Function & Disability Journal
2020, Volume 3

Research Paper:

The Effect of Cognitive Task on Postural Control Dynamic Regularity of Athletes With Chronic Ankle Instability When Standing on an Unstable Surface

Shahab Asgari[1*], Esmaeel Ebrahimi Takamjani[1], Reza Salehi[2], Soheil Mansour Sohani[1], Ghadir Abolghasemi[1]

1. Department of Physiotherapy, Iranian Center of Excellence in Physiotherapy, School of Rehabilitation Sciences, Iran University of Medical Sciences, Tehran, Iran.
2. Department Rehabilitation Management, Iranian Centre of Excellence in Physiotherapy, School of Rehabilitation Sciences, Iran University of Medical Sciences, Tehran, Iran.

Article info:
Received: 27 Oct 2020
Accepted: 03 Dec 2020
Available Online: 30 Dec 2020

Funding

This research did not receive any grant from funding agencies in the public, commercial, or non-profit sectors.

Conflict of interest

The authors declared no conflict of interest.

ABSTRACT

Background and Objectives: Postural control disorder is a common complication in patients with Chronic Ankle Instability (CAI). The present study aimed to investigate the effect of dual cognitive task on postural control behavior with regard to the Center of Pressure (CoP) signal regularity while standing on an unstable surface in athletes with CAI.

Methods: In the present study, 58 men participated in two groups of healthy and patients with CAI. The CoP signal was examined in 4 different unstable states on the wobble board located at the center of the force plate. The regularity of the signals recorded from the force plate was investigated using sample entropy in two directions: anterior-posterior and medial-lateral.

Results: In both groups, there was a significant difference in CoP's sample entropy signal when performing a cognitive task with a postural task ($P<0.001$). There was a significant difference between the two groups in the cognitive task and the single task in the anteroposterior direction while standing on two legs.

Conclusion: During dual tasks, the patients with CAI have a more dynamic regularity in the CoP signal than their normal counterparts. In the dual-task condition, more irregularities are observed in the CoP signal of healthy individuals. In unstable conditions, patients with CAI decrease the adaptability of postural control behavior with increasing CoP signal regularity.

Keywords: Chronic ankle instability, Postural control, Nonlinear dynamic, Dual-task cognitive, Athletes

Use your device to scan and read the article online

Cite this article as Asgari Sh, Ebrahimi Takamjani E, Salehi R, Mansour Sohani S, Abolghasemi Gh. The Effect of Cognitive Task on Postural Control Dynamic Regularity of Athletes With Chronic Ankle Instability When Standing on an Unstable Surface. Function and Disability Journal. 2020; 3:161-168. http://dx.doi.org/10.32598/fdj.4.20

http://dx.doi.org/10.32598/fdj.4.20

*** Corresponding Author:**
Shahab Asgari, MSc. PT.
Address: *Department of Physiotherapy, Iranian Center of Excellence in Physiotherapy, School of Rehabilitation Sciences, Iran University of Medical Sciences, Tehran, Iran.*
Tel: *+98 (21) 22228052*
E-mail: *as.shahab@yahoo.com*

Function & Disability Journal

What is "already known" in this topic:

Investigating the dynamic structure of postural sway in terms of the output signal regularity can provide important information about the health status, stability, and adaptability of the postural control system, which is impossible using linear analysis methods.

What this article adds:

Dual tasks in healthy individuals increase the irregularity in the CoP signal and lead to automatic control. This pattern is not seen in individuals with CAI.

1. Introduction

One of the most common musculoskeletal injuries is lateral ankle sprains, leading to long-term problems in the ankle and lower limbs in people [1]. Many of these people complain of residual symptoms such as recurrent "giving way" and disability [2]. These complications are commonly known as Chronic Ankle Instability (CAI) and can affect their daily, functional, and athletic activities. Mechanical instability and functional ankle instability are two significant types of CAI [3].

Studies support postural control impairments in people with CAI [4]. Researchers have noticed the loss of sensory input from articular mechanoreceptors, mechanical instability of the ankle joint, lower muscle strength and endurance, and different ankle range of motion as influencing factors in postural control impairment [5, 6].

Postural control may be an automatic process that needs minimal cognitive attention. However, recent evidence suggests that postural control necessities some attention even in healthy individuals [7, 8]. Recent research has categorized postural control from simpler to more complex tasks requiring attention processes [9, 10]. This attentional need varies depending on the type of postural activity, age, balancing abilities, and the type of cognitive task [7, 8].

