Central European Journal of Sport Sciences and Medicine | Vol. 17, No. 1/2017: 79–87 | DOI: 10.18276/cej.2017.1-10

THE APPLICABILITY OF USING PARAMETERS OF THE AUTOCORRELATION FUNCTION IN THE ASSESSMENT OF HUMAN BALANCE DURING QUIET BIPENDAL STANCE

Jacek Stodółka,[A, B, C, D, E] Leszek Korzewa,[A, B, C, D] Weronika Stodółka,[B, C, E]
Jarosław Gambal[B, E]

University School of Physical Education in Wroclaw, Department of Track and Field
[A] Study Design; [B] Data Collection; [C] Statistical Analysis; [D] Manuscript Preparation; [E] Funds Collection

Address for correspondence:
Jacek Stodółka
AWF Wroclaw (University School of Physical Education in Wroclaw), Katedra Lekkoatletyki i Gimnastyki (Department of Track and Field)
Ul. Paderewskiego 35, 51-612 Wrocław, Poland
Email: jacek.stodolka@awf.wroc.pl

Abstract The purpose of the study was to analyze the parameters of the autocorrelation function when assessing time series ground reaction force (GRF) signals during quiet standing. GRF in the three directions were recorded on two Kistler force plates during three 15-s trials in a sample of 82 (31 females and 51 males) participants. Autocorrelation was performed on the GRF data and four parameters characterizing the function were computed. Comparisons of the right- and left-foot parameter means showed significant differences in mediolateral GRF for the time of the function's decay to 0, magnitude of the derivative output, and mean decay velocity to the extremum. Significant correlations were observed among all parameters – weak correlations between the time of the function's decay to 0 and the time to the first extremum and strong correlations between the derivative output and mean decay velocity to the extremum. The analyzed autocorrelation function parameters can serve as a precise measure of the motor control process during quiet standing. The strong correlations observed between the four parameters indicate that they evaluate similar properties of the central nervous system as a regulator of balance maintenance.

Key words symmetry, asymmetry, foot, force, balance, quiet standing, autocorrelation

Introduction

While human movement and locomotion has many modes, almost all tasks rely on some form of postural stability (Skelton, 2001; Van Ooteghem et al., 2008). Maintaining balanced erect posture, contrary to appearances, is a very complex and dynamic process (Morningstar et al., 2005). While the postural control processes responsible for balance are almost entirely automatic and reflexive, the effects of aging and disease can introduce a number of impairments and deficits (Brown et al., 1999; Woollacott, Shumway-Cook, 2002).

In static conditions, bipedal standing is most commonly modeled as an inverted pendulum (Winter et al., 1998; Loram, Lakie, 2002; Chao, Xin, 2004). This model assumes that the control mechanisms of standing are guided by changes in the ground reaction force vector at the base of support (Golema, 2002; Kuczyński, 2003; Winter, 1995). The body needs to continuously adapt to any change in the center of gravity (itself dependent on changes in body position and posture). Therefore, any change in the center of gravity is actioned by changes in the ground reaction force vector. For this reason, this variable can be treated as the neuromuscular response (regulator) to imbalances in the body's center of gravity. Even the most simple activities of daily living involve a very high level of neuromuscular function involving a multitude of systems (Brown et al., 1999; Lafond et al., 2009).

Quantitative assessments of balance control are most commonly performed by measuring ground reaction forces with a force platform (Onell, 2000; Lafond et al., 2004; Doyle et al., 2007; Kijowski, 2013; Liang et al., 2015). By determining the magnitudes of the ground reaction force vectors, clinically useful data can be extrapolated on the relationship between the whole body and individual body segments with respect to the supporting surface (Ayyappa, 1997). The registration of ground reaction force data as a function of time has allowed researchers to effectively albeit indirectly measure upright balance control. The acquired time history has been described as a stochastic process (Theiler et al., 1992). To determine the descriptive characteristics of such a time series, probabilistic tools and techniques from statistical mechanics can be applied. Since force data can be treated as a signal, signal processing can aid in comparing the spatial or temporal characteristics of time-varying signals or identify a pattern within a signal such as by comparing it with its own time-shifted copy. Such comparisons involve a phase delay, where one signal is shifted forwards and backwards in time against another. This produces a correlation function of the two signals at each increment of the phase shift and can define the linear relationship between each point in the signal (Szabatin, 2002). When a time-varying signal is compared against itself, this is called an autocorrelation.

