2020

# Effectiveness of the Mini-Balance Evaluation Systems Test (Mini-BESTest) in evaluating Balance in the Controlled Hypertensive Elderly Population

Melanie Sich
*Wright State University - Main Campus*, sich.2@wright.edu

Effectiveness of the Mini-Balance Evaluation Systems Test (Mini-BESTest) in evaluating balance in the controlled hypertensive elderly population

**Melanie Sich**

Jeannette Manger, Ph.D.

Department of Medical Education

Scholarship in Medicine Final Report

☒ **By checking this box, I indicate that my mentor has read and reviewed my draft proposal prior to submission**

**Abstract**

*Objective:* Provide additional evidence about the relationship between controlled hypertension and balance control by evaluating individuals' gait stability, sensorial orientation, reactive postural response, and anticipatory postural adjustment using the Mini-Balance Evaluation Systems Test (Mini-BESTest).

*Methods:* A total of 76 (28 controlled hypertensive, 48 non-hypertensive) individuals were evaluated with the Mini-BESTest protocol. Each of the subscores obtained from the test represented the different subdomains of postural control, and they were compared between controlled hypertensive and non-hypertensive groups using a one-way analysis of variance (ANOVA) statistical analysis.

*Results:* Hypertensive individuals tended to score lower than non-hypertensive individuals in the anticipatory postural adjustment and sensorial orientation subcategories, but they tended to score higher than the non-hypertensive group in the reactive postural response and gait stability subcategories. However, none of these differences were found to be statistically significant.

Key Words: postural control, gait, balance, hypertension, antihypertensive therapy, Mini-BESTest

**Introduction/Literature Review**

Falls are a leading cause of unintentional injuries in the United States.[1,2] A large contributor to the occurrence of falls is balance control dysfunction, particularly among the elderly population.[3] In fact, several previous studies have shown that standing balance impairment may increase fall risk threefold.[4–6] Balance dysfunction may be defined by increased postural sway, poor equilibrium control during other body part movements, excessive or reduced responses to physical disturbances, and abnormal oscillations of the trunk.[7]

Most gait and balance disorders have multiple contributing risk factors.[8] Some of these include old age, certain environmental exposures (e.g., lead), affective disorders and psychiatric conditions (e.g., depression), infectious and metabolic diseases (e.g., diabetes mellitus, hyper- and hypothyroidism, obesity), musculoskeletal disorders (e.g., gout, osteoarthritis), neurologic disorders (e.g., multiple sclerosis, Parkinson disease, stroke), sensory abnormalities (hearing or visual impairment, peripheral neuropathy), and cardiovascular diseases.[8,9] Hypertension, defined as raised blood pressure (average systolic blood pressure >115 mm Hg) is one particular cardiovascular disorder prevalent in the older population.[10,11] Due to the symptoms that tend to accompany hypertension, such as headache, tachycardia, blurring of vision, shortness of breath, a predisposition to orthostatic hypotension (a sudden drop in blood pressure on standing), weakness of limbs, and swollen ankles, this condition could potentially contribute to balance dysfunction and unintentional falls.[12,13]

A previous study by Shen et al. (2015) found that uncontrolled hypertension, orthostatic hypotension, and the decrease in blood pressure on postural change were associated with standing balance impairment in side-by-side and tandem stance.[14] Additional research has recently begun to examine the effect of antihypertensive therapy on fall risk in the elderly population. Gangavati et al. (2011) showed that hypertension control (with or without orthostatic hypotension) has no association with fall risk in older community-dwelling adults, and Acar et al. (2015) also found that controlled hypertension is not a cause of worse balance performance in elderly adults.[13,15] However, each of these studies used different balance evaluation techniques. There is a need for additional data to strengthen the conclusions of recent studies involving controlled hypertensive individuals. Moreover, as postural control consists of several subdomains (e.g., gait stability, sensorial orientation, reactive postural response, and anticipatory postural adjustment), it is important to be able to ascertain how each of these is affected individually by a condition such as hypertension.