However, because of the contradictory results, the relationship between postural control and cognition has remained ill-defined. Studies on young adults have reported higher [11, 12], untroubled [8], and lower [13] postural sway during concurrent cognitive tasks.

There are many situations in everyday life where one has to perform multiple tasks simultaneously—for example, walking and talking simultaneously or crossing the street and paying attention to cars crossing the street. Therefore, the evaluation of dual assignments has more external validity. Various investigations of postural control behavior have been investigated from the aspect of nonlinear dynamics and sample entropy analysis of the Center of Pressure (CoP). As an indicator, the irregularity and regularity of the CoP indicate the degree of automaticity of this behavior [14-16]. They attributed the greater irregularity of the CoP to the decrease in the amount of attention devoted to the posture. They suggested that an increase in irregularity might be considered as an increase in the automation or efficiency of posture control [17].

Therefore, examining the dynamic structure of postural sway in terms of the output signal regularity can provide important information about the health status, stability, and adaptability of the postural control system, which is impossible using linear analysis methods. This study aimed to investigate the CoP regularity between athletes with CAI and healthy subjects in unstable postural conditions.

2. Materials and Methods

The research and its stages have been approved by the Ethics Committee of Iran University of Medical Sciences (Code: IR.IUMS.FMD.REC1396.9411452003). A total of 29 subjects with a history of CAI (ages ranging from 18 to 36) and 29 healthy-matched subjects voluntarily participated in this study. All participants signed an informed consent form. We considered recreationally active as partaking in at least 20 minutes of physical activity 3 times per week. The study samples were volleyball and basketball players. Age, body mass index, height, type and duration of physical activity, and lower-limb dominance were the matching variables.

According to the International Ankle Consortium, the inclusion criteria for the people with CAI were as follows: having a history of at least 1 significant ankle sprain, the

previously injured ankle joint "giving way", and or recurrent sprain, and or "feelings of instability". A general self-reported foot and ankle function questionnaire was used to describe the level of disability of the cohort.

We used a health questionnaire to ensure that participants had no injury or condition that could affect their balance. Individuals for the control group were excluded if they reported a history of ankle sprain or perception of "giving way" in the ankle. The information was gathered by a trained physical therapist using self-report questionnaire and clinical examination.

Postural sway was evaluated by a force plate at 2 different conditions: double-leg standing on the force platform, single-leg standing on the injured limb. All conditions were similar, while a cognitive task was performed concurrently. Subjects stood barefoot with their arms hanging at their sides. Foot placement on the force plate was constant in all tests. They were not allowed to move their limbs or head or talk during the data collection period. The dominant limb was the limb used in at least 2 out of the 3 following tests: stepping up onto a box, recovering balance after a posterior push, and kicking a ball with maximum accuracy through a goal.

Postural task (single task)

The postural task was done as still as possible on the wobble board on the force plate with feet separated and arms hanging loosely at the sides, and eyes fixed on an eye-level target 3 m ahead. During single-leg standing, the subjects were asked to stand as still as possible and to concentrate on a visual target 3 m away in front of them.

Cognitive task

For the cognitive task, the participants were asked to do silent digit backward counting by 7, starting from a random number, for instance, between 400 and 500. They were asked to do correctly as possible. Immediately after the collection of the postural data, the subjects were required to tell the number they had reached.

Three trials with a 1-min rest between each test were performed. To minimize the learning effect, the postural and cognitive tasks were randomized for each participant before starting the measurements. The whole experiment lasted approximately 60 min. CoP data were obtained using a Kistler, 92260 AA6 force platform with a sampling frequency of 100 Hz.

Statistical analysis

The obtained data were analyzed in SPSS version 20. Before the statistical analysis, the normal distribution of the data was evaluated by the Shapiro-Wilk test. The data for each postural stability index were analyzed by a 2-by-2 (group by cognitive difficulty) mixed-model Analysis of Variance (ANOVA). It was used to determine the interactions and main effects of the 2 factors. Comparisons between the 2 groups were made with the Independent t-test.

3. Results

The Independent t test was used to compare the demographic data between groups. There was no significant difference between the two groups (Table 1).

