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Original Research

Relationship Between Activities-specific Balance Confidence (ABC) and Gait Symmetry and Gait Symmetry Variability in Elderly Women

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ABSTRACT

Lack of Balance Confidence is a psychological injury that can lead to limited activities and as a result anxiety, depression and reduced quality of life. There is limited research on Balance Confidence and its effect on gait parameters. The aim of the study was to investigate the relationship between Activities-specific Balance Confidence (ABC) and gait symmetry and the variability of gait symmetry in elderly women. The current research was descriptive and correlational. The sampling method was available. 21 elderly women eligible to include in the study completed ABC scale. Hp Cosmos Mercury treadmill and Optitrack 3D motion capture system were used to record the kinematic and temporo-spatial information of individuals' gait. The data acquisition process was recorded for at least 30 seconds after the treadmill speed was fixed at a data acquisition of 120 frames per second in at least 10 full gait cycles of individuals. The components of gait symmetry and gait symmetry variability were obtained from three temporo-spatial factors of step length, step width and stride time. The results were analyzed using the Spearman's rank correlation coefficient test. Correlation between variables showed that there is a significant and positive relationship between ABC and the variability of total gait symmetry. Also, the results showed that ABC has a positive and significant relationship with the symmetry of step length and width, and a negative and significant relationship with the variability of step length and width. However, there is no relationship between ABC and the variability of symmetry and time. According to the results of the research, it is suggested to design interventions to increase balance confidence among elderly women in order to improve the indices related to gait and subsequently the quality of life.

Keywords: Gait Symmetry, Symmetry Variability, Activities-specific Balance Confidence, Elderly

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INTRODUCTION

The increase in the elderly population is one of the most important economic, social and health challenges in the 21st century which will have many consequences [1,2]. Although population aging is a continuous global phenomenon, world population growth in developing countries is faster than the global average. In 2012, about 70 percent of people over 60 years of age and older lived in developing countries, and by 2050, this amount will increase to about 80 percent [3,4]. Based on the definition of the World Health Organization (WHO), the age of over sixty years is considered old age, which is associated with gradual, progressive and spontaneous attritional changes in most of the physiological systems and functions of the body [5]. One of the common problems of the elderly is due to changes in the involved systems, loss of balance, increases in the height fluctuations and possibility of falling, which can expose the elderly to serious injuries, including bone fractures and long-term disabilities [6].

Research evidence shows that the decline of the sensory organs involved in balance due to aging and consequently the increased risk of fall, cause changes in the gait pattern (step length, step width, stride speed and rhythm, etc.), non-identification of deviations of the center of gravity and the inability to produce appropriate and fast muscle responses to correct the posture.

Although fall as an event that causes a person to drop unintentionally, it occurs as a result of factors such as sustaining a violent blow, loss of consciousness, sudden onset of paralysis or non-convulsive epilepsy as some important concerns of the elderly [7-9]. however the proposition based on Bandura's self-efficacy hypothesis points out that in addition to physical and physiological factors, psychological factors such as fall self-efficacy (having no fear of fall) or reduced balance confidence are related to fall as well.

Activities-specific Balance confidence (ABC) is a psychological construct that includes beliefs and motivations and is a special state of self-efficacy that is defined as a person's perception of his ability to maintain balance while performing daily life activities [4,10]. According to Tinetti et al.'s (1990) definition, fear of fall (FOF) refers to a temporary fear of an obvious threat such as falling, i.e. a lack of confidence that normal activities can be performed without losing balance [11, 12]. In general, FOF and *lack of* ABC are simply psychological injuries that can lead to limiting activities and even avoiding doing activities, which has little relevance to physical disabilities or injuries. Shumway-Cook and Woollacott (2007) also state that the elderly's FOF can lead to their excessive care and excessive movement restrictions, loss of individual independence, isolation, etc. [4,11]. Also, Boyd and Stevens (2007) state that FOF is an important issue that can lead to anxiety and depression and decrease the quality of life [13]. Studies on different populations have shown that FOF is related to balance and changes in temporo-spatial parameters of gait [9,14,15].

