

Effect of Neutral, Internal, and External Focus on Drop Jump Performance: Is Drop Jump Performance Affected by Plyometric Training Experience?

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Abstract

Furuhashi, Y., Hioki, Y., Yoshimoto, S., and Hayashi, R. The effect of neutral, internal, and external focus on drop jump performance: is drop jump performance affected by plyometric training experience? *J Strength Cond XX(X)*: 000–000, 2021—Providing an external focus of attention through verbal instructions can improve the drop jump (DJ) performance, which differs based on the skill level of athletes. The purpose of this study was to assess the effect of change of focus of attention on the performance of DJs in experienced and inexperienced athletes. Thirty-eight male collegiate athletes divided into the experienced group (E group: age, 21.5 ± 1.4 years; height, 173.4 ± 5.7 cm; and body mass, 65.7 ± 6.2 kg) and the inexperienced group (I group: age, 21.9 ± 1.5 years; height, 172.8 ± 5.1 cm; and body mass, 68.7 ± 5.5 kg) performed 2 trials of DJs after listening to instructions designed to evoke a neutral, internal, or external focus of attention. Contact time (CT), jump height (JH), reactive strength index (RSI), and leg-spring stiffness (k_{vert}) were recorded during DJ and compared between the 2 groups using a repeated-measures analysis of variance. In the E group, the neutral condition was associated with a significantly higher RSI, JH, and k_{vert} than the internal and external conditions ($p < 0.05$). In the I group, the external condition was associated with significantly higher RSI and k_{vert} and shorter CT than other conditions ($p < 0.05$). Therefore, this suggests that attentional focus strategies need to be selected depending on DJ experience: A neutral focus may be preferable for athletes experienced in DJs, whereas an external focus may be more suitable for athletes with lesser DJ experience.

Key Words: stretch-shortening cycle, ballistic, reactive strength index, kinetics, awareness

Introduction

A drop jump (DJ) involves stepping from a predetermined height, landing, and immediately performing a maximum vertical jump (2). It is one of the plyometric training techniques that increases the stretch-shortening cycle (SSC) in the muscles of the lower limbs and is generally used by strength and conditioning coaches and athletes for plyometric training (13). Drop jumps are a better form of training than countermovement DJs for athletes who seek to improve the mechanical output of their knee extensors and plantar flexors (4). It also allows for an escalation of training loads by changing the drop height. A high-performance DJ requires minimum contact time (CT) and maximum jump height (JH) (13). Additional indices used to evaluate DJ performance include the reactive strength index (RSI), calculated by dividing the JH by the CT (24). Previous studies have shown a correlation between RSI and sprint times of 30, 100, and 300 m; vertical jumps; and 5-step bounds (15), and several studies have demonstrated that DJ training is effective in improving strength, jumping, and sprinting in athletes (6,7,11).

Moreover, fast SSCs are related to high leg-spring stiffness (k_{vert}) (10,12). k_{vert} is related to the mechanism by which the body's downward velocity is reversed during limb contact and is defined as the ratio of the maximum vertical ground reaction force (vGRF) to the maximum vertical displacement of the center of mass during limb contact (16). Kipp et al. (19) also reported a

correlation between k_{vert} and RSI in DJs. Therefore, k_{vert} can be an informative and reliable indicator to assess DJ performance.

Verbal instructions can change one's consciousness when exercising (23). According to Comyns et al. (9), verbal instructions can be used to promote a neutral, internal, or external focus of attention (9). An external focus of attention refers to focusing one's consciousness on the effects of the exercise environment, an internal focus of attention refers to directing one's consciousness to specific body parts and their movements, and a neutral focus of attention does not aim to induce neither the external nor internal focus of attention and instead promotes nonawareness (23). Moreover, it has been suggested that athletic performance is changed by controlling the focus of the athlete's consciousness to 1 of the 3 focuses of attention through verbal instructions from the coach while the athlete exercises (23).

In previous studies, Comyns et al. (9) investigated the effect of attentional focus strategies on DJ performance in rugby players. It was shown that an external focus of attention showed a higher RSI than neutral and internal focuses of attention and higher vGRF and k_{vert} than a neutral focus of attention. Furthermore, Makaruku et al. (20) found that the external focus group showed the highest vGRF in DJs compared with the other 2 groups. Thus, attentional focus strategies can affect practice effectiveness and DJ performance.

