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Effects of internal focus and external focus of attention on postural balance in school-aged children

Hwa Kyung Shin, Ryu-Min Kim, Jae-Moon Lee

Department of Physical Therapy, College of Bio and Medical Science, Daegu Catholic University, Gyeongsan, Republic of Korea

Objective: Attentional focus is one of the critical factors that has consistently been demonstrated to enhance motor performance and motor skill. Focusing attention on the inside of the body while engaging in a particular exercise is called internal focus (IF) and focus on the external environment is called external focus (EF). The purpose of this study was to identify effects of IF and EF of attention on postural balance in healthy school-aged children.
Design: Cross-sectional study.
Methods: Twenty-four healthy school-aged children participated in this study. School-aged children was defined as children ages 8-12 years old. They performed the one-legged standing with EF (focusing on the marker at the level of participants' chest and 150 cm away), IF (focusing the supporting feet), and control (no instruction) respectively. The order of the focus condition was randomly selected. The center of pressure (COP) range, distance, and velocity was measured to compare the effects of applying different attentional focuses in the three conditions.
Results: The results of our study show that differences in COP range, distance, and velocity among groups were not significant between the different attentional focuses, although all variables of EF were smaller than IF. It is postulated that the reason for this may be that school school-aged children between 8-12 years old go through a transitional phase from IF to EF in effective motor learning.
Conclusions: These findings reveal that the type of attentional focus did not have any effect on postural balance in healthy school-aged children.

Key Words: Attention, Child, Motor skill, Posture

Introduction

Balance involves regulation of movement of linked body segments over supporting joints and base of support [1-4]. Most of these actions include lower limbs, supporting and moving body mass over the feet while standing [3,5,6]. Motor learning for postural control and balance is embedded in the motor development process, and it can have positive effects on motor developmental stages [7].

Attentional focus is one of the critical factors that has consistently been demonstrated to enhance motor performance and motor learning [7,8]. Attentional focus implies 'where' attention is focused while engaging in a specific movement. Focusing attention on the inside of the body while engaging in a particular exercise is called internal focus (IF) and focus on the external environment is called external focus (EF). IF feedback comes from any sensory source from inside the body, such as from proprioceptors or outside the body when a person sees that a target was not hit or a ball was hit out of bounds [7]. IF is directed to specific body segments involved in movement. EF feedback is extra or augmented sensory information received by the mover from an external source [8]. EF is directed to a specific outcome or effects produced by movement in the environment (e.g., a target, implement,

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Corresponding author: Hwa Kyung Shin (**ORCID** https://orcid.org/0000-0003-3876-0710)
Department of Physical Therapy, College of Bio and Medical Science, Daegu Catholic University, 13-13 Hayang-ro, Geumnak-ri, Hayang-eup, Gyeongsan 38430, Republic of Korea
Tel: 82-53-850-2532 **Fax:** 82-53-350-6770 **E-mail:** hkshin1@cu.ac.kr

or apparatus).

Studies have shown that EF is generally more effective on motor performance and motor learning than IF [3,9]. Also, studies on a particular population, such as the elderly, Parkinson's patients, and ankle sprain patients have revealed similar benefits [9,10]. The advantage of EF was also observed in gait conditions. Studies involving patients with multiple sclerosis, Parkinson's disease, and the elderly have shown improvement in gait quality when using EF. Also, benefits of EF have been demonstrated in movement efficiency and kinematics and extend across different types of tasks as well as skill levels [3,9,10].

Several age-based studies have reported that EF is effective in performing balance tasks in healthy elderly and other adults. However, effects of IF or EF on children's motor learning remain controversial [10,11]. Thus, the purpose of this study was to identify effects of IF and EF of attention on postural balance in healthy school-aged children, and to provide more useful information on motor learning.

Methods

Participants

Twenty-four healthy school-aged children were recruited from the Daegu area in Korea for this study. School-aged children was defined as children ages 8-12 years old. They were informed about the procedure and obtained parental consent. Selection criteria of subjects were as follow; those with no limit to range of motion of the ankle joint, those who maintained one-legged standing (OLS) posture for more than 15 seconds, those with no visual problems, and those with no orthopedic or neurological challenges, dizziness, or balance disorders, or those that use drugs that may affect balance. All subjects understood the purpose of this study and provided written informed consent prior to participation in this experiment. The ethical committee of Daegu Catholic University has approved this study (CUIRB-2016-0111).