The autocorrelation function is a powerful and efficient alternative to quantifying associated patterns and events between variables. Autocorrelations can be calculated using large or small data sets based on a stationary or non-stationary time series that do or do not show trends. If the time-series data exhibits a trend, by definition the curve of the autocorrelation function shows a slow decay to a value of 0, whereas a rapid decay of the autocorrelation function in effect indicates the presence of uncontrolled change (typically through noise) in the time series. Furthermore, the autocorrelation function of data with a periodic component will also show periodicity (similar to the frequency of the input signals). In this way, autocorrelation can provide an objective measure of the dependencies relating two variables in a time series (random or not) at a given moment in time from the phase shift of preceding and succeeding events. Therefore the aim of the work was to calculate the autocorrelation function of GRF time series data during quiet standing and determine which autocorrelation parameter best characterizes the strategies utilized by the postural control system to maintain balance. Based on the acquired GRF signals, two research questions were formulated:

1. What are the values of the parameters of the autocorrelation?
2. Do any dependencies exist between the individual parameters?

For the purposes of the study, we assumed that changes in ground reaction force (direction and amount of force applied by the muscles) as a function of time during quiet standing can indirectly quantify the ability to maintain balance. By analyzing the nature of these changes as a time series, the autocorrelation function can identify the characteristics of neuromuscular control (regulator) and therefore serve as an indicator of central nervous system function during erect posture (Traczyk, Trzebski, 2001).

Material and methods

A sample of 82 individuals (31 females and 52 males) representing a wide age range (14–55 years of age) was recruited among an athletic and sedentary population. Mean age was 22.56 ±1.81 years, height 181.69 ±6.39 cm, and body mass 78.73 ±10.7 kg. All individuals provided their written informed consent to participate in the study. Approval from the local ethics committee was obtained. The study was performed at the Laboratory of Biomechanical Analysis of the University of Physical Education in Wrocław, Poland (ISO 9001:2001 certified).

The study protocol involved measuring ground reaction forces (GRF) during quiet standing on two 600 × 400 mm piezoelectric force plates (type 9286B; Kistler Instruments AG, Switzerland) each placed under one foot. The force plates were integrated with the prepackaged BioWare 4 software to synchronize the force–time characteristics from both plates. Four tri-axial force sensors located in the corners of the plates quantified GRF signal components in the mediolateral (F_x), anteroposterior (F_y), and vertical (F_z) directions at a sampling frequency of 50 Hz (measurement range was from 10 kN to 20 kN). All instruments were properly calibrated and the BTS Smart system (BTS Bioengineering, USA) was used to synchronize all data.

The measurement protocol required the participant to stand with feet parallel (no ankle rotation) to one another with a stance width of 30 cm. The participated was asked to assume a relaxed upright posture with the upper extremities resting freely against the trunk. Three trials of 25 s quiet standing were executed one after the other with no change in foot position. GRF signals were recorded 10 s after trial commencement, giving a 15 s time window of data acquisition. In total, 246 trials of quiet standing GRF were collected. The net forces were normalized to participants' body mass and expressed for the right and left foot. An exemplary plot of raw vertical ground reaction force (F_z) synchronized between the right and left foot force platforms is given in Figure 1.

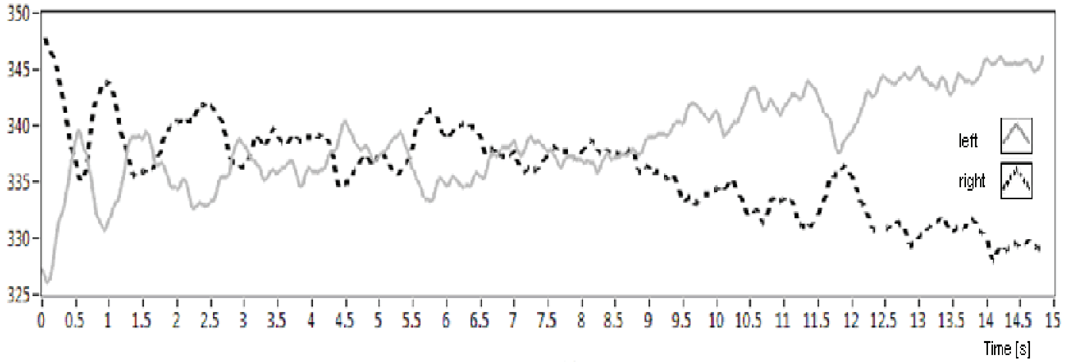

Figure 1. Exemplary plot of vertical ground reaction force (Fz) synchronized between the right and left foot force platforms