Drop jump can be considered as a simple movement involving jumping off a platform. However, according to Jukka, those who regularly practiced DJs had significantly higher JH and significantly shorter CT than those who did not (22). In addition, Singer et al. (21) reported that skilled performers can be more successful when they

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are not thinking about their body movements. Based on these reports, we hypothesized that attentional focus strategies in DJ may be different depending on the experience level of plyometric training in athletes. Consequently, we wanted to investigate this fact further to reveal what athletes should focus their attention on when they perform DJs. This can also enable strength and conditioning coaches to provide appropriate awareness instructions to a wide range of athletes depending on their experience with DJs.

The purpose of this study was to assess the effect of the change of attentional focus through verbal instructions on DJ performance in experienced and inexperienced athletes. It was hypothesized that DJ performance in the experienced group (E group) would be better with a neutral focus of attention, whereas DJ performance in the inexperienced group (I group) would be better with an external focus of attention.

Methods

Experimental Approach to the Problem

This study used a within-subjects experimental design to study the effects of neutral, internal, and external focus strategies on DJ performance. Subjects participated in a single experimental session and received verbal instructions that prompted one of the neutral, internal, and external focuses of attention, followed by 2 trials of DJs from a 30-cm high box. Overall, 6 trials were performed, and the order of the verbal instructions was randomized to eliminate the possibility of order effects. Dependent variables were JH, CT, RSI, and k_{vert} .

Subjects

Thirty-eight male collegiate subjects were divided into the E group (15 sprinters and 4 jumpers) and I group (6 soccer players, 5 handball players, 4 swimmers, 3 kendo players, and 1 basketball player). The exclusion criteria were the following: use of medication affecting exercise capacity or orthopedic limitations. The physical characteristics of the subjects are given in Table 1. The training frequency of all the subjects was 5 days a week. The E group was familiar with the technique of DJs and regularly performed DJs. The I group was not familiar with the technique of DJs and had intermediary experience with DJ. Written informed consent was obtained from all subjects. The consent form and all experimental methods were approved by the Research Ethics Committee of the University of Tsukuba before the initiation of this study (tai 019-18).

Procedures

One week before the experiment, the I group was invited to the laboratory to perform a familiarization protocol consisting of 15 DJs. The practice of DJs in advance was to minimize the change in performance due to the learning effect occurring during measurement and suppress variations in jumping techniques (3). All subjects

were instructed to refrain from resistance training the day before the experiment. Before the experiment, they had to perform 15 minutes of low-intensity jogging, including dynamic stretching. Thereafter, they performed 5 DJs using a 30-cm box. All subjects were given 2 minutes of rest after the warm-up; each subject performed a total of 6 trials of DJs under 3 conditions. If the subject failed a DJ explicitly, the trial was performed again. All trials were performed using a 30-cm box (18). Subjects were instructed to keep their hands on their hips, bend their knees as little as possible, and perform every DJ with maximal intensity (3). Subjects were then instructed to stand on a 30-cm box, and the examiner read aloud the DJ instructions for external, internal, and neutral attentional focuses. Each of the verbal instructions drafted by referring to previous studies (9) is listed in Table 2. The verbal instructions for each condition were always reread before each trial. When on the platform, the posture of the preset phase was standardized by ensuring the same eye height for each trial. DJs were completed under each condition (i.e., neutral, internal, and external focus of attention conditions), and subjects were given a 1-minute rest between trials under the same conditions and a 2-minute rest between each condition (9). Subjects were not provided any feedback regarding their performance.

Data Analysis. JH, CT, RSI, and k_{vert} were examined as variables to evaluate DJ performance. vGRF was collected using a force platform (PH-6210A, 0.9 m × 0.9 m; DKH, Tokyo, Japan) at 1,000 Hz. For values regarding flight time, CT and maximum vGRF data were obtained directly from the force platform data. JH was defined as the flight time component and determined using the equation $JH = (9.81 \times \text{flight time}^2)/8$ adopted from a study by Bosco et al. (5). Reactive strength index for each DJ trial was calculated by dividing JH (m) by CT (s) (24). The mass spring model was used to calculate k_{vert} , which is defined as the ratio of the peak vGRF to the spring displacement when the leg-spring contracts to its maximum (18). The average of the 2 trials was used for the analysis.

