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The Open Sports Sciences Journal

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RESEARCH ARTICLE

Balance Control and Muscles Activity of An Elderly Retired Man During Different Focus of Attention Instructions

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Abstract:

Background:

Good balance and muscle activity are essential to do daily activities. Recent studies have focused on the relations between balance and attention patterns. The study of the balance and muscle activity of people in different patterns of attention can clarify the nature of the effect of attention instructions.

Purpose:

The present study aims to evaluate the changes in different focus of attention instructions and quality of balance control and muscle activity in the elderly retired.

Methods:

Thirty elderly retired men [mean age: 51.6 ± 6.4 years] were recruited for this study. Subjects were selected through the berg balance test. Balance control ability [Biodex Balance System] and muscle activity [electromyography system] were assessed in two conditions, internal attention and external attention task. The data obtained were analyzed using repeated-measures ANOVA at a significant level of $P<0.05$.

Results:

Body sway and muscle activity parameters were correlated with different patterns of attention. During external focus condition, [1] Center of Pressure [CoP] total two-leg balance, CoP medio-lateral and CoP anterior-posterior for external-focus were lowered [$P<0.05$] and [2] Tibialis anterior and soleus for the leg, biceps brachii and triceps brachii for the arm, sternocleidomastoid and semispinalis capitis for external-focus were lowered [$P<0.05$].

Conclusion:

Improved static balance responses and alterations in postural control were observed under external focus conditions. An external focus of attention may be the preferred method for facilitating balance control and muscle activation in an elderly retired man.

Keywords: Elderly retired, Attention instructions, Balance control, Muscle activity, CoP total Two-leg balance, CoP Medio-lateral.

Article History	Received: September 07, 2020	Revised: December 09, 2020	Accepted: December 23, 2020

1. INTRODUCTION

Postural control entitled as "the human balance system" is defined as the ability to maintain the body's center of mass over its base of support [to see clearly while moving, identify orientation concerning gravity and automatic postural adjustments] in various conditions and activities [1]. Balance is a complex life-sustaining physical ability that is impaired in older adults [2]. Balance control plays an important role in the daily routine and motor autonomy of people. In recent years, much attention has been paid to the conscious aspects of balance control, such as attention and cognitive processes for efficient balance function [3]. In daily activities, our balancing in walking, standing, exercising is a type of efficient balance experienced in different forms of balance, static balance, semi-dynamic balance, and dynamic balance [4]. As we grow older, posture changes and proprioceptive mechanisms will be weakened in the elderly and they will depend on their visual

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DOI: 10.2174/1875399X02013010129, 2020, *13*, 129-136

and vestibular systems as well as higher accuracy in their life [5]. Retirement has modest negative effects on cognitive function, especially in older men [6].

Postural sway during human quietly standing is often quantified by measuring the motion of the Center of Pressure [CoP], namely the point of application of the ground reaction force vector [7]. CoP complex fluctuations can be modeled as a two-dimensional stochastic process [8 - 10] in the anterior-posterior [AP] and medio-lateral [ML] directions on the horizontal plane [7].

In childhood, postural sway gradually progresses, static balance control usually improves until the sixth decade, and then balance control experiences a decline [11]. In past years, balance control had been examined as an automatic or controlled reflective mechanism employing minimum attentional sources, but recent researches show important needs for balance control and attentional demands whose experience varies depending on the kind of postural activity, age, and balance abilities [12]. Undoubtedly, chronic and acute diseases increase with age, while functional ability and sensory system and perception reduce. These biological, mental, and social changes threaten the life quality of the elderly [9]. Standing balance control is a complex sensorimotor action capability that is based on automated and reflexive spinal programs under the influence of several distinct and separate supraspinal centers in the brainstem, cerebellum, and cortex [13, 14]. Several recent studies examining postural control have concluded that certain cognitive functions, such as attention, interact with motor function [13, 15, 16].

This is the process through which people use their sensations to perceive the outer world. Attentional focus means being aware of an affair and ignoring other affairs. The employment of these attentional resources depends on age, existing sensory information, the complexity of balance tasks, skill level, and voluntary attention focus on body sways [17, 18].