The Balance Evaluation Systems Test (BESTest) is a new balance assessment tool that may be able to meet this need, as it is designed to identify specific postural control problems.[16] As this assessment includes 36 items and takes between 30-35 minutes to complete, a more feasible, shorter version of the test known as the Mini-BESTest has been developed.[16] It includes 14 tasks that take 10 minutes to complete, and it has been shown to have good intrarater and interrater reliability and concurrent validity in recent studies.[17–19] Though it has been shown to be useful in predicting falls in patients with conditions such as Parkinson disease and stroke, to our knowledge it has not been specifically evaluated for elderly individuals with hypertension.[13-17] As such, the aim of our study is to strengthen or potentially challenge previous studies' claims about the relationship between controlled hypertension and balance control by evaluating specifically hypertensive individuals' gait stability, sensorial orientation, reactive postural response, and anticipatory postural adjustment, as measured by the Mini-BESTest.

## Research Questions

**RQ1** Between controlled hypertensive and non-hypertensive individuals, which group has worse gait stability? Or are they similar?

**RQ2** Between controlled hypertensive and non-hypertensive individuals, which group has worse sensorial orientation? Or are they similar?

**RQ3** Between controlled hypertensive and non-hypertensive individuals, which group has worse reactive postural response? Or are they similar?

**RQ4** Between controlled hypertensive and non-hypertensive individuals, which group has worse anticipatory postural adjustment? Or are they similar?

## Methods

### *Context/Protocol*

The present study comprises one part of an overarching study by Santos and Duarte (2016) which was designed to create a public data set with qualitative and quantitative evaluations related to human balance.[21] The study was approved by the local ethics committee of the Federal University of ABC (#842529/2014). All data collection was performed in the Laboratory of Biomechanics and Motor Control at the Federal University of ABC, Brazil, and it was collected for each subject in a single session that lasted between 1-2 hours. For this current study, the necessary data was retrieved from the open access database “PhysioNet”.[19]

#### *Subjects*

The original study involved 163 subjects (116 females and 47 males) who voluntarily participated to be evaluated. They were first interviewed to collect information about their demographic and health characteristics. Their ages varied from 18 to 85 years, body masses from 44.0 to 75.9 kg, heights from 140.0 to 189.8 cm, and body-mass indexes (BMI) from 17.2 to 31.9 kg/m$^2$. As the present study focused on comparisons between hypertensive and non-hypertensive individuals of the elderly population, only those subjects greater than or equal to the age of 60 were considered for further processing and statistical comparison. Therefore, the current study examined the data of 76 total individuals, 28 of whom were diagnosed with hypertension and were receiving antihypertensive treatment at the time of the study, and 48 of whom were non-hypertensive and treated as controls. All demographic data of these 76 subjects can be found in Table below.

**Table:** Subject demographics

| Subject Type | Gender | Mean Age (yrs) | Mean Height (cm) | Mean Weight (kg) | Mean Body Mass Index (kg/m$^2$) |
|---|---|---|---|---|---|
| **Controlled Hypertensive** | 6 M / 22 F | 72.61 | 156.74 | 64.41 | 26.22 |
| **Healthy Non-Hypertensive** | 10 M / 38 F | 70.28 | 157.51 | 62.43 | 25.16 |

*Data Collection*

The original study used several methods of evaluating the balance of the participants, including stabilography during standing still tasks on a force platform, as well as the completion of the Mini-BESTest, the Short Falls Efficacy Scale International (Short FES-I), International Physical Activity Questionnaire – Short Version (IPAQ-SV), and a Trail Making Test (TMT). The details about the protocol and data collection can be found in Santos and Duarte (2016).[19]

As the present study focuses on the Mini-BESTest evaluation only, it is further described here. The Mini-BESTest contains 14 items classified in four different domains of the human balance: Anticipatory Postural Adjustment; Reactive Postural Response; Sensorial Orientation; and Gait Stability. Anticipatory Postural Adjustment is defined as the activation of postural muscles prior to the beginning of a voluntary movement and in anticipation of destabilizing forces that movement causes.[16] Reactive Postural Response is a complex pattern of muscle activation occurring in response to a disturbance in balance, which helps maintain one's center of mass.[16] Sensory Orientation is defined as an individual's ability to use visual, proprioceptive, and vestibular cues to maintain postural stability.[16] Dynamic Gait measures an individual's ability to modify his or her manner of walking (via changes in speed, direction, etc.) based on changing task demands.[16]