Some research evidence suggests that slower gait speed, shorter step length, increased step width, and increased double support time are associated with earlier FOF in older adults [14,16]. For example, in their research, Makino et al. (2017) showed that elderly people with FOF have a significantly slower gait speed, shorter step length and longer double support time than people without FOF [17]. In their study, Drummond et al. (2022) showed the relationship between FOF and the spatio-temporal parameters of gait, decreasing gait speed, decreasing speed, increasing stride time, and decreasing step and step length in elderly people. However, no correlation was found between FoF and step length variability [18].

Researchers believe that although the mechanisms of increasing the risk of fall in the elderly are not fully understood, it seems that lack of ABC and FOF can reduce the allocation of significant resources during gait [19,20]. Despite the above results, Delbaere et al. found that FOF was not related to gait speed in elderly individuals under normal gait conditions. They reported that changes in gait parameters were observed only in individuals who were afraid of fall when threatened conditions were imposed [21]. Also, Shirini et al showed that although there is a relationship between FOF and balance and anxiety of elderly men and women, the relationship between FOF and functional mobility is not significant [9].

Despite several studies on the gait variables, less attention has been paid to symmetry and variability. The discussion about gait symmetry is of interest because the organs must have complete coordination to achieve a balanced and smooth movement [22].

Asymmetry between the upper limb and gait variability can reflect some disorders in motor control that lead to errors in foot placement and is known as a predictor of falls and imbalance [23-25]. Although the decrease in physical and physiological factors leads to a decrease in balance and falls, and these falls lead to injury, hospitalization, delivery to a nursing home, failure to perform daily activities and decline in social activities, psychosocial factors can strongly shape or change the way the motor system reacts to static and dynamic tasks. Therefore, careful investigation and understanding of the factors that can lead to anxiety and poor control of balance and movement limitations can help to create targeted clinical interventions [16]. Also, the symmetry or asymmetry of gait and its variability in elderly people and the factors affecting it is an important issue for experts to design rehabilitation protocols for gait. Given the inevitable problems and changes (physical, psychological and physiological) of the elderly and the importance of investigating the psychological factors related to gait and the special attention and care of this group, the purpose of the study is to determine the existence of a relationship between ABC and gait symmetry and its variability in elderly women.

MATERIAL AND METHODS

The statistical population of the research included elderly women with an age range of 60 to 70 years. The sample was selected based on the availability method. 21 elderly eligible women were selected for the research. The criteria for inclusion in the research comprised reading and writing literacy, having mental and general health, no history of cognitive behavioral problems, having normal or corrected normal vision, not taking drugs that affect cognitive and motor status, and the ability to walk independently without an assistive device.

Instruments

1. Activities-specific Balance Confidence Scale (ABC Scale): This scale was designed by Powell and Myers (1995) [26] and Shumway-Cook and Woollacott (2007) [6] and is considered to be an important instrument for measuring balance and falls, especially in the elderly. This scale has 16 items related to performing activities, and the subject is asked to score his confidence rate while performing a range of daily life activities, including walking, sweeping , climbing the stairs, etc. (0%: lack of confidence - 100%: complete confidence). The subject's score in this scale is the total score of all items divided by the number of items. The minimum score is zero and the maximum score is 100. A higher score means a higher balance confidence. The validity and reliability of this instrument has been confirmed in Iran by Kashani et al. (2017) [27].
2. Optitrack 3D motion capture system*:* In order to record the kinematic and temporo-spatial information of individuals' gait, the Optitrack 3D motion capture system (Optitrack) model V120 Duo, made in America, with VGA resolution (480*640) and error of less than 0.1 mm was used. In order to create a local coordinate system on each limb, seven cluster markers were installed on the lower limb and seven rigid bodies were formed.
3. *Treadmill:* Hp Cosmos Mercury treadmill, made in Germany, was used for the purpose of gait analysis and extraction of temporo-spatial factors.