Statistical Analyses

All statistical analyses were conducted using IBM SPSS version 25 (IBM, New York, NY). Intraclass correlation coefficients (ICCs) were calculated to determine the test-retest reliability of the measured variables. Data were normally distributed for all conditions, as assessed by the Shapiro-Wilk test. A 2-way analysis of variance (ANOVA) was used to determine the interaction (2 groups × 3 conditions) and the main effects of groups (E group and I group) and conditions (neutral, internal, and external) on each dependent variable. If the assumption of sphericity was rejected using Mauchly's test of sphericity, the Greenhouse-Geisser correction was applied. When a statistically significant interaction and main effects were detected,

Table 1
Physical characteristics of subjects (mean ± SD).

	E group	I group
Age (y)	21.5 ± 1.4 (Between 19 and 24 years)	21.9 ± 1.5 (Between 19 and 24 years)
Height (cm)	173.4 ± 5.7	172.8 ± 5.1
Body mass (kg)	65.7 ± 6.2	68.7 ± 5.5

Table 2
Drop jump verbal instructions designed to invoke neutral, internal, and external focuses of attention.

Attentional focus	Verbal instructions
Neutral	"Perform the jump to the best of your ability"
Internal	"Step off the box, land on the balls of your feet, and after landing fully and explosively extend your ankles, knees, and hips as rapidly as possible to jump high"
External	"Step off the box, jump fast, imagine the ground is a hot surface, get off the ground as quickly as possible, imagine you are like a stiff spring, and focus on jumping to the roof"

Table 3
ICC, CV%, and 90% CI of reactive strength index (RSI) under each condition.*†

	Neutral			Internal			External		
	ICC	CV%	90% CI	ICC	CV%	90% CI	ICC	CV%	90% CI
E group	0.943**	20.6	2.07–2.44	0.932**	20.8	1.92–2.27	0.938**	20.1	1.88–2.23
I group	0.938**	27.4	1.42–1.80	0.960**	27.1	1.47–1.84	0.941**	29.6	1.59–1.99

*ICC = intraclass correlation coefficient; CV = coefficient of variation; CI = confidence interval.

†** $p < 0.01$, * $p < 0.05$.

Bonferroni's post hoc tests were performed using pairwise comparisons of alpha levels to identify differences in variable scores between each condition. Effect sizes using Hedges' g were obtained for any significant pairwise comparisons and interpreted using the following scale: less than 0.2, trivial; between 0.2 and 0.5, small; between 0.5 and 0.8, medium; between 0.8 and 1.3, large; and greater than 1.3, very large (8). The alpha level was set at 0.05. All data are presented as mean $\pm$ SD.

Results

The scores of the ICC and the coefficient of variation with a 90% confidence interval between the first and second RSI measurements are given in Table 3. The mean $\pm$ SD scores for all variables under the neutral, internal, and external conditions in both groups are detailed in Table 4. A 2-way ANOVA showed that in RSI, there was an interaction between groups and conditions ($F_{2,72} = 22.217$, $p = 0.001$, $\eta^2 = 0.382$). A simple main effect for conditions was found in both groups ($p = 0.001$). There was also a simple main effect during internal and neutral conditions ($p = 0.001$ – 0.006) in all groups. In a subsequent analysis of pairwise comparisons, the E group was significantly higher than the I group during internal and neutral conditions ($p = 0.001$ – 0.006). In the E group, the neutral condition was significantly higher than the internal condition ($p = 0.001$, $g = 0.355$, small) and external condition ($p = 0.001$, $g = 0.438$, small). In the I group, the external condition was significantly higher than the neutral condition ($p = 0.001$, $g = 0.280$, small) and internal condition ($p = 0.003$, $g = 0.369$, small).

Regarding JH, there was an interaction between groups and conditions ($F_{2,72} = 8.604$, $p = 0.001$, $\eta^2 = 0.193$). There was a simple main effect in the E group for conditions. A simple main effect for groups was found only in the neutral condition. In a subsequent analysis of pairwise comparisons, the E group was significantly higher than the I group in the neutral condition ($p =$

0.029). In the E group, the neutral condition was significantly higher than the internal condition ($p = 0.003$, $g = 0.261$, small) and external condition ($p = 0.001$, $g = 0.388$, small).

Regarding CT, there was an interaction between groups and conditions ($F_{1,638,58,983} = 14.673$, $p = 0.001$, $\eta^2 = 0.290$). There was a simple main effect for conditions in the I group. A simple main effect for groups was found in all conditions. In a subsequent analysis of pairwise comparisons, the E group was significantly shorter than the I group in all conditions ($p = 0.001$ – 0.023). In the I group, the external condition was significantly shorter than the neutral condition ($p = 0.01$, $g = 0.563$, medium) and internal condition ($p = 0.014$, $g = 0.275$, small).