Each item of the MiniBESTest varies from 0 (abnormal performance) to 2 (normal performance) points.[16] The maximum score that can be achieved by any participant is 28 points, with 6 points being the maximum that can be achieved in the Anticipatory Postural Adjustment, Reactive Postural Response, and Sensorial Orientation subcategories, and 10 points being the maximum score that can be achieved in the Gait Stability subcategory.[16] A higher score in each subcategory indicates more optimal function (e.g., a higher Anticipatory Postural Adjustment score indicates a better ability to sense the need to adjust posture when necessary in instances of imbalance, thus better protecting against falls). Note that in this study, for any Mini-BESTest tasks that required subjects to fix their gaze on a target, the target was placed a distance of 3 meters ahead. Some sample tasks from the Mini-BESTest evaluation, as well as instructions for how to score them, are provided below:

<u>SIT TO STAND</u> (from Anticipatory Postural Adjustment subcategory)

Instruction: "Cross your arms across your chest. Try not to use your hands unless you must. Do not let your legs lean against the back of the chair when you stand. Please stand up now."

(2) Normal: Comes to stand without use of hands and stabilizes independently.

(1) Moderate: Comes to stand WITH use of hands on first attempt.

(0) Severe: Unable to stand up from chair without assistance, OR needs several attempts with use of hands.

<u>CHANGE IN GAIT SPEED</u> (from Dynamic Gait subcategory)

Instruction: "Begin walking at your normal speed, when I tell you 'fast', walk as fast as you can. When I say 'slow', walk very
slowly."

(2) Normal: Significantly changes walking speed without imbalance.

(1) Moderate: Unable to change walking speed or signs of imbalance.

(0) Severe: Unable to achieve significant change in walking speed AND signs of imbalance.

*Data Analysis*

The scores for the first three items of the Mini-BESTest were added for each participant to determine each of their subscores for the anticipatory postural adjustment measurement. The next three items of the assessment were added to determine the reactive postural control subscore, the following three items were added to determine the sensory orientation subscore, and the final five items were added to obtain the dynamic gait subscore. All of the subscores were then separated based on subject type (i.e., hypertensive and non-hypertensive). SPSS data analysis software was used to perform a one-way between subjects analysis of variance (ANOVA) statistical analysis with a significance of $p < 0.05$. Note that the ANOVA did not include a post hoc test, as a comparison was made between two groups only (i.e., controlled hypertensive vs. non-hypertensive).

**Results**

*Anticipatory Postural Adjustment*

Controlled hypertensive individuals were found to score lower than the healthy non-hypertensive participants in the anticipatory postural adjustment assessment category. They scored on average 3.28 points (SD 0.922) compared with the healthy participants who scored an average of 3.43 points (SD 1.021). These differences in mean scores were not found to be statistically significant ($p = 0.520$), however (Figure). The range of scores in the healthy non-hypertensive group varied from 1 to 6, but it varied from 2 to 5 in the hypertensive group.

*Reactive Postural Response*

In the reactive postural response assessment category, the controlled hypertensive group tended to score higher on average than the healthy non-hypertensive group. Hypertensive individuals achieved a mean score of 3.59 (SD 1.150) compared with 3.53 (SD 1.582) of the healthy individuals. These differences in mean scores were not found to be statistically significant ($p = 0.869$) (Figure). The range of scores in both groups varied from 0 to 6.

*Sensory Orientation*

The controlled hypertensive participants scored lower in the sensory orientation category than the healthy non-hypertensive group. They achieved a mean score of 4.86 (SD 1.302), while the healthy participants achieved a mean score of 4.88 (SD 1.053). The differences in scores were not found to be statistically significant ($p$ = 0.954) (Figure). For both groups, the range of scores varied from 1 to 6.