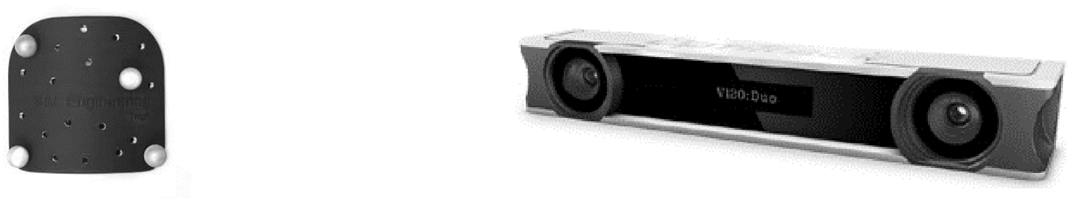

Figure 1: Optitrack V120 Duo 3D camera and cluster reflective marker Implementation procedure

Based on the previously-planned schedule, the participants attended the laboratory individually and before starting the test, they completed a consent form in which they expressed their consent to participate in the test. The process of the test was as follows: first, the subjects got acquainted with the research plan and filled the consent form for voluntary participation in the tests. All the subjects were asked to wear clothes and shoes suitable for gait on the treadmill. Next, the subjects were prepared to perform gait analysis on the treadmill. Considering the subjects old age and the fact that some of them had no history of gait on a treadmill, a few minutes were spent on training them and adjusting the appropriate speed of the treadmill, taking into account all aspects of caution. The preparation process ended when the subjects were able to walk with a pattern similar to gait on the ground without taking protective parallels. After this stage, the reflective markers were connected to the lower limb using the cluster method. In the next stage, the subjects were asked to take an anatomical stance on the treadmill and stay in front of the motion capture system for static data acquisition.

Before data acquisition process, seven rigid bodies (local coordinate system) were installed on the lower limb according to the protocol of the 3Dgait system and labeled inside the Motive software. Next, the treadmill, which was previously set to the desired speed, was turned on and the subjects were asked to walk on the treadmill at a normal gait. The data acquisition process continued for at least 30 seconds after the treadmill speed was fixed at a data acquisition speed of 120 frames per second so that at least 10 complete gait cycles of the subjects' gait were recorded. In order to ensure that all the data are available, the data acquition process was repeated 3 times.

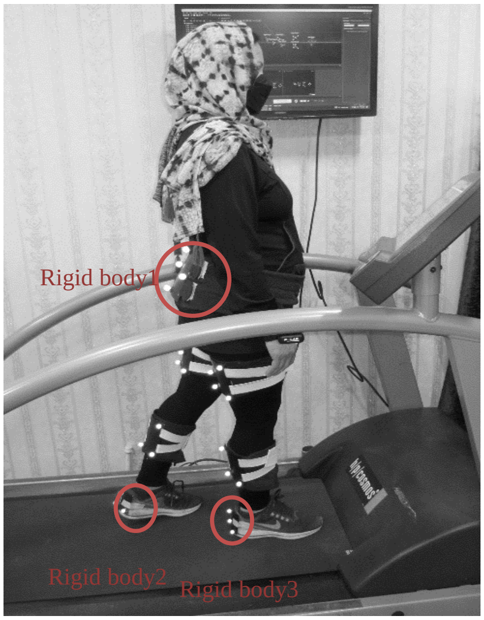

Figure 2: Data acquisition from the subjects' gait on the treadmill

Information processing

Although the marker setting protocol was designed to fully analyze the movement kinematics, in the present study, only the rigid body attached to the pelvis and two heels was used to extract temporo-spatial factors. In this method, the pelvis was considered as a reference and temporo-spatial factors were extracted from the central position of the rigid body attached to the heel.