Table 1. General characteristics of subjects (N=24)

Variable	Value
Age (y)	10.90 (2.20)
Sex (male/female)	12/12
Height (cm)	143.70 (6.49)
Weight (kg)	35.65 (12.20)
Dominant leg (right/left)	23/1

Values are presented as mean (SD) or number only.

General characteristics of subjects are shown in Table 1.

Experimental tools and procedures

A force plate (Newton; AMTI Inc., Watertown, MA, USA) was used to assess postural balance during the OLS posture [12]. Data of the force plate was collected using an A/D card (DT3002; Data Translation, Marlboro, MA, USA) and the sampling frequency was set to 200 Hz. Analog data collected from the force plates was digitally converted by the A/D converter (VSAD-102-3C) and stored in the computer's hard drive.

The examiner explained the procedure of the experiment to the subjects and allowed them to practice the OLS posture two times in barefoot conditions (Figure 1). In the process, subjects looked forward and stood comfortably on both legs. Subjects then transferred their full weight to their dominant legs and maintained balance in one of three conditions for more than 15 seconds with OLS [12]. The dominant leg was defined as the preferred leg used to kick a soccer ball. The IF condition focused attention on the supporting feet. The EF condition focused attention on the circle placed 150 cm away from the subject at chest-height. The control condition enabled the performance of OLS without indication of attention. The interval between three repetitions within each condition was 30 seconds, and interval between each condition was three minutes. All subjects performed the control condition first. Subsequently, to offset the order effect on attentional focus, 12 subjects were in the order of IF and EF,

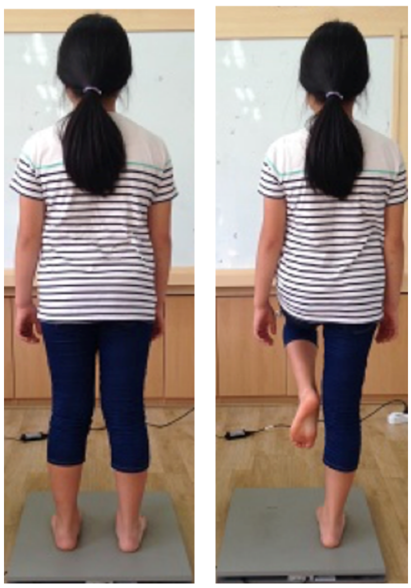

Figure 1. One-legged standing.

and the other eight subjects were reversed. Order of focus condition was randomly selected. In the control, subjects were not provided with instructions regarding attentional focus. In the IF, subjects were instructed to stand on one leg while focusing on his/her lower limb movements. In the EF, subjects were instructed to stand on one leg by focusing on the markers placed in front.

Data analysis and statistics

The center of pressure (COP) data for 10 seconds except the first 5 seconds were used for analysis in order to remove the initial fluctuations that might occur in the subjects. The variables used in the analysis included the following; the range of the COP (R_{AP}, R_{ML}), the coordinates of the COP ($x_{AP(n)}$, $x_{ML(n)}$), the moving distance (MD_{AP}, MD_{ML}), and the moving velocity (MV_{AP}, MV_{ML}) along the anteroposterior (AP) and mediolateral (ML) directions [12]. In the equations below, (n) indicates the number of data points used in the analysis, and T indicates the time for measurement.

$$R_{AP} = AP_{max} - AP_{min}$$

$$R_{ML} = ML_{max} - ML_{min}$$

$$x_{AP(n)} = x_{AP(0)} - \overline{x_{AP}}$$

$$x_{ML(n)} = x_{ML(0)} - \overline{x_{ML}}$$

$$MD_{AP} = \frac{1}{N}\sum |x_{AP(n)}|$$

$$MD_{ML} = \frac{1}{N}\sum |x_{ML(n)}|$$

$$MV_{AP} = \frac{1}{T}\sum_{n=1}^{n-1}\sqrt{|x_{AP(n+1)} - x_{AP(n)}|}$$

$$MV_{ML} = \frac{1}{T}\sum_{n=1}^{n-1}\sqrt{|x_{ML(n+1)} - x_{ML(n)}|}$$

Statistical analysis was performed using IBM SPSS Statistics for Windows, Version 20.0 (IBM Co., Armonk, NY, USA). The repeated one-way ANOVA was used to analyze differences between IF, EF, and control states. The significance level (α) was set to 0.05.