Postural performance for the single-leg standing condition

In both AP and ML directions, there was no main effect of group on entropy (AP: F_1=0.02, P>0.05; ML: F_1=1, P>0.05). In both AP and ML directions, there was a main effect of condition (AP: F_1=0.14, P<0.001; ML: F_1=0.91, P<0.001). The group × cognitive interaction, (F=0.41, P>0.05=0.037) was not statistically significant in the ML direction (Figure 1 & 2). Also, in the AP direction, (F_1=22.55, P<0.001) the results were not statistically significant (Table 2).

According to Table 2 and comparison between the two groups, there was a significant difference between the two groups in the cognitive task and the single task in the anterior-posterior direction while standing on both legs.

Table 1. Demographic data of athletes with chronic ankle instability (n=29) and healthy athletes (n=29)

Variables	Mean±SD		P
	CAI	Healthy	
Age (y)	24.41±3.7	24.76±3.12	0.67
Height (cm)	179.50±8.16	179.64±5.98	0.55
Weight (kg)	75.24±5.86	76.36±5.77	0.96

CAI: Chronic Ankle Instability.

Table 2. Analysis of variance for sample entropy, the center of pressure signal while standing on two and one leg

Variables			Standing on one Leg		Standing on Both Legs	
Sway Plate			AP	ML	AP	ML
Main effect	Group	F	0.14	0.91	0.02	1
		P	0.70	0.34	0.87	0.31
	Condition	F	55.77	9.25	12.44	6.70
		P	P<0.001	P<0.001	P<0.001	P<0.001
Interaction effect	Group × Condition	F	6.53	0.41	22.55	9.28
		P	P<0.001	0.66	P<0.001	P<0.001

AP: Anteroposterior; ML: Mediolateral.

Postural performance for the double standing condition

In both AP and ML directions, there was no main effect of group on entropy (AP: F_1=0.02, P>0.05; ML: F_1=1, P>0.05). In both AP and ML directions, there was a main effect of condition (AP: F_1=12.44, P<0.001; ML: F_1=6.70, P<0.001). The group × cognitive interaction, (AP: F_1=22.55, P<0.001; ML: F_1=6.53, P<0.001), was statistically significant in both AP and ML directions (Table 2).

4. Discussion

The present study investigated the effect of dual cognitive task on postural control behavior based on the CoP signal regularity while standing on an unstable surface in athletes with CAI. The purpose of the present study was to determine whether adding a dual cognitive task to the postural task while standing on an unstable surface could cause changes in the pressure center signal irregularity.

The results of the present study showed that when standing on the wobble board while performing postural and cognitive dual tasks in the healthy group, the CoP irregularity was significantly higher than the patient group. In other words, when adding cognitive task to postural task, healthy subjects will show less predict postural control behavior. Donker et al. suggested increasing regularity signal order implies that postural control behaviors become rigid and attitudinal dependency is attenuated [17]. From the linear dynamics of postural control behavior in the present study, it was observed that CoP displacement

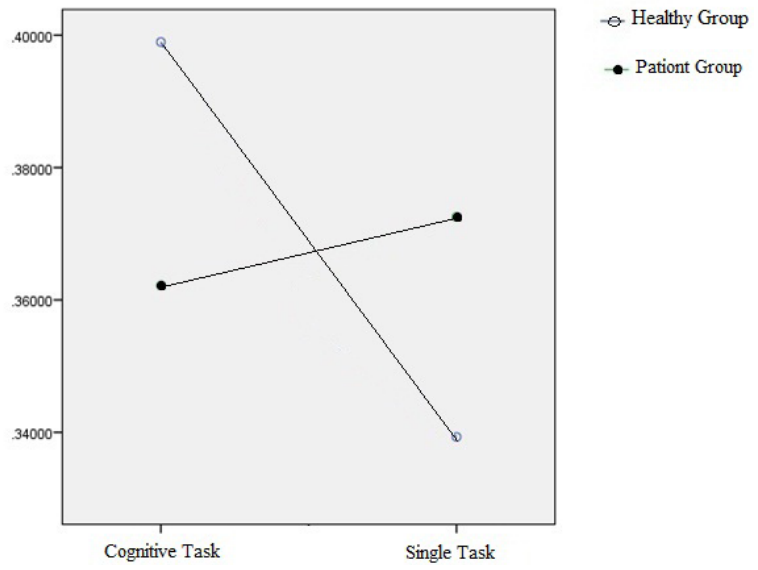

Figure 1. Group × cognitive interaction of center of pressure regularity while standing on two legs in AP direction