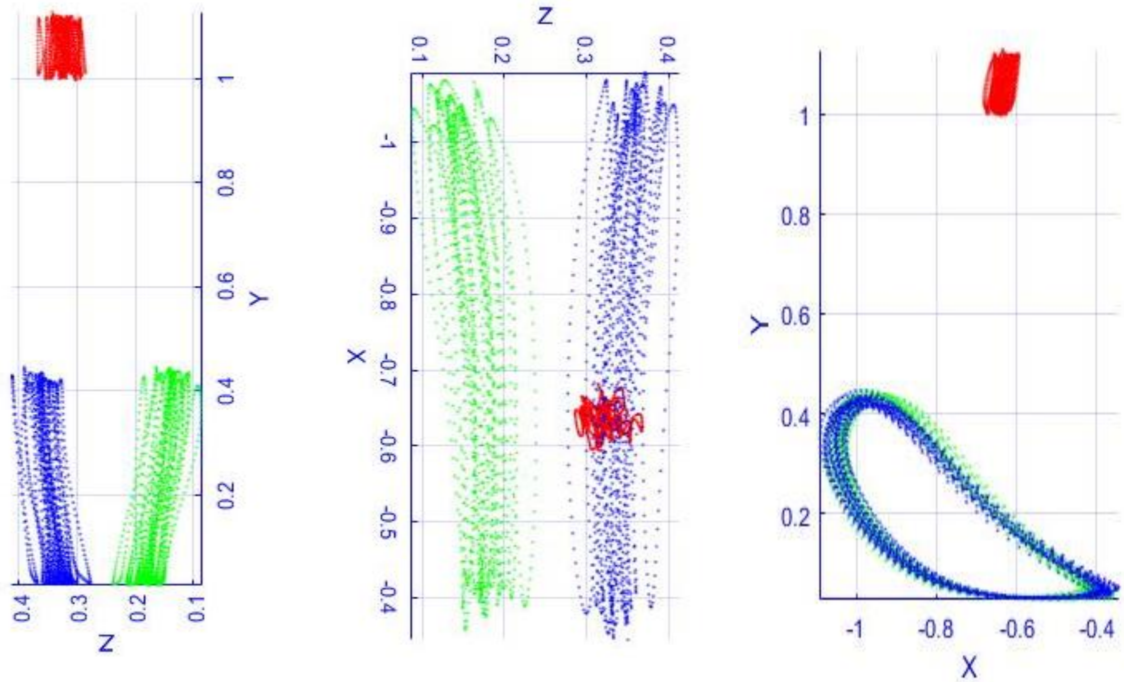

Figure 3: 3D position of the center of the markers attached to the pelvis, left and right heel from three different views

In this research, the gait symmetry component was obtained from three temporo-spatial factors of step length, step width and stride time. The calculation of these factors was done at the moment of the beginning of the double support phase. In this way, the distance of the center of the rigid body on the heels was calculated in the anterior-posterior direction for step length and in the medio-lateral direction for step width. Also, the time interval between these two moments was considered as stride time. Equation 1 shows the method of calculating the symmetry index from the three components of step length, step width and stride time for a complete gait cycle.

$$Symmetry\ ratio_{Step\ Length} = \frac{Step\ Length_{Less}}{Step\ Length_{More}} * 100$$

$$Symmetry\ ratio_{Step\ Width} = \frac{Step\ Width_{Less}}{Step\ Width_{More}} * 100$$

$$Symmetry\ ratio_{Stride\ Time} = \frac{Stride\ Time_{Less}}{Stride\ Time_{More}} * 100$$

$$Symmetry\ ratio_{Total} = mean(Symmetry\ ratios)$$

Equation [28]

Another component of this study was gait symmetry variability. To calculate this index, the symmetry values of the right and left limbs were recorded during 10 complete gate cycles and obtained by taking the standard deviation from these 10 cycles [29].

Data analysis

Statistical analysis was performed in SPSS software (ver. 26, Chicago, IL). The Spearman's rank correlation coefficient test was used to check the relationship between the study variables.