The relationship between posture, balance, and intentional movements is particularly important in the elderly population, where a generalized decrease in balance control is accompanied by an increased frequency of movement-related falls [19, 20]. Studies report that 20%-50% of older adults experience balance impairment that increases their fall risk [21], as in Iran, one-third of falling events occurred due to balance impairment [22]. Moreover, the relationship between balance control and independent mobility becomes vital in older adults where poor postural control is associated with significant mobility losses [19, 23], physical inactivity, and an increase in the fear of falling [19, 24]. Body structure and posture and other anatomical factors [leg length and width] affect postural responses and postural control is reversely associated with the height of the body's center of mass to base of support [25]. Those studies which investigated the effect of attention focus on balance control showed that developmental changes of balance control occur in the first years of life, but their infrastructure mechanisms have not yet been fully identified [26].

The priority of attention focus has been attributed to the more employment of automatic processes. An external focus involves directing one's attention to the effects that body movements have on the environment, while an internal focus is directed at the body movements themselves [27]. Over the last decade, researchers have demonstrated the beneficial effects of an external focus of attention for the acquisition of motor skills [28]. According to Constrained Action Hypothesis, when performers utilize an internal focus of attention [focus on their movements], they may constrain or interfere with automatic control processes that would normally regulate the movement, whereas an external focus of attention [focus on the movement effect] allows the motor system to more naturally self-organize [29]. In contrast, focus on movement effect or external attention instruction allows automatic and unconscious processes to control movements, which result in more effective performance [30].

According to the conscious processing hypothesis, internal focus instructions generate a greater load on working memory [compared to external focus instructions] and thus result in poorer performance [31, 32]. As well as common coding theory provides a possible explanation for the advantages of focusing on the effects of movements rather than on the movements themselves. According to this theory, perception and action require a common representational medium-efferent and afferent codes are stored in the form of distal events [31, 33]. Cluff *et al*. [2010] investigated the role of attention focus on the performance of cognitive and motor tasks along with posture control. The results showed that experimentally manipulated attentional foci [internal, external] did not influence the variability of postural control, but dual-task [cognitive and motor] reduced variability of postural fluctuations [17]. Different researches have examined the effect of attention focus on postural control. Wulf *et al*. [2009] evaluated postural control in individuals with Parkinson's disease with respect to external focus, internal focus, and control groups and found out that the adoption of an external focus resulted in less postural sway. There was no difference between the internal focus and control conditions [34]. It is suggested that an internal focus of attention may disrupt automatic control of posture. Recently, Chow *et al*. [2019] [35] showed that internal focus has a detrimental effect on postural control, especially in young adult populations rather than older adults. Vuillerme and Nafati [2007] investigated postural control in 16 young adults in control and internal attention conditions. The results showed increased amplitudes in the internal focus condition [36]. Shamway-Cook *et al*. [1997] reported that adults could easily perform postural tasks while performing a simple cognitive task. Also, the results showed that this ability declines in older adults so they pay more attention to their balance to prevent falling [37].

The sensory inputs involved in balance control and motor systems are essential for balance maintenance. Therefore, reducing afferent feedback or defect in the mechanical strength of each joint can disrupt the balance [38]. Limiting the senses can be useful in estimating the importance of that information for controlling stature and how the central nervous system adjusts itself to these conditions [39]. Therefore, each of these senses can be manipulated when controlling stature in the different focus of attention instructions.

To our knowledge, this is the first study that performed a mechanistic, dynamical analysis of attentional influences on balance control. The first aim of this research was to investigate if external focus could improve the quality of balance control in retired elderly, and secondly, the different focus of attention instructions induce different muscle activity.