*Dynamic Gait*

In the dynamic gait analysis, the hypertensive group was found to score lower on average compared with the non-hypertensive group. The hypertensive participants achieved a mean score of 6.21 (SD 1.320) compared with 6.67 (SD 1.560) of the non-hypertensive individuals. These score differences, however, were not found to be statistically significant ($p$=0.181) (Figure). While the range of scores in the hypertensive group varied from 4 to 10, it varied from 2 to 10 in the healthy non-hypertensive group.

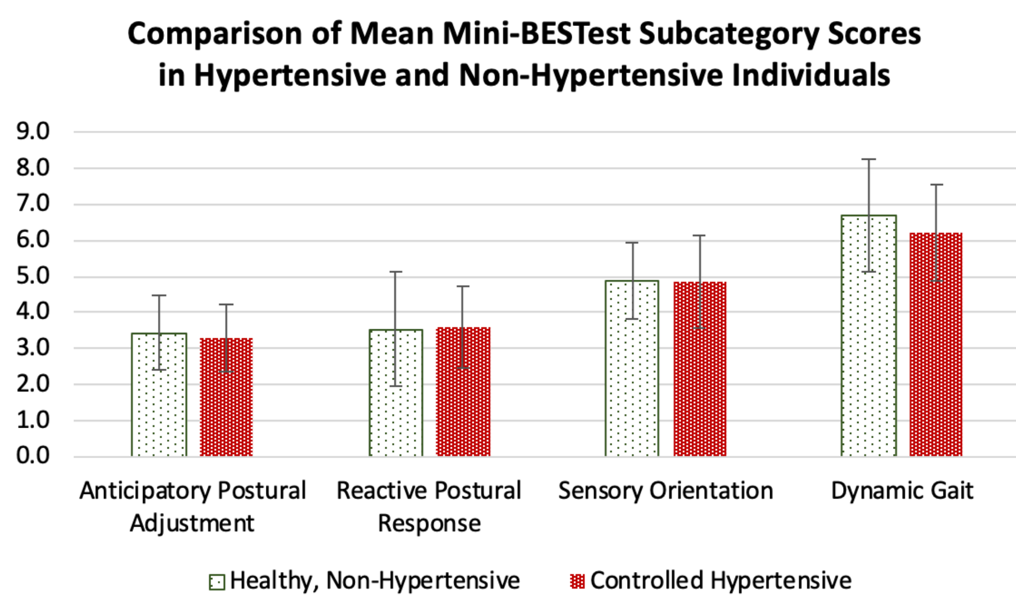


**Figure:** Mean scores for the anticipatory postural adjustment, reactive postural response, sensory orientation, and dynamic gait between controlled hypertensive and healthy non-hypertensive groups are compared in the figure. Error bars represent standard deviation.

**Discussion**

The results of this study demonstrate that there are no significant differences between controlled hypertensive and non-hypertensive individuals' balance scores in any of the four subcategories within the Mini-BESTest. This suggests that it is possible that anti-hypertensive therapy does not significantly increase one's potential to lose control of anticipatory postural adjustment, reactive postural response, sensory orientation, or dynamic gait—therefore not significantly increasing the likelihood for falls. This is in contrast to information from a previous study by Shimbo et al. (2016), which suggested that anti-hypertensive medication use may result in neurological and physical disturbances in older adults.[22] Another study by Hui Ting Ang et al. (2018), however, found that specifically the use of angiotensin converting enzyme inhibitors, β-blockers, or calcium channel blockers may be associated with a lower risk of falls.[23] The results of these studies demonstrate that the effects of anti-hypertensive therapy on balance control and risk of falls is still unclear. Our study aimed to provide additional evidence for the relationship between anti-hypertensive therapy and balance control for this reason. The results of our study were more consistent with those of Acar et al. (2015) and Gangavati et al. (2011) who found that there were no differences in balance control between healthy non-hypertensive and controlled hypertensive groups.[13,15]

Though we compared the balance control of non-hypertensive and controlled hypertensive individuals, this study was limited as we did not have data on uncontrolled (i.e., no anti-hypertensive therapy use) hypertensive individuals. This might have provided a more complete picture of the effects of hypertension on balance both before and after use of antihypertensive medication. The study by Gangavati et al. (2011) did compare these groups and showed that participants with uncontrolled hypertension were at a greater fall risk than those with controlled hypertension.[15] This suggests that the antihypertensive therapy not only does not increase the risk of balance dysfunction and falls in hypertensive individuals, but it also may aid in normalizing the poor balance that they may have as a result of the hypertensive condition itself. However, additional future studies are needed to support this.