RESULTS

The participants' demographic characteristics are presented in Table 1. Descriptive statistics related to the research variables are also presented in Table 2.

Table 1. Demographic characteristics of the participants

N	Mean± Std. Deviation		
	Weight (Kg)	**Height (Cm)**	**Age (Year)**
21	65.60±8.41	156.73±9.36	64.42±2.87

Table 2. Descriptive statistics related to the research variables

Variable	*N*	Minimum	Maximum	Mean	Std. Deviation
Activities-specific balance confidence (ABC)	21	48.75	100.00	81.87	14.973
Length symmetry (LS)	21	83.95	97.09	94.210	3.006
Width symmetry (WS)	21	88.88	97.37	94.409	2.128
Time symmetry (TS)	21	93.00	98.75	96.823	1.405
Total symmetry (TOS)	21	89.93	96.84	95.147	1.701
Length symmetry variability (LSV)	21	1.80	5.73	3.5413	1.114
Width symmetry variability (WSV)	21	2.27	12.20	5.013	2.208
Time symmetry variability (TSV)	21	.97	2.52	1.730	.495
Total symmetry variability (TOSV)	21	2.38	6.58	3.428	.983

Regarding inferential statistics, the normality of the data distribution was investigated using the Shapiro-Wilk test, and given the non-normality of the data distribution, the relationship between the variables was investigated using the Spearman's rank correlation coefficient test. Correlation between the variables showed that there is a significant and positive relationship between ABC and gait symmetry, but there is a negative and significant relationship between ABC and gait symmetry variability. The results are shown in Table 3.

Table 3. Results of the Spearman's rank correlation coefficient test regarding the correlation between activities-specific balance confidence, gait symmetry and gait symmetry variability

Variable	ABC	TGS	GSV
Activities-specific balance confidence (ABC)	-	0.54*	-0.61*
Total gait symmetry (TGS)	-	-	-0.76*
Gait symmetry variability (GSV)	-	-	-

* Significance level at $P<0.05$

Also, the examination of the relationship between ABC and gait symmetry and symmetry variability componenets showed that ABC has a positive and significant relationship with the symmetry of step length and width, and a negative and significant relationship with the variability of step length and width. However, there was no relationship between ABC and time symmetry and time symmetry variability. The results showed that the participants with better scores in activity-specific ABC index had higher scores in length and width symmetry and gait symmetry variability components. The results are presented in Table 4.

Table 4. Results of the Spearman's rank correlation coefficient test regarding the correlation between activity-specific balance confidence index, gait symmetry and gait symmetry variability components

Variable	Gait symmetry and variability components	Correlation value
Activity-specific balance confidence (ABC)	Length symmetry (LS)	**.520***
	Width symmetry (WS)	**.489***
	Time symmetry (TS)	**.194**
	Length symmetry variability (LSV)	**-.623****
	Width symmetry variability (WSV)	**-.472***
	Time symmetry variability (TSV)	**.036**

* Significance level at P<0.05

DISCUSSION

The aim of the present study was to investigate the relationship between ABC and gait symmetry and symmetry variability in elderly women. The results showed that there is a significant and positive relationship between ABC and total gait symmetry, and there is a negative and significant relationship between ABC and total gait symmetry variability. In addition, the results showed that ABC has a positive and significant relationship with the symmetry of stride length and width, and a negative and significant relationship with the variability of stride length and width symmetry. However, there was no relationship between ABC with the symmetry and variability of time symmetry.