2. METHODS

2.1. Subjects

Thirty elderly retired men [age 57.6±3.1 years, height 179±6.7 cm, and weight 74.8±10.6 kg] (Table **1**) were recruited as the study sample. They had no history of lower leg injury or lower extremity pain six months before testing, they were not taking any medication that would affect the balance, and vestibular dysfunction has been excluded. None of the subjects had previous experience with the focus of attention instructions. Before the study began, the subjects were informed about the purpose of this study, gave informed written consent, and were free to withdraw from the study at any time. Ethical approval for this study was granted by the Institutional Ethics Committee of Baqiatallah university of medical sciences with code: IR.BMSU.REC.1397.158 All procedures were performed according to the Declaration of Helsinki.

2.2. Experimental Procedure

The postural performance of each participant was evaluated in two relevant situations: first, while standing in an internal attention condition and afterward while standing in external condition attention. The experimental protocol for both measurements comprised two postural tasks with simulated external and internal conditions during which each participant was instructed to stand quietly for 30s [1]: Eyes open, line of gaze toward the horizon and attention to changes in pressure center on Biodex display were considered as external-focus [2]; Eyes open, line of gaze toward the horizon and attention to body oscillations were considered as internal-focus. At the end of the protocol, the first task was repeated to evaluate potential training and compensatory effects (Fig. **1**).

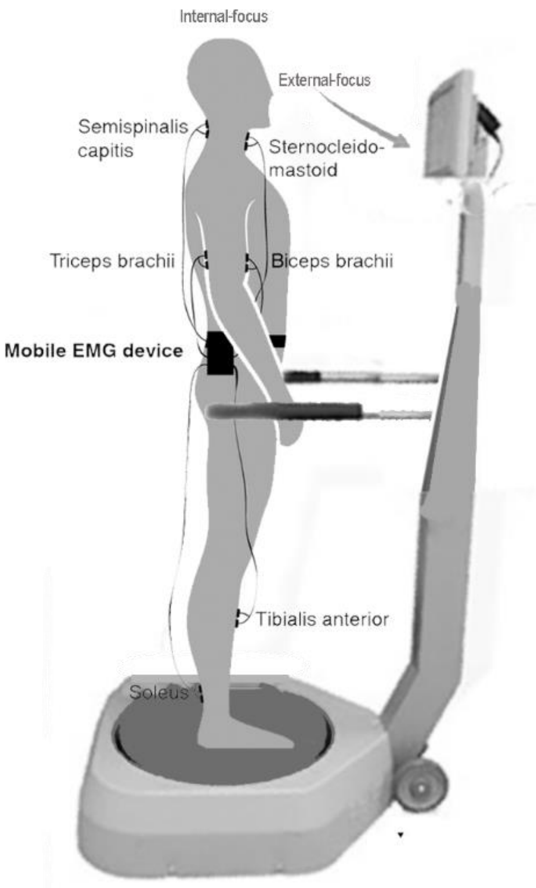

Fig. (1). Experimental setup; Participants were asked to stand on a Biodex mobility platform with an 8 degree surface tilt to assess balance stability. Electromyographic data of three muscle pairs were recorded with a mobile EMG device fixed around the waist [1]: tibialis anterior and soleus for the leg [2], biceps brachii and triceps brachii for the arm, and [3] sternocleidomastoid and semispinalis capitis for the neck. The stance protocol included the following conditions [1]: eyes open, normal head tilt and attention to changes of pressure center on Biodex display were considered as external-focus [2], eyes open, normal head tilt and attention to body oscillations were considered as internal-focus.

Table 1. Participant demographic characteristics.

-	Frequency	Age [years]	Height [cm]	Body Mass [kg]
Internal	15	56.9±3.7	182.1±6.3	72.5±16.4
External	15	57.8±3.4	176.2±6.2	77.3±12.1
Total	30	57.6±3.1	179±6.7	74.8±10.6

Internal: the internal focus of attention; External: external focus of attention.