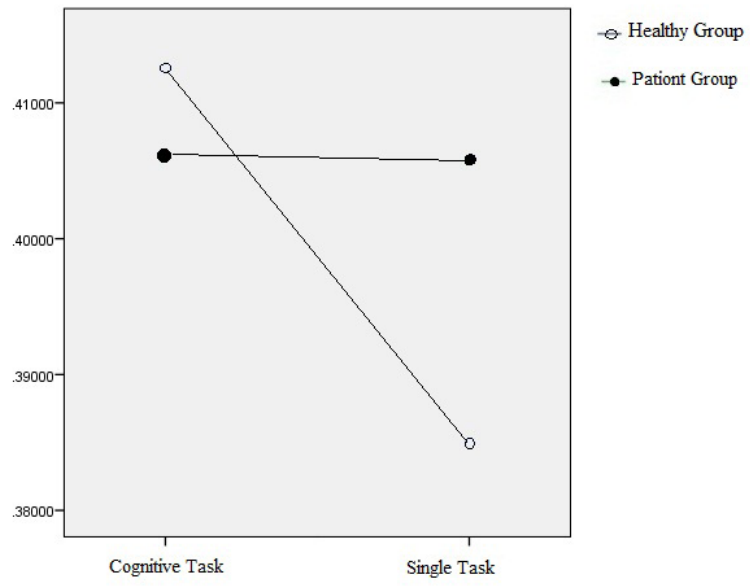

Figure 2. Group × cognitive interaction of center of pressure regularity while standing on two legs in ML direction

in dual cognitive tasks was significantly increased in patients with a chronic ankle sprain. Therefore, in healthy subjects, with increasing irregularity and decreasing CoP displacement, healthy subjects have used more effective postural exploratory behavior in unstable postural conditions than those with CAI. However, the inability to use postural exploratory behavior in subjects with CAI results in increased postural sway in this unstable postural condition [18]. In this state, since insufficient information is provided, the postural control will be conscious of the postural stability [19].

According to Roerdink et al., a decrease in the CoP signal regularity result in distraction attention from postural control, leading to more automatic postural control behavior [18]. Polskaia et al. showed that distracting attention from postural control when performing dual tasks ensued by less interference with the automated motor control process and, consequently, better individual performance [20]. Increasing the CoP signal irregularity indicates more complexity of the system, which results in more automatic postural control. More complexity in postural control will lead to greater adaptation to postural perturbation environmental changes [17].

Terada et al. concluded that while standing on a stable surface, individuals with chronic ankle sprains are less entropic than healthy individuals. They correlated the decrease in CoP signal irregularity with greater postural control rigidity and reduced adaptability in the affected group [1].

Since the subjects should not be talking during the dual postural and cognitive task, the examiner could not check the consistency and accuracy of the counting-backward during the test. Therefore, it is recommended that future studies use the cognitive task that can be used to evaluate its continuity during dual-task. As one of the causes of falls in the elderly is a decrease in postural adaptability, it is recommended that future studies consider the elderly group and other postural disorder groups.

5. Conclusion

In unstable postural conditions, the center of the pressure signal regularity increases in subjects with CAI compared to the healthy group, indicating attentional-dependent behavior and decreased postural control adaptability. Dual tasks in healthy individuals increase the irregularity in the CoP signal and lead to automatic control. This pattern is not seen in individuals with CAI.

Ethical Considerations

Compliance with ethical guidelines

All ethical principles are considered in this article. The participants were informed of the purpose of the research and its implementation stages. They were also assured about the confidentiality of their information and were free to leave the study whenever they wished, and if desired, the research results would be available to them.

Funding

This research did not receive any grant from funding agencies in the public, commercial, or non-profit sectors.

Authors' contributions

All authors equally contributed to preparing this article.

Conflict of interest

The authors declared no conflicts of interest.

References

[1] Terada M, Beard M, Carey S, Pfile K, Pietrosimone B, Rullestad E, et al. Nonlinear dynamic measures for evaluating postural control in individuals with and without chronic ankle instability. Motor Control. 2019; 23(2):243-61. [DOI:10.1123/mc.2017-0001] [PMID]

[2] Anandacoomarasamy A, Barnsley L. Long term outcomes of inversion ankle injuries. Br J Sports Med. 2005; 39(3):e14. [DOI:10.1136/bjsm.2004.011676] [PMID] [PMCID]

[3] Gribble PA, Delahunt E, Bleakley C, Caulfield B, Docherty C, Fourchet F, et al. Selection criteria for patients with chronic ankle instability in controlled research: A position statement of the International Ankle Consortium. J Orthop Sports Phys Ther. 2013; 43(8):585-91. [DOI:10.1136/bjsports-2013-093175] [PMID]