The autocorrelations from the raw ground force data were calculated based on the equation (Greene 2012):

$$Rx(\tau) = \lim_{T\to\infty} \tau\ 1/T \int_0^T x(t)x(t+\tau)dt$$

The signal X (t) at time t (stationary time) was self-correlated but shifted by 1/48 s (t + τ) to represent the phase delay whereas T is the duration of the record in seconds. The increment size for τ was defined by the data sampling frequency. Figure 2 provides an exemplary plot of the autocorrelation function for right and left foot vertical ground reaction force (F_z) during a 15-s standing trial. Based on the computed autocorrelations, a number of relevant parameters were determined to interpret the results:

T_0 – as the elapsed time from the beginning of the record (zero phase shift) when the autocorrelation function by definition has a peak value of +1 to when a value of 0 was reached,

T_{ex} – as the elapsed time from the beginning of the record (zero phase shift) to when the autocorrelation curve reached the first extremum (reversal of direction),

D_{ex} – as the extremum of the derivative output of the autocorrelation function, obtained by differentiation (an exemplary plot is provided in Figure 3),

G_S – as the gradient strength of the autocorrelation function, or the mean decay velocity from a value of 1 to when the extremum is reached (i.e. the quotient of the autocorrelation coefficient by the time to reach the first extremum).

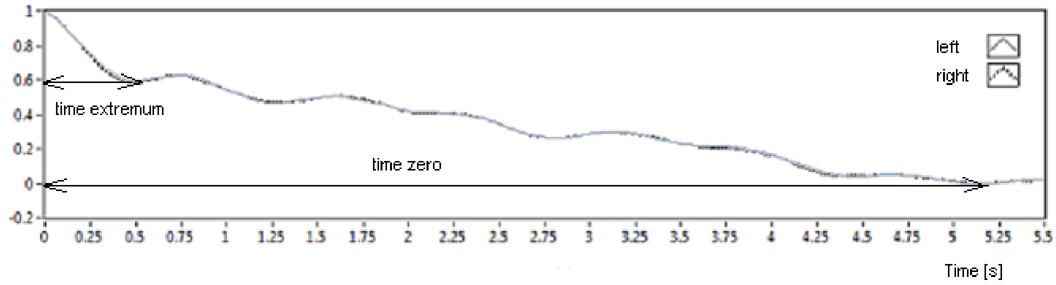

Figure 2. Exemplary plot of the autocorrelation function for right and left foot vertical ground reaction force (F_z) to the point where it reaches a value of 0 and the first extreme

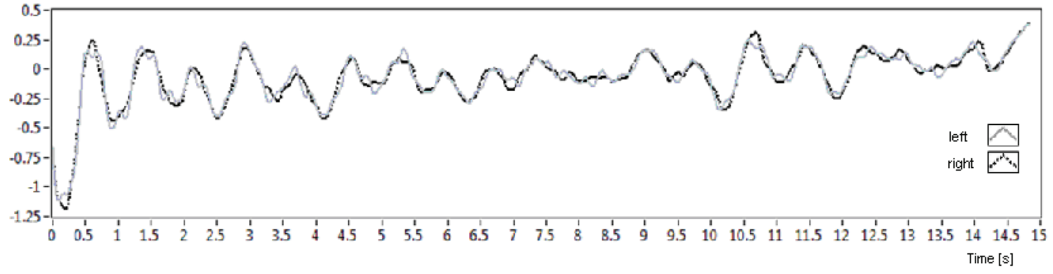

Figure 3. The derivative of the autocorrelation function

Statistical analysis

Basic descriptive statistics were calculated (means ± standard deviations) for all variables. The distribution of the data set was screened for normality using the Shapiro–Wilk test. The means were compared using Student's t test whereas Pearson's correlation coefficients were calculated to determine the dependencies between the variables. The significance level for all statistical procedures was set at $\alpha = 0.05$ ($p \leq 0.05$). Data processing was performed with the Statistica 9.0 software package.