Results

This study measured the range, distance, and velocity of COP during OLS in EF, IF, and the control condition.

Although all variables of EF were smaller than IF, no variables for the COP showed any significant difference between the three conditions (p>0.05) (Table 2).

Discussion

The purpose of this study was to identify effects of IF and EF of attention on postural balance in healthy school-age children, and to provide more useful information on motor learning. Many studies are reporting that EF is more effective for motor learning in healthy adults [9,13]. However, in the case of children, results of previous studies were inconsistent [11,14]. Some studies have reported no significant differences in motor learning between EF and IF, and some studies have reported that IF is more effective [15]. Emanuel *et al*. [11] reported that IF is more effective than EF in transfer of children's motor skills. Cluff *et al*. [6] reported no significant difference between EF and IF for children. External attention can facilitate the automatic processing of the motor system and can be useful for motor learning. On the other hand, conscious control of movement by internal attention can interfere with automatic processing [7]. The constrained action hypothesis states that IF interferes with effective motor control by making conscious control during movement [7]. On the contrary, EF was found to promote automatic information processing of motor skill, thereby improving motor control. However, the kinesthetic sense in school-aged children are immature and may lack experience with phys-

Table 2. Change of range, velocity and distance of COP (N=24)

Variable	Control	IF	EF	F (p)
COP range AP (cm)	7.92 (2.08)	7.90 (2.24)	7.89 (2.52)	0.01 (0.99)
COP range ML (cm)	6.28 (1.50)	6.21 (1.35)	6.20 (1.79)	0.05 (0.95)
COP distance AP (cm)	235.69 (66.18)	240.69 (70.13)	234.30 (64.40)	0.25 (0.78)
COP distance ML (cm)	210.29 (62.84)	212.24 (63.85)	209.85 (55.66)	0.06 (0.94)
COP velocity AP (m/s)	7.86 (2.21)	8.02 (2.34)	7.81 (2.15)	0.25 (0.78)
COP velocity ML (m/s)	7.01 (2.09)	7.07 (2.13)	6.99 (1.86)	0.06 (0.94)

Values are presented as mean (SD).
COP: center of pressure, IF: internal focus, EF: external focus, AP: anterior posterior, ML: medial lateral.

ical activity, and may thereby encounter difficulty with automatic motor processing [9]. Thus, they may cause IF or EF to be more effective in motor learning, or may cause no significant difference between the three conditions [11,16]. In this study, EF did not have a greater significant effect than IF in postural sway. It is postulated that the reason for this that school age-childhood between 8-12 years old go through a transitional phase from IF to EF in effective motor learning.

Some studies have reported that attention focus on motor learning was changing from IF to EF. This is because school-age period in childhood is a transitional stage of development of the kinesthetic system that may affect motor awareness or motor learning. Also, this may be the reason for no significant difference to have been found between IF and EF in this study. To apply attentional focus more effectively for clinical exercise rehabilitation, the physical development level (e.g., developmental age, skill level, task difficulty, etc.) should be considered [3,17-19].

The limitations of this study are as follows: First, it was difficult to generalize the results of the study in all school-aged children as we did not subclassify the subject's group by their age. Second, it was not possible to represent the effect of attentional focus through continuous training by measuring only the immediate effects. Therefore, further studies on the role of attentional focus provided to learners should be continued in order to generalize the results of this study. It is proposed that scientific evidence for more efficient and concrete methods to improve postural balance in school-age children should be continuously reported in connection with various variables.

Conflict of Interest

The authors declared no potential conflicts of interest with respect to the authorship and/or publication of this article.

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