have reported when participants are under a control condition receiving non-focusing instructions, they commonly do not consciously direct their attention or they direct their attention to a combination of internal and external cues (Porter et al., 2010b). Regardless, the present meta-analysis revealed the effect of performances completed under the CON condition was trivial (SMD = 0.07; $p > 0.05$) when compared to the IF condition. When examined collectively, it appears that promoting an external focus of attention has an enhancing effect on jumping performance relative to jumps completed using an internal focus of attention or a control condition.

This is the first systematic review and meta-analysis of attentional strategies to optimize instructions when performing the horizontal and vertical jumps. One strength of this study is that we concentrated specifically on the effectiveness of attentional strategies used in skills commonly used in sport testing environments. The second strength of our review is that the heterogeneity of the attentional intervention effect in the meta-analyses was very low. This suggests that attentional interventions provided consistent effects for jumping performance. Although this meta-analysis does make a unique contribution to the existing body of literature examining the focus of attention effect, it is important to note that there are some limitations of the present review. For example, there is inherent publication bias as a result of all included studies being published in peer–reviewed journals printed in English and we did not include grey literature such as doctoral dissertations or master theses as they have not been vetted through the traditional peer-review process. It is also important to point out that our analysis only included studies that utilized a within-subject design. We encourage future researchers to continue to investigate the efficacy of the focus of attention effect using a between-subject design. It would allow for the investigation of long-term learning effects and the isolation of testing conditions. It is also worth noting that none of the cited studies in our review indicated that researchers were blind to the assigned conditions during testing and only two studies reported that testing was conducted in a distraction-free environment (Porter et al., 2012, 2013). Moreover, two studies (Wulf and Dufek, 2009; Wulf et al., 2010) used a relatively small group of participants and only three papers involved a high trained population (Asadi et al., 2019; Coker, 2016; Porter et al., 2013). In conclusion, our analysis found evidence of a small positive effect of an external focus of attention on jumping performance for adults when compared with internal and no attentional focus conditions. There is a need to further investigate the potential advantages of an external focus of attention in other power-based skills related to strength and conditioning.

Practical implications

Adopting an external focus of attention has immediate beneficial effects on jumping performance. For strength and conditioning professionals, sports coaches and physical education teachers, it is recommended that verbal instructions include cues that explicitly promote an external focus of attention when assessing jumping performance. Based on the present findings, we strongly advised directing attention externally toward a target such as a line or a cone when performing the standing long jump, or a suspended ball or a Vertec rung when executing the vertical jump. Furthermore, we propose that coaches should avoid words or phrases with reference to the movements of muscles or joints during jump testing sessions. Along these lines, coaches should avoid vague cues such as "jump to the best of your ability" when testing jumping performance. Based on the results of the present meta-analysis, providing internal focusing or generally vague cues has no enhancing effect on jumping performance.

We propose textbooks and other coaching education materials should include guidelines for how best to provide instructions and verbal cues. Specifically, personal trainers and strength and conditioning coaches should be educated on how to best inform clients and athletes how to optimally focus their attention when performing skills such as the long and vertical jumps. With this in mind, it is also important that certification

examinations designed to evaluate a strength and condition specialist qualifications to work with athletes or clients include content related to the proper use of instructions when teaching and evaluating jumping performance.

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