Regarding k_{vert} , there was an interaction between groups and conditions ($F_{2,72} = 14.153$, $p = 0.001$, $\eta^2 = 0.282$). A simple main effect for conditions was found in both groups ($p = 0.001$ – 0.003). There was also a simple main effect for groups in the internal and neutral conditions ($p = 0.001$ – 0.006). In a subsequent analysis of pairwise comparisons, the E group was significantly higher than the I group in internal and neutral conditions ($p = 0.001$ – 0.006). In the E group, the neutral condition was significantly higher than the internal condition ($p = 0.003$, $g = 0.465$, small) and external condition ($p = 0.012$, $g = 0.437$, small). In the I group, the external condition was significantly higher than the neutral condition ($p = 0.002$, $g = 0.395$, small) and internal condition ($p = 0.002$, $g = 0.302$, small).

Discussion

The purpose of this study was to assess the effect of changing the focus of attention through verbal instructions on DJ performance in experienced and inexperienced athletes. The main finding of this study was that the attentional focusing strategy for optimal DJ performance depends on the DJ experience level. Therefore, these results generally support our hypothesis that DJ

Table 4
Mean $\pm$ SD scores for each drop jump variable under each condition.§¶

	Neutral	Internal	External	Differences
E group				
RSI ($\text{m}\cdot\text{s}^{-1}$)	2.255 $\pm$ 0.455 ^{††}	2.094 $\pm$ 0.432 ^{††}	2.057 $\pm$ 0.432	Neu > int**, Ext**
JH (m)	0.369 $\pm$ 0.065 [†]	0.352 $\pm$ 0.064	0.342 $\pm$ 0.073	Neu > int**, Ext**
CT (s)	0.165 $\pm$ 0.018 [‡]	0.171 $\pm$ 0.020 ^{††}	0.167 $\pm$ 0.017 [‡]	n.s.
k_{vert} ($\text{kN}\cdot\text{m}^{-1}$)	33.740 $\pm$ 8.637 [†]	29.762 $\pm$ 8.087 ^{††}	30.225 $\pm$ 7.032	Neu > int**, Ext*
I group				
RSI ($\text{m}\cdot\text{s}^{-1}$)	1.611 $\pm$ 0.477	1.657 $\pm$ 0.454	1.792 $\pm$ 0.486	Ext > Neu**, int**
JH (m)	0.322 $\pm$ 0.060	0.317 $\pm$ 0.062	0.325 $\pm$ 0.062	n.s.
CT (s)	0.208 $\pm$ 0.035	0.197 $\pm$ 0.030	0.188 $\pm$ 0.032	Ext > Neu**, int*
k_{vert} ($\text{kN}\cdot\text{m}^{-1}$)	19.828 $\pm$ 10.134	20.878 $\pm$ 9.872	24.145 $\pm$ 11.258	Ext > Neu**, int**

§RSI = reactive strength index; JH = jump height; CT = contact time; k_{vert} = leg-spring stiffness. Neu = neutral focus of attention; Int = internal focus of attention; Ext = external focus of attention; E group = experienced group; I group = inexperienced group.¶** $p < 0.01$, * $p < 0.05$, ††the E group is significantly higher than the I group $p < 0.01$, ‡the E group is significantly higher than the I group $p < 0.05$, ‡‡the E group is significantly shorter than the I group $p < 0.01$, and ‡the E group is significantly shorter than the I group $p < 0.05$.

performance in the E group would be better when a neutral focus of attention is used, whereas DJ performance in the I group would be better when an external focus of attention is used.

The results showed that the E group performed better than the I group on many measured variables and conditions (Table 4). This is most likely because of the influence of daily plyometric training experience.

In the I group, RSI, CT, and k_{vert} under the external condition were significantly higher than under the other 2 conditions (Table 4). Consequently, it can be inferred that the I group can perform better DJs under the external condition. Previous studies (9) have showed that instructions with an external focus before DJ performance resulted in a significantly higher RSI than internal and neutral awareness instructions. Subjects in the study by Comyns et al (9) were familiar with the technique of DJs but only had intermediary experience with DJ. Although the characteristics of the subjects of the study by Comyns et al (9) and our subjects differ, our finding of significantly higher RSI under the external condition in the I group supports their findings. Moreover, although the RSI of the I group in our study ($1.781 \text{ m}\cdot\text{s}^{-1}$) was higher than that reported in the study of Comyns et al. (9) ($1.27 \text{ m}\cdot\text{s}^{-1}$), the subjects in the said study were more proficient in DJs than those in the I group in our study. Thus, the difference in RSI value may be influenced by the difference in the subjects' experience. Furthermore, it has been shown that the performance of subjects when instructed to induce external awareness was higher than when subjects induced internal awareness in nearly all sports events (23). Therefore, those who have no experience or intermediary experience in DJs may be able to demonstrate higher DJ performance with the provision of instructions for external awareness.