Results

Testing the assumption of normality revealed the data to show a normal distribution. No significant between-sex differences for right and left foot GRF were observed. Hence, data were analyzed for the entire sample (n=246 trials). Comparisons of the mean right- and left-foot autocorrelation parameters revealed significant differences only in mediolateral (Fx) GRF for T0, Dex, and GS. Some differences were noted in the other two directions although these were not statistically significant (Table 1).

Table 1. Means and standard deviations of the autocorrelation function parameters (n =246 trials), significant differences ($p \leq 0.05$) between right- and left-foot values are marked in bold

Indexes	Foot	Variable							
		Time zero		Time extremum		Derivative extremum		Gradient strength	
		Means	SD	Means	SD	Means	SD	Means	SD
Mediolateral	right	2.549	1.666	1.997	1.986	-1.736	0.948	0.847	0.529
	left	2.842	1.541	2.137	1.819	-1.437	0.831	0.705	0.457
Anteroposterior	right	2.918	1.746	1.521	1.418	-1.481	0.693	0.811	0.401
	left	2.925	1.712	1.518	1.400	-1.485	0.697	0.815	0.407
Vertical	right	3.081	1.655	1.513	1.597	-1.779	0.839	0.832	0.492
	left	3.126	1.652	1.648	1.733	-1.753	0.809	0.799	0.444

When analyzing Tex (time to the first extremum), it was possible to determine the frequency content of the signal responsible for changes in the direction of GRF. A mean frequency of 0.5–0.7 Hz was found, although the large standard deviations indicate considerable inter-individual variance. Although no significant differences were observed between right- and left-foot Tex, comparisons of the magnitudes of this parameter in each of the three directions revealed that the frequency of the control processes responsible for balance in the mediolateral GRF (F_x) was evidently lower than in the other two directions.

Correlative analysis revealed statistically significant correlations between all of the parameters of the autocorrelation function for both right- and left-foot GRFs in all three directions (Table 2.). The coefficients were the smallest for the relationship between T_0 and T_{ex} ($r = 0.383$, mean for all right and left-foot GRF directions) whereas the highest was between D_{ex} and G_S ($r = 0.898$, respectively).

Table 2. Pearson's correlations (r) observed between the autocorrelation function parameters (n = 246 trials), significant differences ($p \le 0.05$) between right and left foot values are marked in bold

Indexes	Foot	Variable					
		Time zero – time extremum	Time zero – derivative extremum	Time zero – gradient strength	Time extremum – derivative extremum	Time extremum – gradient strength	Derivative extremum – gradient strength
Mediolateral	right	0.59	0.72	-0.73	0.67	-0.69	-0.91
	left	0.44	0.56	-0.52	0.67	-0.66	-0.92
Anteroposterior	right	0.32	0.63	-0.65	0.56	-0.62	-0.90
	left	0.32	0.62	-0.65	0.55	-0.61	-0.91
Vertical	right	0.33	0.67	-0.66	0.54	-0.55	-0.89
	left	0.30	0.60	-0.53	0.58	-0.61	-0.86
r		0.383	0.633	0.623	0.595	0.623	0.898

Discussion

The measurement of GRF provides clinically relevant information in the field of human movement research by indirectly assessing balance function and related motor control processes during gait or standing. As a static condition, standing can be quantified by the spatial positioning of body segments at different angles to form a whole-body kinematic model (Zatsiorsky, 2002). However, upright bipedal stance is itself unstable and features constant mediolateral and/ or anteroposterior sway. Every postural action by an individual requires autonomous neuromuscular input via activation of key muscle groups in order to maintain balance. This requires the central nervous system to integrate information from multiple sensory systems before activating the postural muscles necessary for balance (Traczyk, Trzebski, 2001). For this reason even quiet standing, contrary to appearances, is a complex biomechanical process that requires multiple actions in order to maintain balance. In most cases it is a process entirely involuntary and has no set time duration (although standing is frequently a long-duration task).