2.3. Data Recording

2.3.1. Balance Stability Recording

Static balance behavior was measured on a Biodex balance system [Biodex Medical System Inc., NY, USA, SW45-30D-E6N Model, SD 950-304] [40]. The degree of device stiffness in the standing position on two legs and the opening eye was selected in static mode. It means that the stiffness degree of the plate in the test was static, in which the stiffness degree of the device plate was set on degree 8 [41]. Before performing the main test and before the intervention, a pilot test was performed on the subjects familiarized with the device and the procedure. A static postural stability test was performed in the position of standing on two legs with an open eye. Each test included two trials, each trial lasted for 20 s, and 15-s resting time was given between each trial. The five-minute interval was considered between each test [31, 42].

2.3.2. EMG Recordings

Muscle activity was measured using surface EMG [Desktop DTS, Noraxon USA Inc. Scottsdale, AZ] at a sampling frequency of 1500 Hz. To evaluate activity levels and co-contraction of the leg, arm, and neck musculature, the following three muscle pairs were selected [1]: tibialis anterior and soleus for the leg [43], [2] biceps brachii and triceps brachii for the arm [44], and [3] sternocleidomastoid [SCM] and semispinalis capitis [SSC] for the neck [45]. Bipolar surface electrodes were placed on each of the selected muscles on the dominant leg side (Fig. **1**). The ground electrode was affixed to the skin of the fibula head of the dominant leg. The raw EMG signal was band-pass filtered at 20–500 Hz. The RMS amplitude of the signal was computed using a 50-ms window. EMG activity of each examined muscle was additionally recorded during maximal voluntary contraction [MVC] [46].

2.4. Statistical Analysis

Statistics were used to present the data in a graphical form and to summarize data. The effects of each dependent variable were analyzed using a repeated measurement analysis of variance [ANOVA] and a Bonferroni post-hoc analysis, with stance conditions [internal attention and external attention] as factors. Significant interaction effects were further decomposed into simple main effects. Results were considered significant if $P \leq 0.05$. Statistical analysis was performed using SPSS [Version 20.0; IBM Corp., Armonk, NY].

3. RESULTS

3.1. Body Sway Parameters

At all of the examined CoP parameters, the effects of external focus were significant compared to the internal focus. TLB, ML, and AP ranges were vaster during examination of internal focus (Fig. **2**).

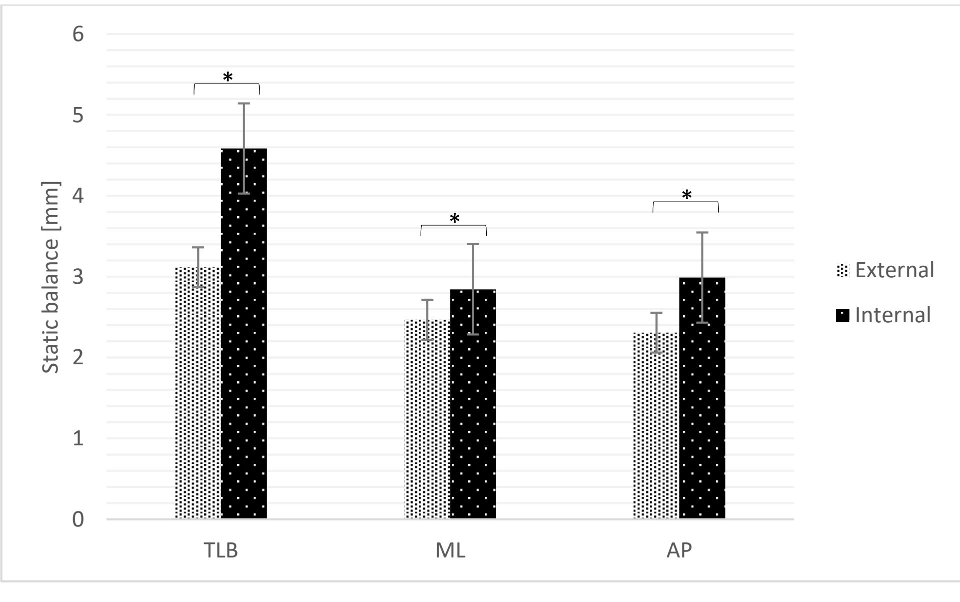

Fig. (2). Body sway parameters; CoP total Two-leg Balance [TLB], CoP Medio-lateral [ML], CoP Anterior-posterior [AP]. Data are represented as means and standard deviations.
*Significant difference between conditions [p=0.05].