[4] de Noronha M, Refshauge KM, Herbert RD, Kilbreath SL. Do voluntary strength, proprioception, range of motion, or postural sway predict occurrence of lateral ankle sprain? Br J Sports Med. 2006; 40(10):824-8. [DOI:10.1136/bjsm.2006.029645] [PMID] [PMCID]

[5] Freeman, M. Instability of the foot affer injuries to the lateral ligament of the ankle. Bone Joint J, 1965; 47(4):669-77. [DOI:10.1302/0301-620X.47B4.669]

[6] Riemann BL. Is there a link between chronic ankle instability and postural instability? J Athl Train. 2002; 37(4):386-93. [PMCID] [PMID]

[7] Shumway-Cook A, Woollacott M. Attentional demands and postural control: the effect of sensory context. J Gerontol A Biol Sci Med Sci. 2000; 55(1):M10. [DOI:10.1093/gerona/55.1.M10] [PMID]

[8] Yardley L, Gardner M, Leadbetter A, Lavie N. Effect of articulatory and mental tasks on postural control. Neuroreport. 1999; 10(2):215-9. [DOI:10.1097/00001756-199902050-00003] [PMID]

[9] Vuillerme N, Nougier V. Attentional demand for regulating postural sway: the effect of expertise in gymnastics. Brain Res Bull. 2004; 63(2):161-5. [DOI:10.1016/j.brainresbull.2004.02.006] [PMID]

[10] Woollacott M, Shumway-Cook A. Attention and the control of posture and gait: A review of an emerging area of research. Gait posture. 2002; 16(1):1-14. [DOI:10.1016/S0966-6362(01)00156-4]

[11] Pellecchia GL. Postural sway increases with attentional demands of concurrent cognitive task. Gait Posture, 2003; 18(1):29-34. [DOI:10.1016/S0966-6362(02)00138-8]

[12] Teasdale N, Bard C, LaRue J, Fleury M. On the cognitive penetrability of posture control. Exp Aging Res. 1993; 19(1):1-13. [DOI:10.1080/03610739308253919] [PMID]

[13] Andersson G, Hagman J, Talianzadeh R, Svedberg A, Larsen, HC. Effect of cognitive load on postural control. Brain Res Bull. 2002; 58(1):135-9. [DOI:10.1016/S0361-9230(02)00770-0]

[14] Cavanaugh JT, Mercer VS, Stergiou N.Approximate entropy detects the effect of a secondary cognitive task on postural control in healthy young adults: A methodological report. J Neuroeng Rehabil. 2007; 4(1):42. [DOI:10.1186/1743-0003-4-42] [PMID] [PMCID]

[15] Ladislao L, Rabini RA, Ghetti G, Fioretti S. Approximate entropy on posturographic data of diabetic subjects with peripheral neuropathy. Gait Posture. 2008; (28):S6-S7. [DOI:10.1016/j.gaitpost.2007.12.018]

[16] Santarcangelo EL, Scattina E, Carli G, Balocchi R, Macerata A, Manzoni D. Modulation of the postural effects of cognitive load by hypnotizability. Exp Brain Res. 2009; 194(2):323-8. [DOI:10.1007/s00221-009-1740-6] [PMID]

[17] Donker SF, Roerdink M, Greven AJ, Beek PJ. Regularity of center-of-pressure trajectories depends on the amount of attention invested in postural control. Exp Brain Res. 2007; 181(1):1-11. [DOI:10.1007/s00221-007-0905-4] [PMID] [PMCID]

[18] Roerdink M, De Haart M, Daffertshofer A, Donker SF, Geurts ACH, Beek PJ. Dynamical structure of center-of-pressure trajectories in patients recovering from stroke. Exp Brain Res. 2006; 174(2):256. [DOI:10.1007/s00221-006-0441-7] [PMID]

[19] Zhang W, Schwenk M, Mellone S, Paraschiv-Ionescu A, Vereijken B, Pijnappels M, et al. Complexity of daily physical activity is more sensitive than conventional metrics to assess functional change in younger older adults. Sensors. 2018; 18(7):2032. [DOI:10.3390/s18072032] [PMID] [PMCID]