The available methodologies to recognize patterns and events in balance maintenance are incredibly complex, as they need to meet multiple conditions in order to provide valid and reliable measures from which relevant biophysical findings can be extracted during the data analysis stage. Duarte and Freitas (2010) indicated that this process can be confounded by various factors including health status, body characteristics, physical fitness, age, environment, and internal causes. The latter is considered the most influential, in that neuromuscular deficits, impaired motor control, and even small perturbations within the body (breathing, shifting weight from one foot to the other, heartbeat) can induce significant imbalance. Hence, as a mechanical event, postural balance is an unattainable state as the forces acting on the body are never at perfect equilibrium.

Currently, the literature has accepted the measurement of ground reaction forces via force plate as the gold standard in balance assessments especially in human movement and rehabilitation research (Lorkowskim et al., 2009; Czamara, 2007; McComis et al., 1997). For example, Czamara (2007; 2011) confirmed the applicability of this methodology in the treatment of foot injury. Due to differences in foot loading during standing between the feet, these authors used two force plates to interdependently determine the GRF time series of the right and left foot. Another aspect contemplated in functional balance assessments via GRF was the standardization of foot positioning (Chiari et al., 2002). For these reasons the present study's investigation of balance during quiet standing considered the differences between the right and left foot completely parallel to one another.

Raymakers et al. (2005) compared GRF-derived parameters from different age and health status groups to find significant differences in the discriminatory ability of said parameters. They concluded that the observed inconsistencies were due to a lack of standardized methodology in balance and stability assessments, such as differences in task duration (from 10 to 120 s), the number of trials (from three to nine repetitions), and sampling rates (from 10 to 100 Hz). In this regard, the measurement protocol of the present study was selected to be in line with that commonly used in the literature.

The application of signals processing techniques to interpret physiologically-relevant data on balance has great potential. Duarte et al. (2000) and Duarte and Zatsiorsky (2000; 2001) analyzed the temporal characteristics of GRF signals during 30 min of standing to find high ergodicity over the entire data range. GRF signal data accrued over different temporal distances (measurement duration) were highly correlated with each other, indicating that the postural control system has fractal properties. They found that a shorter measurement projection, up to a few minutes, produces a non-stationary signal and posited that this was due to low frequency noise, which could be isolated by high-pass filtering.

A number of variables have been used to quantify upright balance, where various studies have focused on using the vertical projection of the COG as an indicator of postural sway (Collins, De Luca, 1993; Duarte, Zatsiorsky, 2000; Baratto et al., 2002). The present study analyzed GRF using the autocorrelation function. Among various parameters that may be extracted from the autocorrelation function as per Pender et al. (2012), we adopted four as physiologically-meaningful measures that can distinguish postural control differences during quiet standing.

The first of the parameters we adopted was the time elapsed from the moment of initial observation, where the autocorrelation curve is equal to 1 to when a value of 0 is reached (T_0). A rapid decay to 0 indicates increased randomness in the motor control process of quiet standing. This reveals the presence of short-term balance disturbance in that there is weak relationship between present motor unit recruitment and the preceding and succeeding mechanical events. In turn, a slow decrease of the autocorrelation function to 0 suggests that the balance process is free of disturbance, in which postural control shows a low-frequency trend.

The second autocorrelation parameter we considered was the time from the beginning of the record to when the autocorrelation curve reached the first extremum (Tex), most commonly this occurred when there was a change in the direction of the GRF vector. This provides a measure of the periodicity or frequency of the motor control system and musculoskeletal system.

The next parameter described the derivative of the autocorrelation function (D_{ex}), or the magnitude of the noise of the GRF signal. In other words, this showed disturbances in the postural control system by the random activation of postural muscles that were not anticipated in the standing task.

The final parameter was the gradient strength (GS) of the autocorrelation function, or the mean decay velocity of the function from a value of +1 to the extremum. It can describe the individual frequency of the postural control system in maintaining balance. While similar to T_{ex}, GS defines the decay velocity as a pulsation of the individual system.