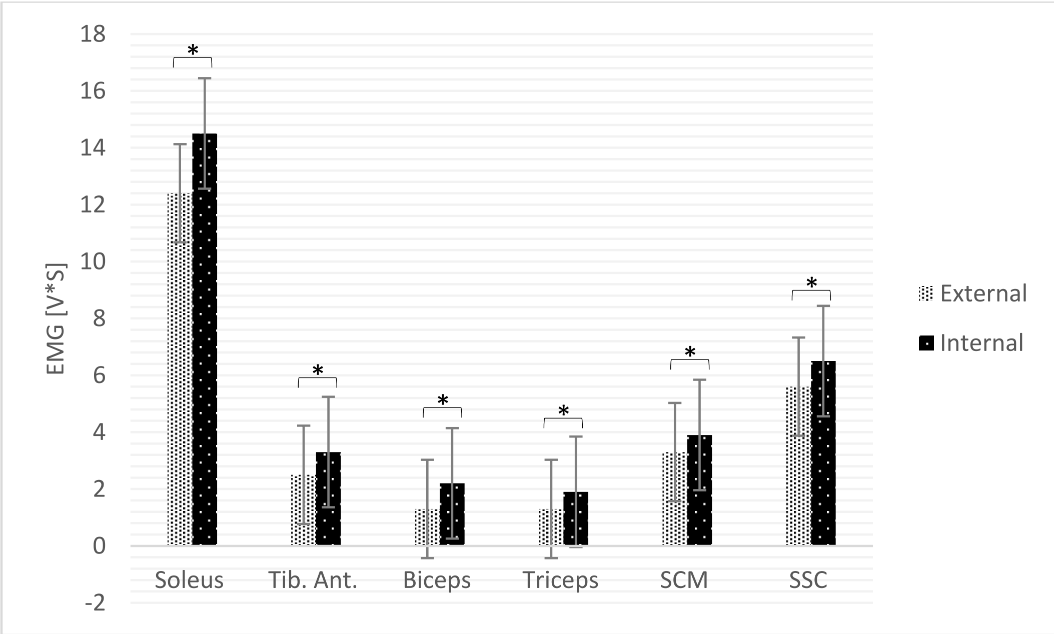

Fig. (3). Muscle activity [EMG]: Tibialis anterior and soleus for the leg, biceps brachii and triceps brachii for the arm, Sternocleidomastoid [SCM], and Semispinalis Capitis [SSC]. Data are represented as means and standard deviations.
*Significant difference between conditions [p=0.05].

3.2. Muscle Activity

At all of the analyzed EMG measures, the effects of external focus were significant compared to the internal focus. Mean normalized EMG activity of the soleus, Tib. Ant, biceps brachii, triceps brachii, SCM, and SSC did show any significant changes between the two different conditions, internal attention and external attention. In such a way, mean normalized muscle activities of tibialis anterior and soleus for the leg, biceps brachii, and triceps brachii for the arm and sternocleidomastoid [SCM] and semispinalis capitis [SSC] for the neck were markedly increased during the examination of internal focus (Fig. **3**).

4. DISCUSSION

This study aimed to investigate muscle activity and balance control while standing on two legs during the different focus of attention instructions in an elderly retired man. We hypothesized that [a] CoP total, medial-lateral, and anterior-posterior balance stability while standing in external conditionand [b] muscle activity would be higher for the internal-focus in comparison with the external-focus.