[20] Polskaia N, Lajoie Y. Reducing postural sway by concurrently performing challenging cognitive tasks. Hum Mov Sci. 2016; 46:177-83. [DOI:10.1016/j.humov.2015.12.013] [PMID]

Function & Disability Journal
2020, Volume 3

تاثیر تکلیف شناختی بر نظم دینامیک کنترل پاسچر ورزشکاران مبتلا به بی ثباتی مزمن مچ پا هنگام ایستادن روی سطح ناپایدار

*شهاب عسگری[1]، اسماعیل ابراهیمی تکامجانی[1]، رضا صالحی[2]، سهیل منصور سوهانی[1]، قدیر ابوالقاسمی[1]

۱. گروه آموزشی فیزیوتراپی، مرکز تحقیقات توانبخشی، دانشکده علوم توانبخشی، دانشگاه علوم پزشکی ایران، تهران، ایران.
۲. گروه آموزشی مدیریت توانبخشی، مرکز تحقیقات توانبخشی، دانشکده علوم توانبخشی، دانشگاه علوم پزشکی ایران، تهران، ایران.

تاریخ دریافت: ۰۶ آبان ۱۳۹۹
تاریخ پذیرش: ۱۳ آذر ۱۳۹۹
تاریخ انتشار: ۱۰ دی ۱۳۹۹

چکیده

مقدمه اختلال کنترل پاسچر یکی از عوارض شایع در افراد مبتلا به بی ثباتی مزمن مچ پا است. هدف از تحقیق حاضر بررسی تاثیر تکلیف دوگانه شناختی بر رفتار کنترل پاسچر از جنبه نظم سیگنال مرکز فشار در هنگام ایستادن بر روی سطح ناپایدار در ورزشکاران مبتلا به بی ثباتی مزمن مچ پا بود.

مواد و روش ها مشارکت کنندگان در طرح حاضر شامل ۵۸ مرد در دو گروه سالم و مبتلا به بی ثباتی مزمن مچ پا بودند. سیگنال مرکز فشار در آن ها در دو وضعیت ناپایدار مختلف بر روی تخته تعادل که در مرکز صفحه نیرو قرار داشت، مورد بررسی قرار گرفت. میزان نظم سیگنال های ثبت شده از صفحه نیرو با استفاده از آنتروپی نمونه در دو جهت قدامی–خلفی و داخلی–خارجی مورد بررسی قرار گرفت.

یافته ها آنتروپی نمونه سیگنال مرکز فشار در هر دو گروه هنگام انجام تکلیف دوگانه با تکلیف پاسچرال تفاوت معنی دار داشت (P<۰/۰۰۱). همچنین، در مقایسه دو گروه تفاوت معناداری بین گروههای تکلیف شناختی و تکلیف انفرادی در صفحه قدامی–خلفی وضعیت ایستادن روی دو پا بدست آمد.

نتیجه گیری نظم دینامیک سیگنال مرکز فشار در تکالیف دوگانه در افراد دارای بی ثباتی مزمن مچ پا نسبت به گروه سالم همتای خود، افزایش می یابد. افراد سالم در شرایط تکلیف دوگانه بی نظمی بیشتری در سیگنال مرکز فشار نشان می دهند. در افراد مبتلا به بی ثباتی مزمن مچ پا افزایش نظم سیگنال مرکز فشار بیانگر کاهش تطابق پذیری رفتار کنترل پاسچر در شرایط ناپایدار است.

کلیدواژه‌ها:
بی‌ثباتی مزمن مچ پا، کنترل پاسچر، دینامیک غیرخطی، تکلیف دوگانه شناختی، ورزشکار

Use your device to scan and read the article online

Cite this article as Asgari Sh, Ebrahimi Takamjani E, Salehi R, Mansour Sohani S, Abolghasemi Gh. The Effect of Cognitive Task on Postural Control Dynamic Regularity of Athletes With Chronic Ankle Instability When Standing on an Unstable Surface. Function and Disability Journal. 2020; 3:161-168. http://dx.doi.org/10.32598/fdj.4.20

doi : http://dx.doi.org/10.32598/fdj.4.20

* **نویسنده مسئول:**
شهاب عسگری
نشانی: تهران، دانشگاه علوم پزشکی ایران، دانشکده علوم توانبخشی، مرکز تحقیقات توانبخشی، گروه آموزشی فیزیوتراپی.
تلفن: ۲۲۲۲۸۰۵۲ (۲۱) ۹۸+
رایانامه: as.shahab@yahoo.com

This Page Intentionally Left Blank