Many researches have reported that with increasing age, a person's gait speed, double support time, and stride length and width are affected [30]. These changes are made in order to better maintain balance during gait [31], because decreased balance in healthy people has a direct relationship with increased rate of falling down [32] and may indicate an effort to increase postural stability to reduce the risk of falling [33]. In the first part, the results of the study showed that ABC has a significant relationship with overall stride symmetry, stride length and width symmetry, so that an increase/decrease in ABC was associated with an increase/decrease in stride length and width symmetry of elderly women. Although previous studies have investigated the effect of ABC on some spatio-temporal variables [34], according to the studies, no research was observed to specifically investigate the relationship of ABC with gait symmetry in the elderly. Some studies have stated that gait symmetry decreases with age. Gait asymmetry indicates weak coordination in walking, which leads to disturbances in walking stability and increases the risk of falling in the elderly. Decreased gait symmetry should be considered as a biomarker of gait control disorders at higher levels [18, 35]. It seems that people with weak ABC have inappropriate timing of muscle activity in the body and movement flexibility and create more compensatory movements during gait, which leads to kinematic and spatio-temporal parameters gait asymmetry, which indicates inefficient control in gait [33, 34]. Another possible explanation for these findings may be that FOF and lack of ABC can alter important cortical pathways that are critical for producing coordinated limb movements [18]. The possible involvement of these neural pathways in high FOF or low ABC may impair the coordination dynamics of lower limb segments to some extent [36]. The non-significance of the relationship between gait symmetry caused by stride time, despite its positive relationship with ABC, can be more caused by the motor control system. In other words, in the motor control system of people with movement problems and poor balance confidence, despite the asymmetry in step length and width, compensatory mechanisms are created that try to maintain the rhythm and frequency of gait and recover the symmetry. Although in many cases, as in the present study, this adaptability leads to the absence of a significant relationship between stride time symmetry and ABC, the compensatory mechanisms resulting from it can increase the existence of imbalances and the problems of asymmetry in step length and width, which are more affected by the health of the skeletal-muscular system. Also, this lack of correlation shows that this psychological variable affects gait symmetry time independently of stride length and width.

The results of the second part of the study regarding the relationship between ABC and the variability of overall symmetry and stride length and width in elderly women's gait are consistent with the findings of most studies conducted on different populations regarding the relationship between ABC and FOF with changes in gait spatial-temporal parameters [33, 37, 38].

The results of this study showed that the elderly who had more ABC experienced less symmetrical variability in stride length and width. The research results are partially consistent with the findings of Danoudis et al. (2016) [39] and Ayubi et al. (2014) [38].

Studies have stated gait variability indicates the fluctuation of gait parameters over time as well as gait disorder [40-42]. Previous studies have suggested increased variability as a marker and predictor of falls in the elderly, and elderly people with a FOF have shown greater gait variability. For example, Maki suggested that cautious walking is a sign of FoF and high gait variability is a sign of falls [43].

On the other hand, lower variability reflects the reliability of lower limb movements and the automatic regular rhythmic characteristic of gait and is associated with safe walking. In terms of motor control, lower variability reflects an automatic process that requires minimal attention, while higher variability is associated with conscious movements and high attentional engagement [38]. Low ABC may involve a person in the conscious attention of the task, which itself can be effective on the information processing stages. In fact, overreliance on attention-seeking processes may lead to performance degradation. in simple tasks such as walking on a treadmill at a constant speed, reduced variability can indicate a more favorable health status. The results of the present study were in line with this view and showed that symmetry variability has an inverse relationship with ABC in the simple task of gait on a treadmill. Based on this, people who had a better ABC and consequently had better motor health, in addition to having more symmetry, showed less variability as well. In other words, these people control movement from the lower levels of the lower central nervous system and show less variability in gait symmetry. The results are not consistent with the findings of Dormand et al. (2022) [38], Donoghue et al. (2013) [44] and Shinkel et al. (2015) [33] . Among the reasons for inconsistency, we can mention the type of samples studied, the gait speed, the tools used, etc. In general, although gait practice and strengthening training are likely to be beneficial in improving gait parameters, studies should emphasize optimal co-occurrence management, which include components of psychological factors.

The results of the study on the relationship between the gait symmetry and a psychological parameter can indicate the importance of these variables in the performance of the elderly, so that increasing ABC and reducing variability can lead to more efficiency in gait and reducing FOF, and as a result, the negative psychological and physiological consequences resulting from it can be reduced and the quality of life of the elderly can be improved.