The results of this study showed a significant difference in postural control of older adults between internal and external focus conditions and that the focus on the environment forces mind and body to use automatic mental resources for postural control, and sensory resources can be efficiently used to enhance the balance. This finding was similar to the results of Wulf, McNevin, & Shea [2001], McNevin & Wulf [2002], Vuillerme & Nafati [2007] and Wulf *et al*. [2009] [29, 34, 36, 47], reporting static balance responses improvement under external focus conditions. No researches with contrary results and similar methodology have been found. According to the present results and hypothesis presented by Wulf *et al*. [1998], focus on the outcome of the movement [external attention] produces an unconscious control process, and consequently learning is facilitated and performance is improved. On the contrary, internal attention enables athletes to make conscious effort to control theirmovements which reduces their performance [27]. Also, Wulf *et al*. [2001] reported that their subjects needed less attention capacity to perform the task, and as a result, they used a more automatic control process [29]. Vance *et al*. [2004] reported that the focus on performance outcome [external focus] was more effective and efficient than a focus on the outcomes of the movement itself [internal focus]. Also, they proved the effectiveness of automatic control capacities of the motor system for external attention focus [48]. Another study by Wulf *et al*. [2009] entitled “External focus instructions reduce postural instability in individuals with Parkinson disease” evaluated individuals with Parkinson in external focus, internal focus and control groups, and found out that external attention focus resulted in less postural sway in these patients; they did not observe any differences in postural sway between internal and control groups [34]. According to Conscious Processing Hypothesis, this finding is interpreted as follows: internal focus condition results in the conscious control process and it imposes cognitive and attentional demands on cognitive process resources and the perception of external changes, due to which reception by sensory information becomes more difficult which in turn leads to a functional decline. However, external attention focus makes individuals use sensory information needed for postural control to a higher extent which results in better performance in postural control. All the mentioned details were in line with the findings of the present study.

Vestibular system adds crucial information to maintain balance throughout the recruiting of eye, head and neck movements. Vestibular function is age-dependent as above one-third of persons over 70 have an abnormal vestibular system. Vestibular nerve fibers decrease by ~5% per decade between the ages of 40 and 90, and one-third of afferents are lost after 70 [35]. However, as our studied samples had no history of vestibular dysfunction and they were below six decades, so it could be assumed that their balance control was less affected by vestibular systems dysfunction.

As noted earlier, proper balance is affected by the coordinate action of multiple factors such as information received by the brain from the eyes, muscles, joints, and vestibular organs in the inner ear, as well as psychological factors. This complex provides a set of sensorimotor control systems through the modification of sensory input and motor commands.

A change in attentional conditions related to postural control in this study and other studies proved that balance is automatically maintained in our everyday life. Nearly all our routine follows external attention and focuses on psychology, but in their daily routine [walking, exercising, etc.], older adults pay more attention to the things they do. In other words, their balance is not automatically maintained and therefore is shaped as a conscious postural control and internal focus, which may fail efficient postural control and in turn lead to falling [the most common problem in the elderly]; moreover, other problems may also happen due to it.

CONCLUSION

As discussed above, the results of this study showed a significant difference in postural control of older adults in internal and external foci, and that focus on the environment forces mind and body to use automatic mental resources for postural control and sensory resources can be efficiently used. Given the changes in postural control in external and internal foci, the results showed that subjects more swayed in internal attention focus. In conclusion, both hypotheses of this study were confirmed. Significant differences were observed between the external focus condition and the internal focus condition for all analyzed parameters.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Ethical approval for this study was granted by the Institutional Ethics Committee of Baqiatallah University of Medical Sciences with code: IR.BMSU.REC.1397.158, Iran.

HUMAN AND ANIMAL RIGHTS

No animals were used in this study. Reported experiments on humans were in accordance with the ethical standards of the committee responsible for human experimentation (institutional national), and with the Helsinki Declaration of 1975, as revised in 2008.

CONSENT FOR PUBLICATION

Written informed consent was obtained from all participants.

AVAILABILITY OF DATA AND MATERIALS

The measured data used to support the findings of this study are available from the corresponding author, [A.A.], upon request.

FUNDING

The authors acknowledge the financial support received from Baqiatallah University of Medical Sciences and for their support and encouragement in the research project with code 97000139 on 17-9-2018.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

ACKNOWLEDGEMENTS

The authors are thankful and grateful to all who participated in this study.

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