Another limitation of this study was that individuals taking different types of antihypertensive medications were not distinguished between each other. It is possible that results might have differed based on different antihypertensive therapies, as was alluded to by Hui Ting Ang et al. (2018). Additionally, a significant limitation to this study was the small sample size that was used, and the group of participants which were studied were not gender matched and were all of the same nationality. Therefore, the results of this study are not completely representative of that of the general population.

Studies such as ours are necessary in order to establish the effectiveness and potential risks of anti-hypertensive therapy on individuals suffering from hypertension. To further the understanding of the effects of anti-hypertensive therapy on balance control, future work may expand upon what was investigated in our study. Specifically, future studies could benefit from choosing a larger, more diverse sample size, separating groups of controlled-hypertensive individuals based on different anti-hypertensive therapy used, and comparing their balance as well as history of falls to non-controlled hypertensive and healthy non-hypertensive groups.

**Conclusion**

This study provides important insight into the potential effects of anti-hypertensive therapy on balance control. We found that scores for anticipatory postural adjustment, sensory orientation, and dynamic gait tended to be higher in the non-hypertensive individuals, while scores for reactive postural response tended to be higher in the controlled-hypertensive group. However, none of these differences were statistically significant, suggesting that anti-hypertensive therapy does not pose any major alterations to a hypertensive patient's balance control. Future work is needed to compare these results to the results of a group of non-controlled hypertensive individuals to determine whether the anti-hypertensive therapy specifically works to normalize any existing balance dysfunction in hypertensive patients.

**References**

1. Adams PE, Martinez ME, Vickerie JL, Kirzinger WK. Summary health statistics for the U.S. population: National Health Interview Survey, 2010. *Vital Health Stat 10*. 2011;(251):1-117. http://www.ncbi.nlm.nih.gov/pubmed/22624451. Accessed February 7, 2020.

2. Hu G, Baker SP. Trends in Unintentional Injury Deaths, U.S., 1999-2005. Age, Gender, and Racial/Ethnic Differences. *Am J Prev Med*. 2009;37(3):188-194. doi:10.1016/j.amepre.2009.04.023

3. Cohen RG, Nutt JG, Horak FB. Errors in postural preparation lead to increased choice reaction times for step initiation in older adults. *Journals Gerontol - Ser A Biol Sci Med Sci*. 2011;66 A(6):705-713. doi:10.1093/gerona/glr054

4. Muir SW, Berg K, Chesworth B, Klar N, Speechley M. Quantifying the magnitude of risk for balance impairment on falls in community-dwelling older adults: a systematic review and meta-analysis. *J Clin Epidemiol*. 2010;63(4):389-406. doi:10.1016/j.jclinepi.2009.06.010

5. Ganz DA, Bao Y, Shekelle PG, Rubenstein LZ. Will my patient fall? *J Am Med Assoc*. 2007;297(1):77-86. doi:10.1001/jama.297.1.77

6. Rubenstein LZ. Falls in older people: Epidemiology, risk factors and strategies for prevention. In: *Age and Ageing*. Vol 35. ; 2006:ii37-ii41. doi:10.1093/ageing/afl084

7. Cerebellar Control of Balance and Locomotion. 2004. doi:10.1177/1073858404263517

8. Salzman B. *Gait and Balance Disorders in Older Adults*. Vol 82.; 2010.

www.aafp.org/afpAmericanFamilyPhysician61. Accessed February 8, 2020.