The correlation observed between T_0, and T_{ex} appears to be quite logical, as the time to a decay of 0 is in effect an assessment of task performance by the preceding, current, and succeeding mechanical events (maintaining steady balance during quiet standing), whereas Tex is a measure of the frequency of these events. Based on Tex, the signals responsible for postural balance were revealed to have periodic nature although with large inter-individual variation. Furthermore, the very strong correlations between Dex and GS confirm that these two parameters evaluate similar properties of the postural control system in maintaining upright balance.

Conclusions

It is difficult to clearly state which of the analyzed parameters of the autocorrelation function best characterize the GRF time series of quiet standing as each describes a different albeit important aspect of the postural control system. Nonetheless, they provide an interesting measure of assessing the response of the central nervous system for balance maintenance during standing. Furthermore, we observed strong correlation between the analyzed parameters, indicating that they evaluate similar properties of the central nervous system as a regulator of balance maintenance. The particularly strong correlation between the derivative output of the autocorrelation function (D_{ex}) and the gradient strength (GS) suggest that only one of these parameters warrants inclusion in future assessments of balance using the autocorrelation function.

References

Ayyappa, E. (1997). Normal human locomotion, part 2: motion, ground reaction force and muscle activity. *Journal of Prosthetics and Orthotics*, *9* (2), 42–57.

Baratto, L., Morasso, P.G., Re, C., Spada, G. (2002), A new look at posturographic analysis in the clinical context: sway-density versus other parameterization techniques. *Motor Control*, *6* (3), 246–270.

Brown, L.A., Shumway-Cook, A., Woollacott, M.H. (1999). Attentional demands and postural recovery: the effects of aging. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, *54* (4), 165–171.

Chao, X., Xin Y. (2004). Mathematical modeling of elastic inverted pendulum control system. *Journal of Control Theory and Applications*, *2* (3), 281–282.

Chiari, L., Rocchi, L., Cappello, A. (2002). Stabilometric parameters are affected by anthropometry and foot placement. *Clinical Biomechanics*, *17* (9–10), 666–677.

Collins, J.J., De Luca, C.J. (1993). Open-loop and closed-loop control of posture: a random-walk analysis of center-of-pressure trajectories. *Experimental Brain Research*, *95* (2), 308–318.

Czamara, A. (2007). Physiotherapeutic treatment after surgery of total Achilles tendon rupture. *The Journal of Orthopedics Trauma Surgery and Related Research*, *1* (5), 75–93.

Czamara, A. (2011). Fizjoterapia w częściowych uszkodzeniach ścięgna Achillesa. [W]: *Medycyna sportowa*, Red. Klukowski K, Wydawnictwo Medical Tribune. Warszawa, 240–244.

Doyle, R.J., Hsiao-Wecksler, E.T., Ragan, B.G., Rosengren, K.S. (2007). Generalizability of center of pressure measures of quiet standing. *Gait Posture*, *25* (2), 166–171.

Duarte, M., Freitas, S.M. (2010). Revision of posturography based on force plate for balance evaluation. *Revista Brasileira de Fisioterapia*, *14* (3), 183–192.

Duarte, M., Harvey, W., Zatsiorsky, V.M. (2000). Stabilographic analysis of unconstrained standing. *Ergonomics*, *43* (11), 1824–1839.

Duarte, M., Zatsiorsky, V.M. (2000). *Neuroscience Letters*, *283* (3), 173–176.

Duarte, M., Zatsiorsky, V.M. (2001). Long-range correlations in human standing. *Physics Letters A*, *283* (1–2), 124–128.

Golema, M. (2002). Charakterystyka procesu utrzymywania równowagi ciała człowieka w obrazie stabilograficznym. *Studia i Monografie AWF*. Wrocław.

Greene, W.H. (2012). Econometric analysis. *Pearson*, 7rd edition.

Kijowski, S. (2013). Zastosowanie platform Kistlera do oceny rehabilitacji chorych po urazach ścięgna Achillesa. *Kwartalnik Ortopedyczny*, *1*, 30–40.

Kuczyński, M. (2003). Model lepko-sprężysty w badaniach stabilności postawy człowieka. *Studia i Monografie 65*, AWF Wrocław.