Despite the practical implications, the present study had limitations. One of the limitations of the research was the small number of samples, so that caution should be taken in generalizing the results. Also, the uniqueness of data acquisition by questionnaire and the use of available sampling method were other limitations of this research. Since the research participants did not have acute mental and physical problems, it may not be possible to generalize our results to the whole group of elderly people. In addition, accounting for the possible disturbing variables (such as the history of falling, gender, cognitive impairment, visual impairment, and the use of drugs), as well as examining the relationship between ABC and other spatial and temporal gait variables can help further to design more effective interventions and preventive strategies.

CONCLUSION

The results showed that there is a significant relationship between ABC and step length symmetry, step width symmetry and step length and width variability in elderly women. These results provide insight into the relationship between ABC and fall risk in elderly women. Considering the impact of psychological factors on changes in the reaction of movement system and gait parameters, and that the gait asymmetry and variability can reflect some disorders in movement control, which is known as a predictor of falls and imbalance, it is suggested to design appropriate interventions for increasing ABC among elderly women in order to improve gait-related indices.

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Informed Consent: All participants completed the consent form before partaking in the study.

Conflict of Interest: The authors declare no conflict of interest.

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ارتباط اعتماد به تعادل ویژه فعالیت‌ها با تقارن گام‌برداری و تغییرپذیری تقارن گام‌برداری در زنان سالمند

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چکیده:

عدم اعتماد به تعادل یک آسیب روانشناختی است که می‌تواند منجر به محدود شدن فعالیت‌ها و در نتیجه اضطراب، افسردگی و کاهش کیفیت زندگی شود. تحقیقات محدودی در مورد اعتماد به تعادل و تأثیر آن بر پارامترهای راه رفتن وجود دارد. هدف مطالعه، بررسی ارتباط اعتماد به تعادل با تقارن گام‌برداری و تغییرپذیری تقارن گام‌برداری در زنان سالمند بود. پژوهش حاضر توصیفی و از نوع همبستگی بود. ۲۱ زن سالمند دارای شرایط ورود به مطالعه، مقیاس اعتماد به تعادل ویژه فعالیت‌ها را تکمیل نمودند. به‌منظور ثبت اطلاعات کینماتیکی و فضایی- زمانی گام‌برداری افراد، از تردمیل Hp Cosmos Mercury و سیستم ضبط حرکت سه‌بعدی Optitrack استفاده شد. فرایند داده‌برداری به مدت حداقل ۳۰ ثانیه پس از ثابت شدن سرعت تردمیل با سرعت داده‌برداری ۱۲۰ فریم بر ثانیه در حداقل ۱۰ سیکل کامل گیت از راه‌رفتن افراد ثبت و مؤلفه‌های تقارن و تغییرپذیری تقارن گام‌برداری از سه فاکتور فضایی زمانیِ طول گام، عرض گام و استراید تایم بدست آمد. نتایج با استفاده از آزمون ضریب همبستگی اسپیرمن تجزیه و تحلیل شد. همبستگی بین متغیرها نشان داد که اعتماد به تعادل و تقارن کل ارتباط معنادار و مثبت و با تغییرپذیری تقارن کل گام برداری ارتباط منفی و معناداری وجود دارد. همچنین نتایج نشان داد که اعتماد به تعادل با تقارن و تغییرپذیری طول و عرض گام برداری ارتباط معناداری دارد. با این حال بین اعتماد به تعادل و تقارن و تغییرپذیری زمان ارتباطی وجود نداشت. با توجه به نتایج، پیشنهاد می‌شود طراحی مداخلات برای افزایش اعتماد به تعادل در بین زنان سالمند به منظور بهبود شاخص‌های مرتبط با گام برداری مورد توجه قرار گیرد.

واژه‌های کلیدی: تقارن گام‌برداری، تغییرپذیری تقارن، اعتماد به تعادل ویژه فعالیت‌ها، سالمند.