In a study by Comyns et al. (9), the RSI under the external condition was significantly higher compared with other conditions, but there was no change in JH and CT. By contrast, in our study, although the CT under the external condition was significantly shorter than that in other conditions, there was no significant difference in JH. Reactive strength index is the JH divided by CT during DJ, and it can be increased by maximizing JH and minimizing CT (13). Thus, the factors that led to an improvement in RSI may differ among the 2 groups.

In the E group, the neutral condition was associated with a higher RSI, JH, and k_{vert} than the other 2 conditions (Table 4). The E group had a higher DJ ability than the I group because this group performed plyometric training, including DJs as a part of their daily training. Singer et al. (21) reported that skilled performers can be more successful when they are not thinking about their body movements. Garfield et al. (14) also suggested that highly skilled athletes lose awareness when they perform at their best. Thus, it is possible that subjects in the E group had higher values of RSI, JH, and k_{vert} in the neutral condition compared with other conditions. By contrast, the CT in the E group was not significantly different between the neutral condition and other conditions. In a longitudinal study examining the change in performance of the rebound jump, it was suggested that the CT changed when the initial value was large but was difficult to change when it was already small (25). Therefore, this result may also have been influenced by the DJ experience of the subjects in the E group.

In a previous study, optimizing leg-spring stiffness was demonstrated as one of the factors that improved DJ performance (13). Furthermore, Arampatzis et al. (1) reported that leg stiffness was related to a shorter installation time. It is suggested that directing awareness to an external focus may increase k_{vert} for subjects without experience in plyometric training. Thus, the shorter CT under the external condition in the I group may explain the

increased k_{vert} . By contrast, in the E group, although the highest k_{vert} was seen under a neutral condition, CT was not significantly different. Consequently, the role of k_{vert} in CT may vary depending on the level of experience with DJs.

Comyns et al. (9) reported that there may be an increased risk of injury when using DJs as a test or training program. Moreover, spring stiffness is associated with a higher risk of ACL injury compared with soft spring stiffness (19). In the I group in this study, because the k_{vert} in the external condition was higher than in other conditions, it is possible that their risk of injury was greater. It is necessary for inexperienced plyometric trainers to reconfigure attentional focusing strategies on athletes with no DJ experience. For example, internal, rather than external, awareness can be initially created to avoid the risk of injury when performing DJs.

This study has a few limitations. First, we adopted instructions that promoted both the shortening of CT and the increase of JH. However, the actual focus of consciousness is unknown and may have been different for each subject. In addition, it may have been difficult for some subjects to change their attentional focus between conditions. This may be especially the case for the I group. More reliable results may be obtained by asking subjects what they focused on during instructions by using questionnaires and other similar assessments. This may allow for a more accurate understanding of the effects of attentional strategies. Second, the instructions given to the subjects were determined based on a previous study (9). Three conditions, which are neutral, internal, and external conditions, were set when investigating attentional focusing strategies during DJ, but results may differ depending on the verbal instructions used. Therefore, using various instructions may clarify the attentional focus strategy during DJs.

Practical Applications

Many studies have shown that the external focus of attention strategy elicits higher performance (9,17,20). However, our results suggest that the group proficient in plyometrics performed a DJ with higher RSI, JH, and k_{vert} when the neutral focus of attention strategy was adopted. By contrast, the group with lesser proficiency in plyometrics showed that the external focus of attention strategy resulted in greater RSI, k_{vert} , and shorter CT. This suggests that an external focus of attention may help athletes who do not normally use DJs in training to perform better. Contrastingly, it should be noted that athletes with a certain level of muscular strength and extensive experience with plyometrics may not perform well in DJ training if they use any attentional focus strategy, whether external or internal. In addition, as noted in a previous study (9), the resulting higher levels of rigidity may potentially increase the risk of skeletal injury; therefore, it may be necessary to use an internal focus of attention when targeting subjects with low muscle strength levels. Therefore, strength and conditioning coaches must understand that external focus of attention strategies are not a panacea for all athletes for optimum DJ performance. One must consider the need to modify the attentional focus strategy based on the subject's ability, strength level, and other conditions.

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