Lafond, D., Corriveau, H., Hébert, R., Prince, F. (2004). Intrasession reliability of center of pressure measures of postural steadiness in healthy elderly people. *Archives of Physical Medicine and Rehabilitation*, *85* (6), 896–901.

Lafond, D., Champagne, A., Descarreaux, M., Dubois, J.D., Prado, J.M., Duarte, M. (2009). Postural control during prolonged standing in persons with chronic low back pain. *Gait Posture*, *29* (3), 421–427.

Liang, S., Ning, Y., Li H., Wang, L., Mei, Z., Ma, Y., Zhao, G. (2015). Feature Selection and Predictors of Falls with Foot Force Sensors Using KNN-Based Algorithms. *Sensors* (*Basel*), *15* (11), 29393–29407.

Loram, I.D., Lakie, M. (2002). Human balancing of an inverted pendulum: position control by small, ballistic-like, throw and catch movements. *Journal of Physiology*, *1* (540/3), 1111–1124.

Lorkowski, J., Trybus, M., Hładki, W., Zarzycki, D. (2009). Zastosowanie pedobarografii w holistycznej ocenie wyników leczenia urazów ścięgna Achillesa u osób uprawiających sport. *The Journal of Orthopaedics Trauma Surgery & Related Research*, *1*, 30–40.

McComis, G.P., Nawoczenski, D.A., De Haven, K.E. (1997). Functional baracing for rupture of the Achilles tendon. Clinical results and analysis of groundreaction forces and temporal date. *Journal of Bone and Joint Surgery AM*, *79 A*, 1799–1808.

Morningstar, M.W., Pettibon, B.R., Schlappi, H., Schlappi, M., Ireland, T.V. (2005). Reflex control of the spine and posture: a review of the literature from a chiropractic perspective. *Chiropractic and Osteopathy*, *13* (16), 1–17.

Onell, A. (2000). The vertical ground reaction force for analysis of balance? *Gait Posture*, *12* (1), 7–13.

Pender, W., Saddler, D., Shea, J., Ward, D. (2012). *Cambridge 2 Unit Mathematics Year 12 Enhanced*. Cambridge University Press.

Raymakers, J.A., Samson, M.M., Verhaar, H.J. (2005). The assessment of body sway and the choice of the stability parameter(s). *Gait Posture*, *21* (1), 48–58.

Skelton, D.A. (2001). Effects of physical activity on postural stability. *Age and Ageing*, *30-S4*, 33–39.

Szabatin, J. (2002). *Podstawy teorii sygnałów*. Wydawnictwa Komunikacji i Łączności. Warszawa.

Theiler, J., Eubank, S., Longtin, A., Galdrikian, B., Farmer, J.D. (1992). Testing for nonlinearity in time series: the method of surrogate data, *Physica D. Nonlinear Phenomena*, *58* (1–4), 77–94.

Traczyk, W., Trzebski, A. (2001). *Fizjologia człowieka z elementami fizjologii stosowanej i klinicznej*. Wydawnictwo Lekarskie PZWL. Warszawa.

Van Ooteghem, K., Frank, J.S., Allard, F., Buchanan, J.J, Oates, A.R., Horak, F.B. (2008). Compensatory postural adaptations during continuous, variable amplitude perturbations reveal generalized rather than sequence-specific learning. *Experimental Brain Research*, *187* (4), 603–611.

Winter, D.A. (1995). Human balance and posture control during standing and walking. *Gait Posture*, *3*, 193–214.

Winter, D.A., Patla, A.E., Prince, F., Ishac, M., Gielo-Perczak, K. (1998). Stiffness control of balance in quiet standing. *Journal of Neurophysiology*, *80*, 1211–1221.

Woollacott, M., Shumway-Cook, A. (2002). Attention and the control of posture and gait: a review of an emerging area of research. *Gait and Posture*, *16*, 1–14.

Zatsiorsky, V.M. (2002). Kinetics of human motion. *Human Kinetics.* Champaign.

Cite this article as: Stodółka, J., Korzewa, L., Stodółka, W., Gambal, J. (2017). The Applicability of Using Parameters of the Autocorrelation Function in the Assessment of Human Balance During Quiet Bipendal Stance. *Central European Journal of Sport Sciences and Medicine*, *17* (1), 79–87. DOI: 10.18276/cej.2017.1-10.