9. Iwata T, Yano E, Karita K, Dakeishi M, Murata K. Critical Dose of Lead Affecting Postural Balance in Workers. *Am J Ind Med*. 2005;48:319-325. doi:10.1002/ajim.20220

10. Poulter NR, Prabhakaran D, Caulfi M. Hypertension. *www.thelancet.com*. 2015;386. doi:10.1016/S0140-6736(14)61468-9

11. Carey RM, Whelton PK, Aronow WS, et al. Prevention, detection, evaluation, and management of high blood pressure in adults: Synopsis of the 2017 American College of Cardiology/American Heart Association Hypertension Guideline. *Ann Intern Med*. 2018;168(5):351-358. doi:10.7326/M17-3203

12. Abate M, Di Iorio A, Pini B, et al. Effects of hypertension on balance assessed by computerized posturography in the elderly. *Arch Gerontol Geriatr*. 2009;49(1):113-117. doi:10.1016/j.archger.2008.05.008

13. Acar S, Demirbüken İ, Algun C, Malkoç M, Tekin N. Is hypertension a risk factor for poor balance control in elderly adults? *J Phys Ther Sci*. 2015;27(3):901-904. doi:10.1589/jpts.27.901

14. Shen S, He T, Chu J, He J, Chen X. Uncontrolled hypertension and orthostatic hypotension in relation to standing balance in elderly hypertensive patients. *Clin Interv Aging*. 2015;10:897-906. doi:10.2147/CIA.S81283

15. Gangavati A, Ihab Hajjar Ã, Lien Quach Ã, et al. Hypertension, Orthostatic Hypotension, and the Risk of Falls in a Community-Dwelling Elderly Population: The Maintenance of Balance, Independent Living, Intellect, and Zest in the Elderly of Boston Study. *J Am*

*Geriatr Soc*. 2011;59:383-389. doi:10.1111/j.1532-5415.2011.03317.x

16. Franchignoni F, Horak F, Godi M, Nardone A, Giordano A. Using psychometric techniques to improve the balance evaluation systems test: The mini-bestest. *J Rehabil Med*. 2010;42(4):323-331. doi:10.2340/16501977-0537

17. Duncan RP, Leddy AL, Cavanaugh JT, et al. Comparative Utility of the BESTest, Mini-BESTest, and Brief-BESTest for Predicting Falls in Individuals With Parkinson Disease: A Cohort Study. *Phys Ther*. 2013;93(4):542-550. doi:10.2522/ptj.20120302

18. Leddy AL, Crowner BE, Earhart GM. Utility of the mini-BESTest, BESTest, and BESTest sections for balance assessments in individuals with Parkinson disease. *J Neurol Phys Ther*. 2011;35(2):90-97. doi:10.1097/NPT.0b013e31821a620c

19. King LA, Priest KC, Salarian A, Pierce D, Horak FB. Comparing the Mini-BESTest with the Berg Balance Scale to evaluate balance disorders in Parkinson's disease. *Parkinsons Dis*. 2012;2012:375419. doi:10.1155/2012/375419

20. Tsang CSL, Liao L-R, Chung RCK, Pang MYC. *Psychometric Properties of the Mini-Balance Evaluation Systems Test (Mini-BESTest) in Community-Dwelling Individuals With Chronic Stroke Background. The Mini-Balance Evaluation Systems Test (Mini-BESTest) Is a New.*; 2013. https://academic.oup.com/ptj/article-abstract/93/8/1102/2735542. Accessed February 2, 2020.

21. Santos DA, Duarte M. A public data set of human balance evaluations. *PeerJ*. 2016;2016(11). doi:10.7717/peerj.2648

22. Shimbo D, Bowling CB, Levitan EB, et al. Short-term risk of serious fall injuries in older

adults initiating and intensifying treatment with antihypertensive medication. *Circ Cardiovasc Qual Outcomes*. 2016;9(3):222-229. doi:10.1161/CIRCOUTCOMES.115.002524

23. Ting Ang H, Keat Lim K, Heng Kwan Y, et al. A Systematic Review and Meta-Analyses of the Association Between Anti-Hypertensive Classes and the Risk of Falls Among Older Adults Key Points. *Drugs Aging*. 2018;35:625-635. doi:10.1007/s40266-018-0561-3